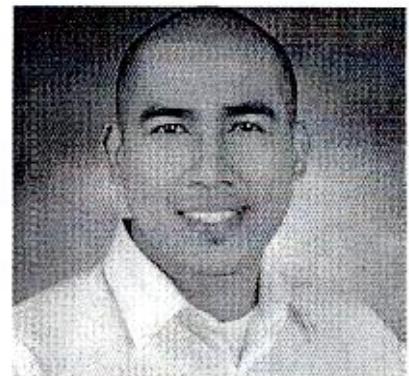


HERNANDO SIY SALAPARE III

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EDUCATIONAL BACKGROUND

June 2010 – April 2012	Doctor of Philosophy in Physics University of the Philippines - Diliman
November 2007 - April 2010	Master of Science in Physics University of the Philippines – Diliman Thesis: Bacterial adhesion performance of poly(tetrafluoroethylene) after surface modification using hydrogen and oxygen low-energy gas discharges
June 2003- October2007	Bachelor of Science in Applied Physics (Instrumentation Physics Concentration) University of the Philippines – Diliman Thesis: Low Energy Hydrogen Ion Shower (LEHIS) Treatment of Polytetrafluoroethylene (Teflon) Materials
June 2002- April 2003	BS Computer Science University of the Philippines – Manila
June 2001-April 2002	BS Pharmacy University of the Philippines – Manila
June 1997-April 2001	High School Makati Science High School
June 1991-April 1997	Elementary San Jose Elementary School

INTERNATIONAL PUBLICATIONS

ISI-Indexed Journal

- **H.S. Salapare III**, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, "Low-energy hydrogen ion shower treatment (LEHIS) of polytetrafluoroethylene (PTFE) materials", *Appl. Surf. Sci.* 255 (2008) 2951-2957.

Book Chapter

- **H.S. Salapare III**, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, " The porosity and wettability properties of hydrogen ion treated poly(tetrafluoroethylene)," in *Contact Angle, Wettability, and Adhesion*, Volume 6, Chapter 13, pp. 207-216, Kash L. Mittal (Ed.), VSP/Brill, Leiden (2009).

ISI-Indexed Journal (In Transit)

- **H.S. Salapare III**, G.Q. Blantocas, W.L. Rivera, V.A. Ong, R.S. Hipolito, H.J. Ramos, "Bacterial adhesion performance of poly(tetrafluoroethylene) after surface modification using hydrogen and oxygen low-energy gas discharges", *Journal of Adhesion Science and Technology*, submitted for publication, 2010.

INTERNATIONAL CONFERENCE/SYMPOSIUM

- "Cellular adhesion performance of poly(tetrafluoroethylene) after surface modification using hydrogen and oxygen low-energy gas discharges", 7th Polymer Surface Modification: Relevance to Adhesion, University of Maine, Orono, Maine, U.S.A, July 12-15, 2009. (not presented but accepted for publication)
- "The Porosity and Wettability Properties of Hydrogen Ion Treated Polytetrafluoroethylene", 6th International Symposium on Contact Angle, Wettability, and Adhesion, University of Maine, Orono, Maine, U.S.A, July 14-16, 2008. (not presented but accepted for publication)

HONORS AND ACHIEVEMENTS

Graduate School

- 2010 Most Outstanding Master of Science Graduate Batch 2010 (Class Valedictorian), College of Science, University of the Philippines – Diliman
- 2010 Recipient, Master's Thesis Grant, Philippine Council for Advanced Science and Technology Research and Development - Department of Science and Technology (under the Accelerated Science and Technology Human Resource Development program).
- 2009 International Publication Award (Contact Angle, Wettability, and Adhesion, Volume 6, Chapter 13, pp. 207-216, Kash L. Mittal (Ed.), VSP/Brill, Leiden, 2009), University of the Philippines
- 2009 International Publication Award (App. Surf. Sci., 255:2951-2957, 2008), University of the Philippines
- 2008-2010 Department of Science and Technology Graduate Scholarship Award (Accelerated Science and Technology Human Resource Development)

Undergraduate Level

- 2007-2008 Leticia Shahani Award for Best Undergraduate Thesis in Applied Physics
- 2001-2007 Department of Science and Technology Scholarship Award
(Republic Act 7687)
- 1st Semester, AY 2003-2004 College Scholar (*GWA = 1.68)
- 1st Semester, AY 2006-2007 College Scholar (*GWA = 1.48)
- 2nd Semester, AY 2006-2007 College Scholar (*GWA = 1.60)
- 1st Semester, AY 2007-2008 College Scholar (*GWA = 1.69)

High School

- Seventh Honorable Mention (2001)
- Model Student of the Year (2001)
- Best in Math, PEHM, Computer (2001)
- Best in Constitution (1999)
- Corps Commander (AY 2000-2001)
- Consistent Finalist, Metrobank -MTAP Math Challenge Regional Level (1997-2001)
- 1st Place, Search for Makati Science High School Math Wizard (2001)

LOCAL RESEARCH PUBLICATIONS (peer-reviewed)

- H. S. Salapare III, G.Q. Blantocas, A. Gines, M. Poral, M.T. Agcaoili, and H.J. Ramos, "Influence of oxygen plasma on the wettability of polytetrafluoroethylene", Proceedings of the 27th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 4, October 2009, p.28.

- **H. S. Salapare III**, G.Q. Blantocas, V.R. Noguera, and H.J. Ramos, "Fourier transform infrared spectroscopy (FTIR) characterization of low energy hydrogen ion shower (LEHIS) treatment of polytetrafluoroethylene (PTFE) materials", Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 5, October 2008, p.17.
- **H. S. Salapare III**, G.Q. Blantocas, V.R. Noguera, and H.J. Ramos, "Wetting dynamics model of hydrogen ion treated polytetrafluoroethylene (PTFE) materials", Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 5, October 2008, p.10.
- **H. S. Salapare III**, G.Q. Blantocas, E.V.B. Lagsa, V.R. Noguera, and H.J. Ramos, "Effects of low energy hydrogen ion shower (LEHIS) treatment on the optical property and thickness of polytetrafluoroethylene (PTFE) materials", Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 5, October 2008, p.13.
- **H. S. Salapare III**, A.M. Ulano, H.V. Lee Jr., G.Q. Blantocas, V.R.M. Daria, V.R. Noguerra, M.A.C. Camacho, and H.J. Ramos, "Optical Characterization of Hydrogen Ion Treated Polytetrafluoroethylene (Teflon®) Materials", Proceedings of the 25th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 4, October 2007, p.21.
- **H. S. Salapare III**, J.I.E. Palay, R. Kekim, G.J. Perez, and C.M.Y. Blanca, "Dynamic Contact Angle Measurements on Various Fabric Surfaces Using a Simple Optical Vision System.", Proceedings of the 25th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 4, October 2007, p.9.

LOCAL NEWS FEATURES ON SALAPARE'S RESEARCH/LOCAL JOURNAL

- **H.S. Salapare III**, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, Low-energy hydrogen ion shower (LEHIS) treatment of polytetrafluoroethylene (PTFE) materials, Research News on PISIKA Vol. 2 Issue 1, ISSN 1908-7640, October 2008, pp. 10-11.

LOCAL CONFERENCE/TRAININGS/SEMINARS

- Oral Presentation, "Influence of oxygen plasma on the wettability of polytetrafluoroethylene", 27th Samahang Pisika ng Pilipinas Physics Congress, Tagaytay City, October 30, 2009.
- Teaching Effectiveness Course (TEC), May 26-30, 2008 (40 hours), Office of the Director of Instruction, University of the Philippines Diliman.
- Research and Development Workshop, June 28, 2008 (7 hours, 45 minutes), Intel Philippines and Plasma Physics Laboratory, University of the Philippines Diliman.
- Oral Presentation, "Fourier transform infrared spectroscopy (FTIR) characterization of low energy hydrogen ion shower (LEHIS) treatment of polytetrafluoroethylene (PTFE) materials", 26th Samahang Pisika ng Pilipinas Physics Congress, University of the Philippines Baguio, October 23, 2008.
- Poster Presentation, "Wetting dynamics model of hydrogen ion treated polytetrafluoroethylene (PTFE) materials", 26th Samahang Pisika ng Pilipinas Physics Congress, University of the Philippines Baguio, October 23, 2008.

- Poster Presentation, "Effects of low energy hydrogen ion shower (LEHIS) treatment on the optical property and thickness of polytetrafluoroethylene (PTFE) materials", 26th Samahang Pisika ng Pilipinas Physics Congress, University of the Philippines Baguio, October 23, 2008.
- Poster Presentation, "Dynamic Contact Angle Measurements on Various Fabric Surfaces Using a Simple Optical Vision System", 25th Samahang Pisika ng Pilipinas Physics Congress, University of the Philippines Los Baños, October 25, 2007.
- Poster Presentation, "Optical Characterization of Hydrogen Ion Treated Polytetrafluoroethylene (Teflon®) Materials", 25th Samahang Pisika ng Pilipinas Physics Congress, University of the Philippines Los Baños, October 26, 2007.

PROFESSIONAL RESEARCH ACTIVITIES/MEMBERSHIPS IN ORGANIZATIONS

- Regular Member, National Research Council of the Philippines 2010-present
- Reviewer, African Journal of Pure and Applied Chemistry 2010-present
- Reviewer, International Journal of Physical Sciences (ISI-Indexed Journal) 2010-present
- Referee/Reviewer, Applied Surface Science (ISI-Indexed Journal) 2009-present
- Referee/Reviewer, Journal of Medicinal Plants Research (ISI-Indexed Journal) 2009-present
- Associate Member, National Research Council of the Philippines (NRCP) 2008-2010
- Member, Samahang Pisika ng Pilipinas (Physical Society of the Philippines) 2008 -present
- Referee/Reviewer, Samahang Pisika ng Pilipinas (Physical Society of the Philippines) 2008 -present
- Researcher, Plasma Physics Laboratory (National Institute of Physics) 2005-present
- Junior Staff, Plasma Physics Laboratory (National Institute of Physics) 2008-present
- 1st Councilor, College of Science Student Council Jun 2007-Oct 2007
- 1st Councilor, College of Science Student Council 2006-2007
- Councilor, College of Science Student Council 2005-2006
- Physics Representative, College of Science Student Council 2004-2005
- Logistics Committee Head, College of Science Student Council June 2007-October 2007
- Student Services Committee Head, College of Science Student Council 2004-2007
- Member, Membership Committee, UP Physics Association 2003-2004
- Member, Public Affairs Committee, UP Physics Association 2004-2007
- Member, UP Latter Day Saints Student Association 2003-2007
- CSSC Representative to Agham Editorial Board (Yearbook) 2004-2007
- Graduation Committee Head, College of Science, UP Diliman 2004-2008

WORK EXPERIENCE

- Assistant College Secretary, College of Science, UP Diliman June 1, 2010 – May 31, 2011
- Instructor of Physics, National Institute of Physics, UP Diliman
teaches Classical Mechanics June 1, 2008 – Present
- Science Research Assistant Nov 1, 2007-May 31, 2008
 - Plasma Physics Laboratory, National Institute of Physics
 - University of the Philippines Diliman
 - o DOST-PCASTRD Funded Project
- Researcher, Plasma Physics Laboratory April 2007 – May 2007
 - National Institute of Physics, UP Diliman
 - o DOST-SEI Summer OJT Program
- UPCAT Review Lecturer and Tutor – UPAP Tutorial Center June 2006 -August 2007

PART II: DETAILS OF THE PROPOSAL

I. SIGNIFICANCE OF THE STUDY

The study aims to alleviate the problems of implanted biomaterials specifically for implanted poly(tetrafluoroethylene) materials. These implanted biomaterials experiences excessive bacterial colonization when not treated properly before being implanted on the body. The goal of the study is to produce a biomaterial that will not experience excessive bacterial colonization. The process we are proposing is better than other techniques because it is less expensive and can easily be reproduced in large scales.

II. BACKGROUND OF THE STUDY

Biomaterials such as polytetrafluoroethylene (PTFE) are extensively utilized in synthetic vascular surgery and medical devices because of its chemical and mechanical stability, and low flammability [1-4]. Some of the implanted materials experiences failures due to common complications such as bacterial colonization on the surface and the subsequent device infections [5-11]. The most common solutions to these biomaterial-related infections often require the removal or the replacement of the implanted device as well as the immediate aggressive antibiotic therapy [12]. These methods of dealing with biomaterial-related infections are usually expensive and increases patient's discomfort [12].

III. STATEMENT OF THE PROBLEM

We propose to modify the surface property of polytetrafluoroethylene (PTFE) materials by exposing it to hydrogen and oxygen low energy gas discharges using a gas discharge ion source (GDIS) facility at different discharge conditions. We plan to test the bacterial adhesion performance of polytetrafluoroethylene (PTFE) materials by using contact angle measurements, scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), ellipsometry technique, surface energy calculations, and *Serratia marcescens* adhesion tests.

IV. OBJECTIVES

- A. Modify the surface of PTFE materials using using hydrogen low-energy gas discharge and oxygen low-energy gas discharge.
- B. Evaluate the bacterial adhesion performance of the samples in terms of contact angle measurements, scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), ellipsometry, surface energy calculations, and *Serratia marcescens* adhesion techniques.

V. DISCUSSION OF LITERATURE RELATED TO THE FIELD

Surface modification technology is seen to alleviate the problems of implanted biomaterials [1, 13-18]. There are different techniques on modifying the surface of a polymer material, some of these uses plasma, UV-activation, ion-beams, corona discharge, and hydrogels [19]. Different techniques usually offer a different result especially on its ability to reduce bacterial adherence [19]. Studies have shown that the surface modification of biomaterials using different gases could enhance or modify its desirable characteristics to better fit for adhesions and biocompatibility [4, 20-22].

VI. METHODOLOGY

PTFE tape of size $1 \times 2 \text{ cm}^2$ was wrapped around a $2 \times 2 \text{ cm}^2$ stainless steel plate holder. The surface of the clean samples was blow-dried to prevent the formation of moisture on the surface. PTFE was then irradiated using a low-energy hydrogen ion shower (LEHIS) from a gas discharge ion source (GDIS) system. Another set of PTFE samples were irradiated using oxygen low-energy gas discharge from the GDIS system. Figure 1(a) shows the schematic diagram of the experimental set-up and figure 1 (b) shows the schematic diagram of the GDIS. It has a compact discharge region of volume 0.8 cm^3 and an exit aperture of 2.0 mm in diameter. The extraction and focusing electrodes are grounded to ensure a diffused ion shower configuration. The GDIS fits a standard 70 mm knife-edge flange coupled to the diagnostic chamber whose volume is about 2400 cm^3 . A 10 cm-diameter oil diffusion pump coupled to an $8 \text{ m}^3/\text{h}$ rotary pump evacuates the system. Complete details of the facility and its operation are described in [23-27].

Pirani and ionization gauges monitor the pressure inside the chamber. The base pressure was $\sim 7.0 \times 10^{-5}$ Torr. The total gas filling pressure was kept at 5 mTorr for all the experimental runs. Plasma was produced when a potential difference, V_d , was applied across the discharge region. The PTFE samples were placed on a holder positioned 70 mm downstream from the entrance port of the processing chamber. This position was determined to give maximum ion current density [23-24]. The irradiation time is set to 30 minutes.

The bacterial adhesion performance of polytetrafluoroethylene (PTFE) materials is determined using contact angle measurements, scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), ellipsometry techniques, surface energy calculations, and *Serratia marcescens* adhesion tests.

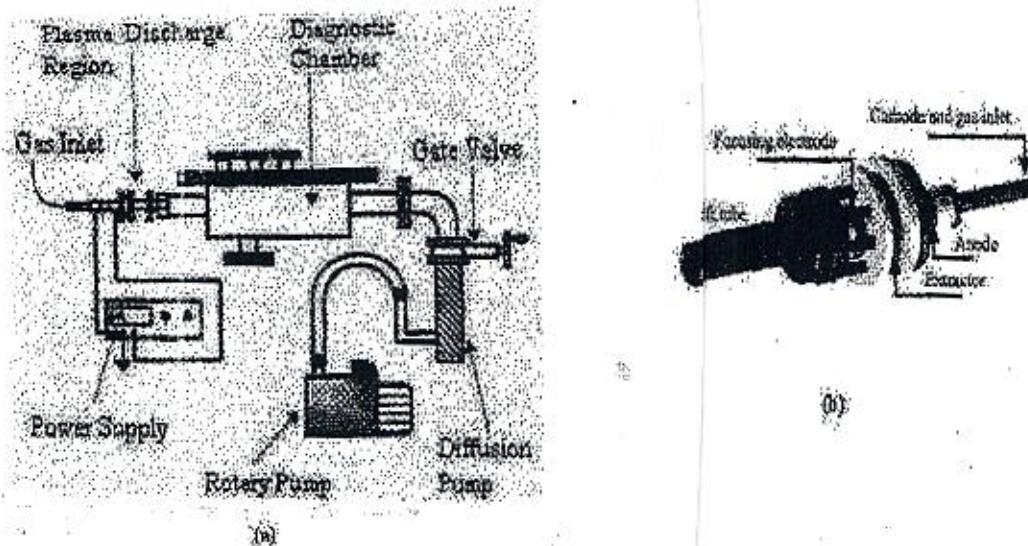


Figure 1: Illustrations of the experimental setup. (a) Schematic diagram of the overall facility. (b) Schematic diagram of the GDIS.

IX. PROPOSED BUDGET

ITEM	Total
Electrical, polymer and metal components	10,000.00
Bacterial adhesion tests (i.e. reagents, glasswares)	10,000.00
SEM/FTIR/Contact Angle/Ellipsometry Characterizations	20,000.00
Thesis Manuscript Printing, Reproduction and Binding	5,000.00
Publication Cost (for submission to ISI indexed journals, i.e. postal fees)	5,000.00
TOTAL	PhP 50,000.00

X. REFERENCES

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- [19] J.H. Loh, *Med. Device Technol.* **10** (1), 24-30 (1999).
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THESIS PROPOSAL**PART I: PROPOSAL SUMMARY****I. TITLE**

Serratia marcescens adhesion performance of poly(tetrafluoroethylene) after surface modification using hydrogen and oxygen low-energy gas discharges

II.**KEYWORDS TO DESCRIBE THE SUBJECT AREA OF THE STUDY**

poly(tetrafluoroethylene) (PTFE), gas discharge ion source (GDIS), surface modification, bacterial adhesion, surface energy, wettability

III.**DURATION OF THE STUDY**

7 months

IV.**BUDGET REQUESTED**

PhP 50,000.00

V.**ABOUT THE PROPONENT**

Last Name: SALAPARE

First Name: HERNANDO III

Middle Name: SIY

Residence Address: Room 126 West 1 Main, Ipil Residence Hall, Magsaysay Avenue, University of the Philippines Diliman, Quezon City, Philippines 1101

Contact Number: +63-915-7456-224

E-mail Address: jethrosy@gmail.com, hssalapare@up.edu.ph

Degree Program: Master of Science in Physics

College/University: University of the Philippines

Address: Diliman, Quezon City, Philippines 1101

Department: National Institute of Physics

Adviser: Dr. Henry J. Ramos

VI.**EXECUTIVE SUMMARY**

We propose to modify the surface property of polytetrafluoroethylene (PTFE) materials by exposing it to hydrogen and oxygen low energy gas discharges using a gas discharge ion source (GDIS) facility at different discharge conditions. The surface modification would change the property of the material and it also the goal of this study to produce a bio-mimetic polymer material. We plan to test the bacterial adhesion performance of polytetrafluoroethylene (PTFE) materials by using contact angle measurements, scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), ellipsometry technique, surface energy calculations, and *Serratia marcescens* adhesion tests. Bacterial colonization on implanted biomaterials is one of the major problems in the field of medicine. The main purpose of the study is to engineer a bio-mimetic polymer material that is not susceptible to bacterial colonization.

VII. PRESENT STATUS

Plasma treatment of the samples is complete. We are now on the 5th month of the project. 70% of the characterizations were already finished especially for hydrogen treatment. Results of hydrogen and oxygen treatments were already reported in different international and local scientific journals/books/conference proceedings. The lists of the publications related to the work are listed as follows:

International Publications

- H.S. Salapare III**, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, "Low-energy hydrogen ion shower treatment (LEHIS) of polytetrafluoroethylene (PTFE) materials", *Appl. Surf. Sci.* 255 (2008) 2951-2957.
H.S. Salapare III, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, "The porosity and wettability properties of hydrogen ion treated poly(tetrafluoroethylene)", in *Contact Angle, Wettability, and Adhesion*, Volume 6, Chapter 13, pp. 207-216, Kash L. Mittal (Ed.), VSP/Brill, Leiden (2009).

Local Publications

- H. S. Salapare III**, G.Q. Blantocas, A. Gines, M. Poral, M.T. Agcaoili, and H.J. Ramos, "Influence of oxygen plasma on the wettability of polytetrafluoroethylene", Proceedings of the 27th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 4, October 2009, p.28.
H.S. Salapare III, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, Low-energy hydrogen ion shower (LEHIS) treatment of polytetrafluoroethylene (PTFE) materials, *Research News on PISIKA* Vol. 2 Issue 1, ISSN 1908-7640, October 2008, pp. 10-11.
H. S. Salapare III, G.Q. Blantocas, V.R. Noguera, and H.J. Ramos, "Fourier transform infrared spectroscopy (FTIR) characterization of low energy hydrogen ion shower (LEHIS) treatment of polytetrafluoroethylene (PTFE) materials", Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 5, October 2008, p.17.
H. S. Salapare III, G.Q. Blantocas, V.R. Noguera, and H.J. Ramos, "Wetting dynamics model of hydrogen ion treated polytetrafluoroethylene (PTFE) materials", Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 5, October 2008, p.10.
H. S. Salapare III, G.Q. Blantocas, E.V.B. Lagasa, V.R. Noguera, and H.J. Ramos, "Effects of low energy hydrogen ion shower (LEHIS) treatment on the optical property and thickness of polytetrafluoroethylene (PTFE) materials", Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 5, October 2008, p.13.

VIII. WORKPLAN AND SCHEDULE OF ACTIVITIES

RESEARCH ACTIVITY	TIMETABLE	OUTPUT
Hydrogen Plasma Treatment	Months 1, 2, and 5	Hydrogen treated PTFE samples
Oxygen Plasma Treatment	Months 3, 4, and 5	Oxygen treated PTFE samples
SEM Characterization	Month 5	Surface morphology
FTIR Characterization	Month 5	Chemical properties
Contact Angle Measurements	Month 5	Wettability of PTFE
Bacterial Adhesion Tests	Months 5 and 6	Bacterial adhesion profile
Surface Energy Calculations	Month 6	Surface energies
Thesis Writing and Presentation	Month 7	MS Physics thesis

DOST Accelerated S&T Human Resource Development Program

Scholar's Thesis/Dissertation Progress Report

for the 1st 2nd 3rd 4th Quarter / Year 2009

THESIS/DISSERTATION TITLE:

Bacterial adhesion performance of Poly(tetrafluoroethylene) after surface modification using hydrogen and oxygen low-energy gas discharges

GRANTEE:

HERNANDO S. SALAPARE III

DEGREE PROGRAM:

MS PHYSICS

DURATION:

17 months

DATE STARTED:

NOVEMBER 2008

EXPECTED DATE OF COMPLETION:

MARCH 2010

OBJECTIVES:

- * modify the surface of poly(tetrafluoroethylene) (PTFE) using hydrogen and oxygen low-energy gas discharges
- * investigate the interaction of bacterial cells with the modified PTFE
- * determine the effects of surface modification

SCHEDULE OF ACTIVITIES:

November 2008 - October 2009 - treatment of PTFE, characterizations (SEM, FTIR, CA)

November 2009 - February 2010 - bacterial adhesion tests
(includes bacterial culturing)

March 2010 - finish writing the manuscript
thesis defence

1/07/09gt

RESULTS AND DISCUSSION:

Results show that both the hydrogen and oxygen plasma treatments modify the PTFE surface in morphology but only oxygen treatment modified the PTFE in chemical composition. Both treatment exhibited changes in the wettability of the samples at different discharge currents, lower I_d improved material hydrophobicity while higher I_d resulted in enhanced hydrophilicity.

PROBLEMS ENCOUNTERED/PROPOSED SOLUTIONS:

- * lack of materials for bacterial adhesion → coordinate with biological laboratories in UP, apply for grant to buy disposable petri dishes, beakers, flasks and reagents/agar
 - * imaging of biological samples → use phase contrast microscope instead of SEM
 - * E. coli is the same color as of the sample → use different bacteria, maybe Serratia marcescens because of its red color
- REMARKS:
Partial results were already published in an ISI indexed journal and an internationally circulated book as a book chapter.
- * H.S. Salapare III, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, "Low-energy hydrogen ion shower treatment (LEHTS) of polytetrafluoroethylene (PTFE) materials", Appl. Surf. Sci. 255 (2008) 2951-2957.
- * H.S. Salapare III, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, "the porosity and wettability properties of hydrogen ion treated PTFE" in contact angle, wettability, and Adhesion, Volume 6, chapter 13 pp. 207-216, Kash L. Mittal (Ed.), VSP/Brill, Leiden (2009).

Prepared by:

HERNANDO S. SALAPARE III
Grantee's name/signature

This portion is to be filled up by adviser and returned to PCASTRD in a sealed envelope together with the scholar's report:

PERCENTAGE OF TOTAL WORK COMPLETED:

~70%

COMMENTS:

Treatments of PTFE were done using the gas mixture from source. This is to determine the optimum addition conditions for bacterial culture. The process will lead to the synthesis of biomimetic materials. His well on his way towards tests of interaction between bacterial cells and the treated polymer.

ADVISER'S NAME/SIGNATURE:

mg
H. Komes

12 November 2009

DATE

THESIS PROPOSAL

PART I: PROPOSAL SUMMARY

I. TITLE

Serratia marcescens adhesion performance of poly(tetrafluoroethylene) after surface modification using hydrogen and oxygen low-energy gas discharges

II. KEYWORDS TO DESCRIBE THE SUBJECT AREA OF THE STUDY

poly(tetrafluoroethylene) (PTFE), gas discharge ion source (GDIS), surface modification, bacterial adhesion, surface energy, wettability

III. DURATION OF THE STUDY

7 months

IV. BUDGET REQUESTED

PhP 50,000.00

V. ABOUT THE PROPONENT

Last Name: SALAPARE

First Name: HERNANDO III

Middle Name: SIY

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Degree Program: Master of Science in Physics

College/University: University of the Philippines

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Department: National Institute of Physics

Adviser: Dr. Henry J. Ramos

VI. EXECUTIVE SUMMARY

We propose to modify the surface property of polytetrafluoroethylene (PTFE) materials by exposing it to hydrogen and oxygen low energy gas discharges using a gas discharge ion source (GDIS) facility at different discharge conditions. The surface modification would change the property of the material and it also the goal of this study to produce a bio-mimetic polymer material. We plan to test the bacterial adhesion performance of polytetrafluoroethylene (PTFE) materials by using contact angle measurements, scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), ellipsometry technique, surface energy calculations, and *Serratia marcescens* adhesion tests. Bacterial colonization on implanted biomaterials is one of the major problems in the field of medicine. The main purpose of the study is to engineer a bio-mimetic polymer material that is not susceptible to bacterial colonization.

PART II: DETAILS OF THE PROPOSAL

I. SIGNIFICANCE OF THE STUDY

The study aims to alleviate the problems of implanted biomaterials specifically for implanted poly(tetrafluoroethylene) materials. These implanted biomaterials experiences excessive bacterial colonization when not treated properly before being implanted on the body. The goal of the study is to produce a biomaterial that will not experience excessive bacterial colonization. The process we are proposing is better than other techniques because it is less expensive and can easily be reproduced in large scales.

II. BACKGROUND OF THE STUDY

Biomaterials such as polytetrafluoroethylene (PTFE) are extensively utilized in synthetic vascular surgery and medical devices because of its chemical and mechanical stability, and low flammability [1-4]. Some of the implanted materials experiences failures due to common complications such as bacterial colonization on the surface and the subsequent device infections [5-11]. The most common solutions to these biomaterial-related infections often require the removal or the replacement of the implanted device as well as the immediate aggressive antibiotic therapy [12]. These methods of dealing with biomaterial-related infections are usually expensive and increases patient's discomfort [12].

III. STATEMENT OF THE PROBLEM

We propose to modify the surface property of polytetrafluoroethylene (PTFE) materials by exposing it to hydrogen and oxygen low energy gas discharges using a gas discharge ion source (GDIS) facility at different discharge conditions. We plan to test the bacterial adhesion performance of polytetrafluoroethylene (PTFE) materials by using contact angle measurements, scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), ellipsometry technique, surface energy calculations, and *Serratia marcescens* adhesion tests.

IV. OBJECTIVES

- A. Modify the surface of PTFE materials using using hydrogen low-energy gas discharge and oxygen low-energy gas discharge.
- B. Evaluate the bacterial adhesion performance of the samples in terms of contact angle measurements, scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), ellipsometry, surface energy calculations, and *Serratia marcescens* adhesion techniques.

V. DISCUSSION OF LITERATURE RELATED TO THE FIELD

Surface modification technology is seen to alleviate the problems of implanted biomaterials [1, 13-18]. There are different techniques on modifying the surface of a polymer material, some of these uses plasma, UV-activation, ion-beams, corona discharge, and hydrogels [19]. Different techniques usually offer a different result especially on its ability to reduce bacterial adherence [19]. Studies have shown that the surface modification of biomaterials using different gases could enhance or modify its desirable characteristics to better fit for adhesions and biocompatibility [4, 20-22].

VI. METHODOLOGY

PTFE tape of size $1 \times 2 \text{ cm}^2$ was wrapped around a $2 \times 2 \text{ cm}^2$ stainless steel plate holder. The surface of the clean samples was blow-dried to prevent the formation of moisture on the surface. PTFE was then irradiated using a low-energy hydrogen ion shower (LEHIS) from a gas discharge ion source (GDIS) system. Another set of PTFE samples were irradiated using oxygen low-energy gas discharge from the GDIS system. Figure 1(a) shows the schematic diagram of the experimental set-up and figure 1.(b) shows the schematic diagram of the GDIS. It has a compact discharge region of volume 0.8 cm^3 and an exit aperture of 2.0 mm in diameter. The extraction and focusing electrodes are grounded to ensure a diffused ion shower configuration. The GDIS fits a standard 70 mm knife-edge flange coupled to the diagnostic chamber whose volume is about 2400 cm^3 . A 10 cm-diameter oil diffusion pump coupled to an $8 \text{ m}^3/\text{h}$ rotary pump evacuates the system. Complete details of the facility and its operation are described in [23-27].

Pirani and ionization gauges monitor the pressure inside the chamber. The base pressure was $\sim 7.0 \times 10^{-5}$ Torr. The total gas filling pressure was kept at 5 mTorr for all the experimental runs. Plasma was produced when a potential difference, V_d , was applied across the discharge region. The PTFE samples were placed on a holder positioned 70 mm downstream from the entrance port of the processing chamber. This position was determined to give maximum ion current density [23-24]. The irradiation time is set to 30 minutes.

The bacterial adhesion performance of polytetrafluoroethylene (PTFE) materials is determined using contact angle measurements, scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), ellipsometry techniques, surface energy calculations, and *Serratia marcescens* adhesion tests

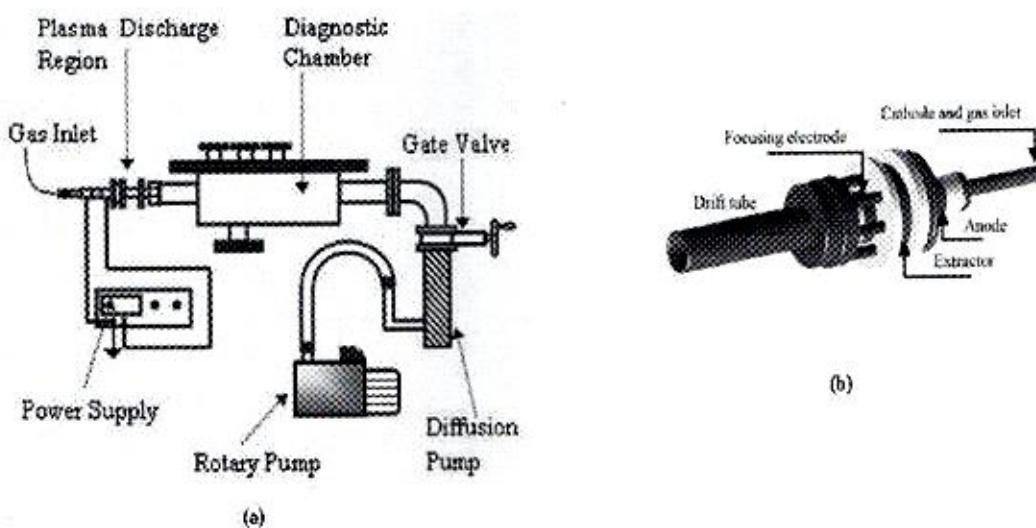


Figure 1: Illustrations of the experimental setup. (a) Schematic diagram of the overall facility. (b) Schematic diagram of the GDIS.

VII. PRESENT STATUS

Plasma treatment of the samples is complete. We are now on the 5th month of the project. 70% of the characterizations were already finished especially for hydrogen treatment. Results of hydrogen and oxygen treatments were already reported in different international and local scientific journals/books/conference proceedings. The lists of the publications related to the work are listed as follows:

International Publications

- H.S. Salapare III, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, "Low-energy hydrogen ion shower treatment (LEHIS) of polytetrafluoroethylene (PTFE) materials", *Appl. Surf. Sci.* 255 (2008) 2951-2957.
H.S. Salapare III, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, "The porosity and wettability properties of hydrogen ion treated poly(tetrafluoroethylene)," in *Contact Angle, Wettability, and Adhesion*, Volume 6, Chapter 13, pp. 207-216, Kash L. Mittal (Ed.), VSP/Brill, Leiden (2009).

Local Publications

- H. S. Salapare III, G.Q. Blantocas, A. Gines, M. Poral, M.T. Agcaoili, and H.J. Ramos, "Influence of oxygen plasma on the wettability of polytetrafluoroethylene", Proceedings of the 27th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 4, October 2009, p.28.
H.S. Salapare III, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, Low-energy hydrogen ion shower (LEHIS) treatment of polytetrafluoroethylene (PTFE) materials, *Research News on PISIKA* Vol. 2 Issue 1, ISSN 1908-7640, October 2008, pp. 10-11.
H. S. Salapare III, G.Q. Blantocas, V.R. Noguera, and H.J. Ramos, "Fourier transform infrared spectroscopy (FTIR) characterization of low energy hydrogen ion shower (LEHIS) treatment of polytetrafluoroethylene (PTFE) materials", Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 5, October 2008, p.17.
H. S. Salapare III, G.Q. Blantocas, V.R. Noguera, and H.J. Ramos, "Wetting dynamics model of hydrogen ion treated polytetrafluoroethylene (PTFE) materials", Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 5, October 2008, p.10.
H. S. Salapare III, G.Q. Blantocas, E.V.B. Lagsa, V.R. Noguera, and H.J. Ramos, "Effects of low energy hydrogen ion shower (LEHIS) treatment on the optical property and thickness of polytetrafluoroethylene (PTFE) materials", Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 5, October 2008, p.13.

VIII. WORKPLAN AND SCHEDULE OF ACTIVITIES

RESEARCH ACTIVITY	TIMETABLE	OUTPUT
Hydrogen Plasma Treatment	Months 1, 2, and 5	Hydrogen treated PTFE samples
Oxygen Plasma Treatment	Months 3, 4, and 5	Oxygen treated PTFE samples
SEM Characterization	Month 5	Surface morphology
FTIR Characterization	Month 5	Chemical properties
Contact Angle Measurements	Month 5	Wettability of PTFE
Bacterial Adhesion Tests	Months 5 and 6	Bacterial adhesion profile
Surface Energy Calculations	Month 6	Surface energies
Thesis Writing and Presentation	Month 7	MS Physics thesis



IX. PROPOSED BUDGET

ITEM	Total
Electrical, polymer and metal components	10,000.00
Bacterial adhesion tests (i.e. reagents, glasswares)	10,000.00
SEM/FTIR/Contact Angle/Ellipsometry Characterizations	20,000.00
Thesis Manuscript Printing, Reproduction and Binding	5,000.00
Publication Cost (for submission to ISI indexed journals, i.e. postal fees)	5,000.00
TOTAL	PhP 50,000.00

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Jethro Salapare <jethrosy@gmail.com>

SURFACE MODIFICATION SYMPOSIUM, U. MAINE, JULY 2009

1 message

Robert Lacombe <rhlacombe@compuserve.com>
To: Hernando Salapare III <jethrosy@gmail.com>

Mon, Sep 29, 2008 at 8:55 AM

Dear Hernando

It is our pleasure to invite you to present a paper at the upcoming SEVENTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION: RELEVANCE TO ADHESION to be held July 12-15, 2009 at the University of Maine, Orono, Maine, USA. Your contributions to this field are known to us through either your participation in previous symposia, your publications or the recommendations of others. We would therefore be interested learning of your latest endeavors in this field. Your paper can deal with any of the topics listed in the attached "Call for Papers" or allied topic and could be either an overview or an original research contribution.

If you should decide to accept this invitation, which we certainly hope you will, please signify your acceptance by responding to the Chairman, Dr. Lacombe at the address below. Questions relating to the technical details should be directed to him. More general questions concerning the overall content of the symposium may be directed to the Conference Director Dr. Mittal (Tel. 845-897-1654, E-mail klm@mstconf.com).

We certainly hope your response to this invitation will be in the affirmative. Apropos, all signals indicate a great deal of interest in this Symposium, and your contribution will be a significant plus to the overall program. For your information we also attach the announcement for an additional symposium that you or one of your colleagues might also find of interest.

Looking forward to hearing from you soon.

With kind regards,

Dr. K. L. Mittal
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Dr. Robert H. Lacombe
Chairman
Materials Science and Technology
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3 Hammer Drive
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FAX 212-556-1016

E-mail: rhlacombe@compuserve.com

2 attachments

 **Surfmod7-cfp.pdf**
51K

 **Silane7-cfp.pdf**
51K



Jethro Salapare <jethrosy@gmail.com>

POLYMER SURFACE MODIFICATION

1 message

Robert Lacombe <rhlacombe@compuserve.com>

To: Hernando Salapare <jethrosy@gmail.com>

Fri, Jan 9, 2009 at 10:06 AM

Dear Hernando

Thank you for accepting our invitation to present a paper at the upcoming
SEVENTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION: RELEVANCE
TO ADHESION to be held July 12-15, 2009 at the University of Maine, Orono,
Maine, USA.

We have your title and abstract and will be including them in the program.
I am putting you on our registration list and you will be hearing from us
again as soon as the final program is ready.

Papers will be allowed approximately 25 minutes under normal circumstances.
Authors requiring more time need to contact the Conference Director, Dr.
Mittal (Tel. 845-897-1654, Fax 845-897-2361, E-mail: klm@mstconf.com), to
make appropriate arrangements.

Presenters have a range of options for audio-visual support as follows:

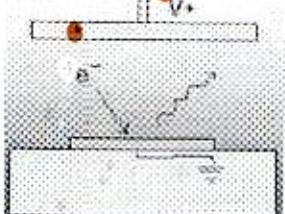
1. MST will provide a digital projector for those who want to bring just a memory stick or a CD containing their presentation. This works out best for relatively straightforward presentations without videos or other exotic features.
2. Presenters can also bring their own laptops which can be plugged into the digital projector. This may be necessary if the presentation includes features that might not be supported by the available software.
3. Facilities for using overhead transparencies and 35mm slides will also be provided.

Finally we suggest that all presenters have backup copies of their talks on either a CD or a memory stick.

Dr. Mittal and I both look forward to meeting you at the symposium.

Best regards and BEST WISHES FOR THE NEW YEAR

Dr. Robert H. Lacombe
Chairman
Materials Science and Technology
CONFERENCES
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Hopewell Junction, NY 12533-6124
Tel. 845-897-1654
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E-mail: rhlacombe@compuserve.com



PRELIMINARY PROGRAM SEVENTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION: RELEVANCE TO ADHESION

To be held July 12-15, 2009; University of Maine, Orono, Maine, USA

This symposium continues the tradition set by the first in the series entitled: "Polymer Surface Modification: Relevance to Adhesion" which was held in Las Vegas, NV, 1993. As with its predecessors, this symposium will be concerned with the technological areas where surface modification is a key technology which allows for the processing and manufacture of products which would otherwise be unobtainable.

We are indeed happy to announce that this the 7th symposium in the series will be organized in collaboration with Prof. Douglas Gardner in the Advanced Engineered Wood Composites Center at the University of Maine, Orono, Maine. Prof. Gardner is well acquainted with problems of polymer surface modification as applied to wood composites and is also serving on the editorial board of the Journal of Adhesion Science and Technology which is edited by the Conference Director Dr. Mittal.

Prof. Gardner has been an active researcher in the field and he and his group look forward to hosting this

BIOLOGICAL/BIOMEDICAL INVESTIGATIONS

Charles Anamelechi; Biomedical Engineering Department, Duke University (CIEMAS 1313), 144 Hudson Hall, Durham, NC 27708; **Endothelial Cell Adhesion to Synthetic Vascular Grafts Using Biotinylated Fibronectin in a Dual Ligand Protein System**

Frédéric Busnel; Vincent Blanchard, Bernard Riedl and Pierre Blanchet; Centre de Recherche sur le Bois, Faculté de Foresterie et De Géomatique Pavillon Kruger-Université Laval, Québec, QC G1V 0A6, CANADA; **Atmospheric Pressure Plasma Treatment on Sugar Maple (*Acer Saccharum*) and on Black Spruce (*Picea Mariana*) Wood. Study of Surface Free Energy Using Contact Angle Measurements.**

Gijo Raj, Eric Balnois, Christophe Baley and **Yves Grohens;** Laboratoire d'Ingénierie des Matériaux de Bretagne (LIMATB), Université de Bretagne Sud, Rue de Saint Maudé BP 92116, F-56321 Lorient Cedex, FRANCE; **Interfaces in Biocomposites: Colloid Force Measurements Between Cellulose and Polylactic Acid**

Josè M. Kenny; European Center of Nanostructured Polymers (ECNP) and University of Perugia - UdR INSTM, Loc. Pentima Bassa 21, 05100 Terni, ITALY; **Plasma Modification and Surface Functionalization of Biodegradable Polymers for Controlling the Adhesion of Stromal Cells**

symposium and greeting all participants from both academia and industry from all corners of the globe.

Proper adhesion characteristics are vital to the success of any practical implementation of polymer materials. Though polymers are generally not very adhesionable, careful surface modification can result in greatly improved adhesion without altering bulk properties. This symposium is organized to bring together scientists, technologists and engineers interested in all aspects of polymer surface modification, to review and assess the current state of knowledge, to provide a forum for exchange and cross-fertilization of ideas, and to define problem areas which need intensified efforts.

The invited speakers have been selected so as to represent widely differing disciplines and interests, and they hail from academic, governmental and industrial research laboratories. This meeting is planned to be a truly international event with participation from research groups from academia and industry worldwide.

Sean X. Liu; Cereal Products and Food Science Research Unit, National Center for Agricultural Utilization Research, U.S. Department of Agriculture, ARS, 1815 N. University Street, Peoria, IL 61604; **The Effect of Polymer Surface Modification on Polymer-Protein Interaction via Interfacial Polymerization and Hydrophilic Polymer Grafting**

N.Gomathi, Debasish Mishra, Tapas Kumar Maity, and **Sudarsan Neogi;** Department of Chemical Engineering, Indian Institute of Technology, Kharagpur, 721302 INDIA; **Low Pressure Radio Frequency Plasma Treatment of Polypropylene for Improved Cell Adhesion**

Z. L. Shi, F. Zhang, E. T. Kang and **K. G. Neoh;** Department of Chemical and Biomolecular Engineering, National University of Singapore, Kent Ridge, Singapore 119260, SINGAPORE; **Exploiting Natural Biopolymers for Selective Bio-interactivity with Bacteria and Bone Cells in Orthopedic Applications**

Hernando S. Salapare III, Gene Q. Blantocas, and Henry J. Ramos; Plasma Physics Laboratory, National Institute of Physics, University of the Philippines, Diliman, Quezon City 1101, PHILIPPINES; **Cellular Adhesion Performance of Polytetrafluoroethylene (PTFE) after Surface Modification Using Hydrogen and Oxygen Low-Energy Gas Discharges**

K. Schröder[†], B. Finke, F. Lüthen, J. Blasche, J. Rychly, U. Walschus, M. Schlosser, A. Ohl and K. D. Weltmann; Leibniz Institute for Plasma Science and Technology (INP), F.-Hausdorff Straße 2, 17489 Greifswald, GERMANY; Plasma Polymer Coatings for Improved Cell Adhesion to Titanium Surfaces

T. Tanaka, K. Vutova, E. Koleva, G. Mladenov and I. Koyama; Department of Electronics and Photonic System Engineering, Hiroshima Institute of Technology, 2-1-1 Miyake Saeki-ku, Hiroshima 731-5193, JAPAN; Room Temperature PBII Sterilization of Materials

Yao Wang, Ke Yao and Zhi-Kang Xu; Institute of Ophthalmology, and Eye Center, Affiliated Second Hospital, College of Medicine, Zhejiang University, Hangzhou 310009, P. R. CHINA; Surface Modification of Artificial Intraocular Lenses with Plasma Techniques

K.-D. Weltmann, R. Brandenburg, R. Foest, E. Kindel, M. Stieber, and T. V. Woedtke; Leibniz-Institute for Plasma Science and Technology e.V. (INP Greifswald), Felix-Hausdorff-Str. 2, D-17489 Greifswald, GERMANY; Atmospheric Pressure Plasma Jets for Surface Treatment and Medical Applications

ADHESION STUDIES

N. A. Darwish, A. A. El-Wakil and A. I. Abou-Kandil; National Institute of Standards, Tersa Street, El-Haram, El-Giza, P.O.Box 136 Giza, Post Code 12211, EGYPT; Graft Co-Polymerization of 1, 5 diaminonaphthalene to improve adhesion between EPDM Rubber and Polyester Fabric

Martin Buggy; Department of Materials Science and Technology, University of Limerick, Plassey, Limerick, IRELAND; Wedge Testing for Assessment of Effect of Surface Modification on the Durability of Adhesively Bonded Composite Materials

S.A. Pihan, T. Tsukruk, A. Chifan and R. Förch; Max-Planck-Institut für Polymerforschung, Ackermannweg 10, 55128 Mainz, GERMANY; Plasma Polymerized Hexamethyl Disiloxane in Adhesion Applications

Karin Grundke, Jan Roth, Victoria Albrecht, Mirko Nitschke, Cornelia Bellmann, Frank Simon, Stefan Zschoche, Stefan Michel, Claudia Luhmann and Brigitte Voit; Leibniz Institute of Polymer Research Dresden, P. O. Box 120 411, D-01005 Dresden, GERMANY; Surface Functionalization of Silicone Elastomers to Form Permanently Stable Adhesion Joints

Horst-Christian Langowski; TU Muenchen, WZW Center of Life and Food Science, Chair of Food Packaging Technology, Weihenstephaner Steig 22, 85350 Freising-Weihenstephan, GERMANY; Surface Modification of Polymer Films for Improvement of the Adhesion of Deposited Metal Layers

Sang Wook Park and Dai Gil Lee; Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology, ME3221, Guseong-dong, Yuseong-gu, Daejeon 305-701, REPUBLIC OF KOREA; Adhesion Characteristics of Surface-treated Glass/Epoxy Composite with Nanoparticle

E. V. Shun'ko and V. V. Belkin; WINTEK Electro-Optics Corporation, 1665 Highland Dr., Ann Arbor, Michigan 48108; Cleaning And Improving Adhesion of Surfaces by Their Treatment With Excited Nitrogen

Sam Siau; Surface Functionalisation, ArcelorMittal R&D Industry Gent, OCAS NV, Pres. J. F. Kennedylaan 3, BE-9060 Zelzate, BELGIUM; Adhesion Improvement of Polymers and Glues to Steel Substrates by Various Surface Modifications

Peter Vicca, Soeren Steudel, Jan Genoe and Paul Heremans; Polymer & Molecular Electronics Group, IMEC, Kapeldreef 75, 3001 - Leuven, BELGIUM; Polymer Adhesion Layers for Ag Layers Deposited in OLED Processing

H. Willeck, W. Eberhardt and H. Kück; Hahn-Schickard-Institute of Microassembly Technology HSG-IMAT, Stuttgart, GERMANY; A New Measuring Tool for Determining the Adhesive Strength of Micro Structured Metal Layers and Conductors Directly on Polymer Micro Devices

PLASMA PROCESSES I: METHODOLOGIES

Roel Dams; VITO - Flemish Institute for Technological Research, Materials Technology Department, Boeretang 200, 2400 Mol, BELGIUM; Inline Plasma Processes in Modified Gas Atmosphere for Adhesion Improvement

F. Fracassi; Dipartimento di Chimica, Università di Bari, Via Orabona 4, I-70126 Bari, ITALY; Non Equilibrium Plasma Treatment of Surfaces at Low and Atmospheric Pressure

Ranjit Joshi and Jeorg Friedrich; Bundesanstalt für Materialforschung und Prufung (BAM), Unter den Eichen 87, D-12205 Berlin, GERMANY; Underwater Plasma and Glow Discharge Electrolysis (Liquid Electrode) for Polymer Surface Modification

F. J. Guild and B.R.K. Blackman; Department of Mechanical Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ; Air-plasma Pre-treatment for Promotion of Thermoplastic Adhesion

PLASMA PROCESSES II: APPLICATIONS

Denis Dowling; University College Dublin, Room 223 Engineering Building, UCD, Belfield, Dublin 4, IRELAND; Influence of Processing Conditions on the Adhesion Performance of Atmospheric Plasma Polymerized Primer Coatings on Steel

Claus-Peter Klages, Alena Hinze and Michael Thomas; Institut für Oberflächentechnik, Technische Universität Braunschweig, Bienroder Weg 53, D-38108 Braunschweig, GERMANY; Atmospheric-Pressure Plasma Amination of Polymer Surfaces

Masukuni Mori; Mori Consultant Engineering, 36-1 Shinmeikuruwa Kaime, Ichinomiya, Aichi 494-0001, JAPAN; Modification of Wool fibers by Atmospheric Pressure Plasma Treatment

Ulrike Schulz, Fraunhofer Institute of Applied Optics and Precision Engineering, 07745 Jena, GERMANY; **Plasma Modification of Polymers for Optical Applications**

Hyuk Yu; Department of Chemistry, University of Wisconsin, Madison, Wisconsin 53706; **Plasma Treatment of Hydrocarbon Polymers & Post-treatment Dynamics of Surface Polarity**

RADIATION/ SURFACE CHEMICAL MODIFICATION

Thomas Bahners and Eckhard Schollmeyer; Deutsches Textilforschungszentrum Nord-West e. V., Adlerstr. 1, 47798 Krefeld, GERMANY; **Photo-initiated Inter-Linking of Coatings on Textiles and Other Polymer Substrates**

M. Masudul Hassan, Marco Mueller and Manfred H. Wagner; Technical University of Berlin, Institute of Material Science and Technology, Polymertechnik/ Polymerphysik, Fasanen Str. 90, D-10623, Berlin, GERMANY; **Improvement of Mechanical Performance of Hybrid Seaweed/Rice Straw Polypropylene Composite: Effect of Maleic Anhydride**

F.J. Xu, S.J. Yuan, G. L. Li, K.G. Neoh and **E.T. Kang**; Dept. of Chemical and Biomolecular Engineering, National University of Singapore, Kent Ridge, SINGAPORE 119260; **Surface Functionalization via Controlled Radical Polymerizations**

Takaomi Kobayashi; Department of Chemistry, Nagaoka University of Technology, 1603-1 Kamitomioka, Nagaoka, Niigata, JAPAN; **Surface Modification of Polymer Textiles by Thermally Dried Ozone**

D. Schubroeck, J. De Baets, E. Schacht and A. Van Calster; Centre for Microsystems Technology (CMST)/ELIS, IMEC, Ghent University, Technologiepark 914A, BE-9052 Ghent -Zwijnaarde, BELGIUM; **Chemical Modification of a Photo Definable Epoxy Resin to Improve Adhesion with Electroless Copper**

M. Razdan, A. Entenberg, T. Debies, B. Parekh, P. Rai, and **G. A. Takacs**; Department of Chemistry, Center for Materials Science and Engineering, Rochester Institute of Technology, Rochester, NY 14623; **Surface Oxidation of Polyimides with UV Photo-oxidation in the Absence of Ozone**

NOVEL APPROACHES

F. Griffon, C. Delval and P. Hoffmann; EPFL, Station 17, Lausanne VD, 1015 SWITZERLAND; **Hot-Embossing: a Novel Technique for the Replication of Superhydrophobic Polymer Samples.**

Alexander Stadnick and **Grigoriy Kyryk**; Ukrrosmetall Concern, International Institute, 6 Kursky Avenue, Sumy 40020, UKRAINE; **New Ways of Drawing Metal Films on Polymeric Materials**

Thomas Luxbacher; Anton Paar GmbH, Anton-Paar-Strasse 20, A-8054 Graz, AUSTRIA; **Activation and Targeted Modification of Polymer Surfaces Assessed by Streaming Current Measurement**

Erhan Piskin; Hacettepe University, Beytepe, Ankara, TURKEY; **Self-Assembling of Molecules at the Surface**

Susan B. Sinnott; Department of Materials Science and Engineering, University of Florida, Gainesville, FL, 32611-6400; **Selective Chemical Modification of Polymer Surfaces through Low-Energy Ion-Beam Deposition**

Thomas Strunskus; Ruhr University Bochum, D-44780 Bochum, GERMANY; **Ion Modifications of Metal/Polymer Interfaces**

Zhi-Kang Xu; Key Laboratory of Macromolecular Synthesis and Functionalization (Ministry of Education), Department of Polymer Science & Engineering, Zhejiang University, Hangzhou 310027, CHINA; **Surface Engineering of Microporous Polypropylene Membranes**

K. Zuo, B.R.K. Blackman, J.G. Williams and H. Steininger; Department of Mechanical Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ, UK; **Toughening Research of Thermoplastics Modified by Surface Treated Nano-Particles**

DATES:
JULY 12-15, 2009: SEVENTH INTERNATIONAL
SYMPOSIUM ON POLYMER SURFACE
MODIFICATION: RELEVANCE TO ADHESION
JULY 15-18, 2009: SEVENTH INTERNATIONAL
SYMPOSIUM ON SILANES AND OTHER
COUPLING AGENTS

LOCATION:
University of Maine, Orono, Maine

<http://www.umaine.edu/>

HOTEL TRAVEL

These area hotels are offering special conference room rates for the nights of July 10 - 19, 2009 on a first come first serve basis.

Additional nights may be available. Continental breakfast and wireless access are included at each hotel. Rooms in July go fast. Call now to book your room.

To receive these rates, you must mention the MST Conference.

University Inn Academic Suites
5 College Ave, Orono, ME 04473

Tel: (207) 866-4921
Toll-free: (800)321-4921
Fax: (207) 866-4550

\$95.00 per night/single occupants
\$105.00 per night/2 occupants

(Be sure to mention the code MST09 to get the conference rate)

<http://universitymotorinn.com/>

Best Western Black Bear Inn
3 Godfrey Blvd. 04473

Tel: (207) 866-7120

\$109.95 per night
\$5.00 per night/each additional person

<http://www.blackbearinnorono.com>

REGISTRATION INFORMATION

The following are hotels that offer free shuttles to and from the airport.

Bangor Motor Inn	(207) 947-0355
Comfort Inn	(207) 942-7899
Days Inn	(207) 942-8272
Econo Lodge	(207) 945-0111
Hampton Inn	(207) 990-4400
Holiday Inn - Oldrid.	(207) 947-0101
Ramada Inn	(207) 947-6961
Super 8 Motel - Igor	(207) 945-5681

AIRPORT AND AVAIL:

Please see the comprehensive listing on the website:

<http://www.flgor.com/>

Taxis are available at the exit doors on a 24 hour basis.

REGISTRAT

Speaker/stu \$395 each; regular attendee \$595 each. A 20% discount applies if you are attending both symposia. An additional 10% discount applies if more than three people from the same organization are participating.

ON CAMPUS

Housing is also available at a location convenient by the conference meeting room. Full details regarding accommodations are given in the form attached to the end of this document. Registrants are asked to fill in the form and FAX it to the conference manager. Questions should be directed to Debra Wright at the University of Maine. Her telephone number and E-mail address are listed at the bottom of the form. Online registration is available at:

<http://www.umaine.edu/conferences>

TO REGISTER FOR SYMPOSIUM:

BY PHONE: 845-897-1654; 845-227-7026
BY FAX: 212-656-1016
E-mail: rhl@mstconf.com

REGISTER ONLINE:

www.mstconf.com/mstreg.htm

BY MAIL:

SEND COMPLETED FORM BELOW TO:

Dr. Robert Lacombe
Chairman
MST Conferences
3 Hammer Drive
Hopewell Junction, NY 12533-6124, USA

**SHORT COURSE ON APPLIED ADHESION
MEASUREMENT METHODS**

JULY 10 and 19, 2008: Associated with these symposia MST gives a short course on adhesion measurement methods. Since nearly all of the MST symposia have some relation to adhesion phenomena, the ability to quantify the adhesion of one material layer to another is clearly one of the unifying themes. This course is designed to mesh with the topical symposia by presenting an overview of the most useful adhesion measurement techniques which are being used to evaluate the **PRACTICAL ADHESION** of coatings. Emphasis will be given to methods which can be carried out in a manufacturing environment as well as in the lab and which give results that are directly relevant to the durability and performance of the coatings. The effects of material elastic properties and residual stress are considered as well as other external influences which affect coating adhesion.

How You Will Benefit From This Course:

- Understand advantages and disadvantages of a range of adhesion measurement techniques.
- Gain insight into mechanics of adhesion testing and the role of intrinsic stress and material properties
- Learn optimal methods for setting adhesion strength requirements for coating applications.
- Learn how to select the best measurement technique for a given application.
- Gain perspective from detailed discussion of actual case studies of product manufacturing and development problems.

A complete syllabus of the short course is available at:

www.mstconf.com/AdhesionShortCourse.pdf

SHORT COURSE ON DURABILITY OF ADHESIVE JOINTS AND COMPOSITES

JULY 11, 2009: When you make an adhesive joint or a composite as part of some device or product there is always the concern of the durability of the joint bond or the strength of the filler/matrix adhesion. Whether the

product is something as prosaic as a cereal box or as high tech as a jet aircraft, the consequences of failure can range anywhere from an annoying nuisance to the endangerment of lives. Thus this course will give an overview of the technology and tools available for evaluating beforehand the expected performance of adhesive joints and composites subjected to the environmental and load conditions under which they must survive.

How You Will Benefit from this Course:

Understand advantages and disadvantages of a range of test methods for adhesive joints and composites

Gain insight into mechanics of adhesion testing and the role of material properties

Explore the full range of phenomena affecting composite and joint reliability including: adhesion to substrate, thermal-mechanical properties of adhesive and matrix binder materials and the effect of residual stress.

Review most important non-destructive inspection methods for discovering flaws in joint formation and composite structure

Gain perspective from detailed discussion of actual case studies of product manufacturing and development problems

A complete syllabus of the short course is available at:
www.mstconf.com/JointDurabilityV2.pdf

Audience: Both of the above short courses are tailored to meet the needs of scientists and professional staff in R&D, manufacturing, processing, quality control/reliability involved with adhesion aspects of coatings, laminate structures, composite materials or adhesive joining processes.

Level: Beginner to Intermediate

Prerequisites: Elementary background in chemistry, physics or materials science.

Duration: 1 day

Registration fee: \$595: Includes course notes, handouts and a copy of the newly published handbook and reference volume: **ADHESION MEASUREMENT METHODS: THEORY AND PRACTICE** (CRC Press, 2006).

CANCELLATIONS: Registration fees are refundable, subject to a 15% service charge, if cancellation is made by **June 20, 2009**. **NO** refunds will be given after that date. All cancellations must be in writing. Substitutions from the same organization may be made at any time without penalty. MST Conferences reserves the right to cancel any of the symposia or the short course if it deems this necessary and will, in such event, make a full refund of the registration fee. No liability is assumed by MST Conferences for changes in program content.

REGISTRATION FORM: CHECK ALL THAT YOU WANT TO ATTEND

SEVENTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION, JULY 12-15, 2009 (speaker/student)	\$395
SEVENTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION, JULY 12-15, 2009 (regular attendee)	\$595
SEVENTH INTERNATIONAL SYMPOSIUM ON SILANES AND OTHER COUPLING AGENTS, JULY 15-18, 2009 (speaker/student)	\$395
SEVENTH INTERNATIONAL SYMPOSIUM ON SILANES AND OTHER COUPLING AGENTS, JULY 15-18, 2009, (regular attendee)	\$595
Sub Total	
Deduct 20% if attending both Symposia. Deduct additional 10% if more than 1 participant from same institution	
Short Course on Applied Adhesion Measurement Methods, Select Date: <input type="checkbox"/> July 10; <input type="checkbox"/> July 19	\$595
Short Course on Durability of Adhesive Joints and Composites, <input type="checkbox"/> July 11	\$595
TOTAL REGISTRATION FEE	

METHOD OF PAYMENT, CHECK WHICH METHOD YOU PREFER

CREDIT CARD: Check here and fill out box below	
BANK WIRE TRANSFER: Check here and contact the symposium Chairman, Dr. Lacombe for bankwire information either by phone, FAX or E-mail: Tel. 845-897-1654 FAX: 212-656-1016 E-mail: rhlacombe@compuserve.com	
CHECK: Make check payable to MST Conferences, LLC and mail to: Dr. Robert H. Lacombe Conference Chairman 3 Hammer Drive Hopewell Junction, NY 12533-6124, USA	

CREDIT CARD INFORMATION

- VISA
- MASTER CARD
- AMERICAN EXPRESS
- DINERS CLUB

Expiration Date: _____

ADDRESS INFORMATION

NAME: _____

ADDRESS: _____

E-mail: _____

PHONE: _____ FAX: _____

Card Number: _____ Card Holder Name:
(As it appears on card) _____

MST Conference July 9 - 19, 2009

Housing Registration Form. Deadline for form return - Friday, June 16, 2009

Cancellation policy: Through July 1, full payment will be refunded less the \$15 processing fee.

Name: _____ Day phone _____
Mailing address: _____

Evening phone _____ Fax # _____
E-mail address: _____

Lodging on campus will be available on the nights of July 9, 2009 through July 19, 2009

Check in date: _____	Check out date: _____
Single room ~ twin bed	\$60.50 per night for _____ nights
Double room ~ twin beds	\$40.65 per person per night for _____ nights
Processing fee	\$15.00
TOTAL REMITTED _____	

Payment Information

Charge to: Visa MasterCard

Important: Please submit card information by fax only (207) 581-4097, not via email.

Card Number: _____
Signature: _____ Expiration Date: _____

Lodging will be at Edith Patch Hall in suites with a living area and kitchen facilities (refrigerator, stove, but no coffee maker, cooking vessels, china, or utensils). Suites have between 2 and 4 bedrooms. In suites with two bedrooms, the bedrooms are doubles. In suites with three bedrooms, there are two singles and one double. In suites with four bedrooms, there are four singles. Thus, you may list up to 4 suite mates (being sure that those you list also list you!). If you don't list suite mates, those bedrooms may be assigned to others in your program.

1 3
2 4

Please use a separate form with payment for each individual

Special needs: Please tell us about any special needs, such as access to accommodations:

Please fax or mail completed housing form and payment to:

University of Maine

Conference Services Division – MST Conference

5713 Chadbourne Hall

Orono, ME 04469-5713

Tel (207) 581-4094, Fax: (207) 581-4097

Questions about housing at the University of Maine: Debra Wright at tel (207) 581-4094

Email: Debra.Wright@unit.maine.edu

Meeting space details of residence halls can be viewed at:
www.umaine.edu/conferences/meetingspacegallery/meetingspace.htm

INTERNATIONAL PUBLICATIONS

ISI-Indexed Journal

- **H.S. Salapare III**, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, "Low-energy hydrogen ion shower treatment (LEHIS) of polytetrafluoroethylene (PTFE) materials", *Appl. Surf. Sci.* 255 (2008) 2951-2957.

Book Chapter

- **H.S. Salapare III**, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, "The porosity and wettability properties of hydrogen ion treated polytetrafluoroethylene," in *Contact Angle, Wettability, and Adhesion*, Volume 6, Kash L. Mittal, editor (VSP-Brill, 2009), In Press.

LOCAL PUBLICATIONS

Local News Features On Salapare's Research/Local Journal

- **H.S. Salapare III**, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, Low-energy hydrogen ion shower (LEHIS) treatment of polytetrafluoroethylene (PTFE) materials, *Research News on PISIKA* Vol. 2 Issue 1, ISSN 1908-7640, October 2008, pp. 10-11.

Local Proceedings

- **H. S. Salapare III**, G.Q. Blantocas, V.R. Noguera, and H.J. Ramos, "Fourier transform infrared spectroscopy (FTIR) characterization of low energy hydrogen ion shower (LEHIS) treatment of polytetrafluoroethylene (PTFE) materials", *Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress*, ISSN 1656-2666 Vol. 5, October 2008, p.17.
- **H. S. Salapare III**, G.Q. Blantocas, V.R. Noguera, and H.J. Ramos, "Wetting dynamics model of hydrogen ion treated polytetrafluoroethylene (PTFE) materials", *Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress*, ISSN 1656-2666 Vol. 5, October 2008, p.10.
- **H. S. Salapare III**, G.Q. Blantocas, E.V.B. Lagsa, V.R. Noguera, and H.J. Ramos, "Effects of low energy hydrogen ion shower (LEHIS) treatment on the optical property and thickness of polytetrafluoroethylene (PTFE) materials", *Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress*, ISSN 1656-2666 Vol. 5, October 2008, p.13.
- **H. S. Salapare III**, A.M. Ulano, H.V. Lee Jr., G.Q. Blantocas, V.R.M. Daria, V.R. Noguerra, M.A.C. Camacho, and H.J. Ramos, "Optical Characterization of Hydrogen Ion Treated Polytetrafluoroethylene (Teflon[®]) Materials", *Proceedings of the 25th Samahang Pisika ng Pilipinas Physics Congress*, ISSN 1656-2666 Vol. 4, October 2007, p.21.
- **H. S. Salapare III**, J.E. Palay, R. Kekim, G.J. Perez, and C.M.Y. Blanca, "Dynamic Contact Angle Measurements on Various Fabric Surfaces Using a Simple Optical Vision System.", *Proceedings of the 25th Samahang Pisika ng Pilipinas Physics Congress*, ISSN 1656-2666 Vol. 4, October 2007, p.9.

Japan 12, 2009

DR. REYNALDO V. EBORA

Director

Philippine Council for Advanced Science and Technology Research and
Department of Science and Technology
Bicutan, Taguig, Metro Manila

Dear Dr. Ebora:

I am glad to inform you that I am invited to present my latest research entitled "Cellular adhesion of polytetrafluoroethylene (PTFE) after surface modification using hydrogen and oxygen low-energy plasma" (with Dr. Gene Q. Blantocas and Dr. Henry J. Ramos as co-authors) at the 7th International Symposium on Surface Modification: Relevance to Adhesion. The symposium is scheduled from July 12, 2009 to July 16, 2009, at the University of Maine, Orono, Maine, USA. I will arrive at the University of Maine on July 11, 2009 and leave on July 16, 2009.

Attached herewith is a copy of the invitation letter, acceptance letter, and preliminary program from Dr. James Lacombe who chairs the conference program committee.

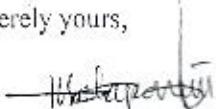
In particular I would like to ask for financial support of USD 995 (Registration fee: USD 395 and per diem of USD 600). I have asked the University of the Philippines Diliman for the transportation expenses.

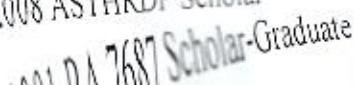
I have published 1 article in an ISI-accredited journal (*Applied Surface Science*), 1 book chapter (*Contact Angle, Wettability, and Adhesion*, Vol.6, VSP-Brill, In press), 5 articles in a local proceeding (*Samahang Pisika ng Pilipinas Annual Physics Conference*), and 1 scientific news feature in a local journal (*Pisika*) along with Drs. Henry J. Ramos, Gene Q. Blantocas, and Virginia R. Noguera for the year 2007 and 2008. All my publications are related to my study on polytetrafluoroethylene (PTFE) materials. My undergraduate thesis was awarded the Leticia Shahani Award for Best Undergraduate Thesis in Applied Physics, College of Science, University of the Philippines Diliman last April 2008. Attached is a complete bibliographic list of my publications related to my work in PTFE. The conference and symposium would be a great opportunity for us to showcase our research in the field of plasma applications. It is also a chance for us to see future developments in this field with discussions from colleagues all over the world. Contributed papers are to be published in a special issue of the ISI-accredited *Journal of Adhesion Science and Technology*. Referees for the papers to be published are in attendance during the conference. The research paper that I will be presenting in the conference will be a part of my MS thesis.

I am a DOST-SEI scholar from June 2001 until October 2007 under RA 7687 and currently under the Accelerated Science and Technology Human Resource Development scholarship program. I finished BS in Applied Physics at the National Institute of Physics, University of the Philippines, Diliman, Quezon City. I am currently a first year MS Physics student in the same institute.

Thank you very much in anticipation of your favorable endorsement and approval.

Sincerely yours,


HERNANDO S. SALAPARE III
2008 ASTHRDP Scholar


2001 RA 7687 Scholar Graduate


DR. HENRY J. RAMOS
Co-adviser/Co-author


Blantocas

Jethro Salapare <jethrosy@gmail.com>

SURFACE MODIFICATION SYMPOSIUM, U. MAINE, JULY 2009

1 message

Robert Lacombe <rhlacombe@compuserve.com>
To: Hernando Salapare III <jethrosy@gmail.com>

Mon, Sep 29, 2008 at 8:55 AM

Dear Hernando

It is our pleasure to invite you to present a paper at the upcoming SEVENTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION: RELEVANCE TO ADHESION to be held July 12-15, 2009 at the University of Maine, Orono, Maine, USA. Your contributions to this field are known to us through either your participation in previous symposia, your publications or the recommendations of others. We would therefore be interested learning of your latest endeavors in this field. Your paper can deal with any of the topics listed in the attached "Call for Papers" or allied topic and could be either an overview or an original research contribution.

If you should decide to accept this invitation, which we certainly hope you will, please signify your acceptance by responding to the Chairman, Dr. Lacombe at the address below. Questions relating to the technical details should be directed to him. More general questions concerning the overall content of the symposium may be directed to the Conference Director Dr. Mittal (Tel. 845-897-1654, E-mail klm@mstconf.com).

We certainly hope your response to this invitation will be in the affirmative. Apropos, all signals indicate a great deal of interest in this Symposium, and your contribution will be a significant plus to the overall program. For your information we also attach the announcement for an additional symposium that you or one of your colleagues might also find of interest.

Looking forward to hearing from you soon.

With kind regards,

Dr. K. L. Mittal
Editor: Journal of Adhesion Science
and Technology
1983 Route 52, Suite C
P.O. Box 1280
Hopewell Junction, NY 12533-1280
Tel. 845-897-1654
FAX 845-897-2361
E-mail: klm@mstconf.com

Dr. Robert H. Lacombe
Chairman
Materials Science and Technology
CONFERENCES, LLC



Jethro Salapare <jethrosy@gmail.com>

POLYMER SURFACE MODIFICATION

1 message

Robert Lacombe <rhlacombe@compuserve.com>
To: Hernando Salapare <jethrosy@gmail.com>

Fri, Jan 9, 2009 at 10:06 AM

Dear Hernando

Thank you for accepting our invitation to present a paper at the upcoming
SEVENTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION: RELEVANCE
TO ADHESION to be held July 12-15, 2009 at the University of Maine, Orono,
Maine, USA.

We have your title and abstract and will be including them in the program.
I am putting you on our registration list and you will be hearing from us
again as soon as the final program is ready.

Papers will be allowed approximately 25 minutes under normal circumstances.
Authors requiring more time need to contact the Conference Director, Dr.
Mittal (Tel. 845-897-1654, Fax 845-897-2361, E-mail: klm@mstconf.com), to
make appropriate arrangements.

Presenters have a range of options for audio-visual support as follows:

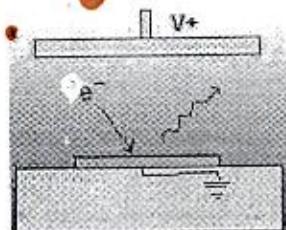
1. MST will provide a digital projector for those who want to bring just a memory stick or a CD containing their presentation. This works out best for relatively straightforward presentations without videos or other exotic features.
2. Presenters can also bring their own laptops which can be plugged into the digital projector. This may be necessary if the presentation includes features that might not be supported by the available software.
3. Facilities for using overhead transparencies and 35mm slides will also be provided.

Finally we suggest that all presenters have backup copies of their talks on either a CD or a memory stick.

Dr. Mittal and I both look forward to meeting you at the symposium.

Best regards and BEST WISHES FOR THE NEW YEAR

Dr. Robert H. Lacombe
Chairman
Materials Science and Technology
CONFERENCES
3 Hammer Drive
Hopewell Junction, NY 12533-6124
Tel. 845-897-1654
FAX 212-656-1016
E-mail: rhlacombe@compuserve.com



PRELIMINARY PROGRAM SEVENTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION: RELEVANCE TO ADHESION

To be held July 12-15, 2009; University of Maine, Orono, Maine, USA

This symposium continues the tradition set by the first in the series entitled: "Polymer Surface Modification: Relevance to Adhesion" which was held in Las Vegas, NV, 1993. As with its predecessors, this symposium will be concerned with the technological areas where surface modification is a key technology which allows for the processing and manufacture of products which would otherwise be unobtainable.

We are indeed happy to announce that this the 7th symposium in the series will be organized in collaboration with Prof. Douglas Gardner in the Advanced Engineered Wood Composites Center at the University of Maine, Orono, Maine. Prof. Gardner is well acquainted with problems of polymer surface modification as applied to wood composites and is also serving on the editorial board of the Journal of Adhesion Science and Technology which is edited by the Conference Director Dr. Mittal.

Prof. Gardner has been an active researcher in the field and he and his group look forward to hosting this

BIOLOGICAL/BIOMEDICAL INVESTIGATIONS

Charles Anamelechi; Biomedical Engineering Department, Duke University (CIEMAS 1313), 144 Hudson Hall, Durham, NC 27708; **Endothelial Cell Adhesion to Synthetic Vascular Grafts Using Biotinylated Fibronectin in a Dual Ligand Protein System**

Frédéric Busnel; Vincent Blanchard, Bernard Riedl and Pierre Blanchet; Centre de Recherche sur le Bois, Faculté de Foresterie et De Géomatique Pavillon Kruger-Université Laval, Québec , QC G1V 0A6, CANADA; **Atmospheric Pressure Plasma Treatment on Sugar Maple (*Acer Saccharum*) and on Black Spruce (*Picea Mariana*) Wood. Study of Surface Free Energy Using Contact Angle Measurements.**

Gijo Raj, Eric Balnois, Christophe Baley and **Yves Grohens**; Laboratoire d'Ingénierie des MATériaux de Bretagne (LIMATB), Université de Bretagne Sud, Rue de Saint Maudé BP 92116, F-56321 Lorient Cedex, FRANCE; **Interfaces in Biocomposites: Colloid Force Measurements Between Cellulose and Polylactic Acid**

Josè M. Kenny; European Center of Nanostructured Polymers (ECNP) and University of Perugia - UdR INSTM, Loc. Pentima Bassa 21, 05100 Terni, ITALY; **Plasma Modification and Surface Functionalization of Biodegradable Polymers for Controlling the Adhesion of Stromal Cells**

symposium and greeting all participants from both academia and industry from all corners of the globe.

Proper adhesion characteristics are vital to the success of any practical implementation of polymer materials. Though polymers are generally not very adhesionable, careful surface modification can result in greatly improved adhesion without altering bulk properties. This symposium is organized to bring together scientists, technologists and engineers interested in all aspects of polymer surface modification, to review and assess the current state of knowledge, to provide a forum for exchange and cross-fertilization of ideas, and to define problem areas which need intensified efforts.

The invited speakers have been selected so as to represent widely differing disciplines and interests, and they hail from academic, governmental and industrial research laboratories. This meeting is planned to be a truly international event with participation from research groups from academia and industry worldwide.

Sean X. Liu; Cereal Products and Food Science Research Unit, National Center for Agricultural Utilization Research, U.S. Department of Agriculture, ARS, 1815 N. University Street, Peoria, IL 61604; **The Effect of Polymer Surface Modification on Polymer-Protein Interaction via Interfacial Polymerization and Hydrophilic Polymer Grafting**

N.Gomathi, Debasish Mishra, Tapas Kumar Maity, and **Sudarsan Neogi**; Department of Chemical Engineering, Indian Institute of Technology, Kharagpur, 721302 INDIA; **Low Pressure Radio Frequency Plasma Treatment of Polypropylene for Improved Cell Adhesion**

Z. L. Shi, F. Zhang, E. T. Kang and **K. G. Neoh**; Department of Chemical and Biomolecular Engineering, National University of Singapore, Kent Ridge, Singapore 119260, SINGAPORE; **Exploiting Natural Biopolymers for Selective Bio-interactivity with Bacteria and Bone Cells in Orthopedic Applications**

Hernando S. Salapare III, Gene Q. Blantocas, and Henry J. Ramos; Plasma Physics Laboratory, National Institute of Physics, University of the Philippines, Diliman, Quezon City 1101, PHILIPPINES; **Cellular Adhesion Performance of Polytetrafluoroethylene (PTFE) after Surface Modification Using Hydrogen and Oxygen Low-Energy Gas Discharges**

K. Schröder, B. Finke, F. Lüthen, J. B. Nebe, J. Rychly, U. Walschus, M. Schlosser, A. Ohl and K. D. Weltmann; Leibniz Institute for Plasma Science and Technology (INP), F.-Hausdorff Straße 2, 17489 Greifswald, GERMANY; **Plasma Polymer Coatings for Improved Cell Adhesion to Titanium Surfaces**

T. Tanaka, K. Vutova, E. Koleva, G. Mladenov and I. Koyama; Department of Electronics and Photonic System Engineering, Hiroshima Institute of Technology, 2-1-1 Miyake Saeki-ku, Hiroshima 731-5193, JAPAN; **Room Temperature PBII Sterilization of Materials**

Yao Wang, Ke Yao and Zhi-Kang Xu; Institute of Ophthalmology, and Eye Center, Affiliated Second Hospital, College of Medicine, Zhejiang University, Hangzhou 310009, P. R. CHINA; **Surface Modification of Artificial Intraocular Lenses with Plasma Techniques**

K.-D. Weltmann, R. Brandenburg, R. Foest, E. Kindel, M. Stieber, and T. V. Woedtke; Leibniz-Institute for Plasma Science and Technology e.V. (INP Greifswald), Felix-Hausdorff-Str. 2, D-17489 Greifswald, GERMANY; **Atmospheric Pressure Plasma Jets for Surface Treatment and Medical Applications**

ADHESION STUDIES

N. A. Darwish, A. A. El-Wakil and **A. I. Abou-Kandil**; National Institute of Standards, Tersa Street, El-Haram, El-Giza, P.O.Box 136 Giza, Post Code 12211, EGYPT; **Graft Co-Polymerization of 1, 5 diaminonaphthalene to Improve adhesion between EPDM Rubber and Polyester Fabric**

Martin Buggy; Department of Materials Science and Technology, University of Limerick, Plassey, Limerick, IRELAND; **Wedge Testing for Assessment of Effect of Surface Modification on the Durability of Adhesively Bonded Composite Materials**

S.A. Pihan, T. Tsukruk, A. Chifan and **R. Förch**; Max-Planck-Institut für Polymerforschung, Ackermannweg 10, 55128 Mainz, GERMANY; **Plasma Polymerized Hexamethyl Disiloxane in Adhesion Applications**

Karin Grundke, Jan Roth, Victoria Albrecht, Mirko Nitschke, Cornelia Bellmann, Frank Simon, Stefan Zschoche, Stefan Michel, Claudia Luhmann and Brigitte Voit; Leibniz Institute of Polymer Research Dresden, P. O. Box 120 411, D-01005 Dresden, GERMANY; **Surface Functionalization of Silicone Elastomers to Form Permanently Stable Adhesion Joints**

Horst-Christian Langowski; TU Muenchen, WZW Center of Life and Food Science, Chair of Food Packaging Technology, Weihenstephaner Steig 22, 85350 Freising-Weihenstephan, GERMANY; **Surface Modification of Polymer Films for Improvement of the Adhesion of Deposited Metal Layers**

Sang Wook Park and **Dai Gil Lee**; Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology, ME3221, Guseong-dong, Yuseong-gu, Daejeon 305-701, REPUBLIC OF KOREA; **Adhesion Characteristics of Surface-treated Glass/Epoxy Composite with Nanoparticle**

E. V. Shun'ko and V. S. Belkin; WINTEK Electro-Optics Corporation, 1665 Highland Dr., Ann Arbor, Michigan 48108; **Cleaning And Improving Adhesion of Surfaces by Their Treatment With Excited Nitrogen**

Sam Siau; Surface Functionalisation, ArcelorMittal R&D Industry Gent, OCAS NV, Pres. J. F. Kennedylaan 3, BE-9060 Zelzate, BELGIUM; **Adhesion Improvement of Polymers and Glues to Steel Substrates by Various Surface Modifications**

Peter Vicca, Soeren Steudel, Jan Genoe and Paul Heremans; Polymer & Molecular Electronics Group, IMEC, Kapeldreef 75, 3001 - Leuven, BELGIUM; **Polymer Adhesion Layers for Ag Layers Deposited in OLED Processing**

H. Willeck, W. Eberhardt and H. Kück; Hahn-Schickard-Institute of Microassembly Technology HSG-IMAT, Stuttgart, GERMANY; **A New Measuring Tool for Determining the Adhesive Strength of Micro Structured Metal Layers and Conductors Directly on Polymer Micro Devices**

PLASMA PROCESSES I: METHODOLOGIES

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Ranjit Joshi and Jeorg Friedrich; Bundesanstalt für Materialforschung und Prufung (BAM), Unter den Eichen 87, D-12205 Berlin, GERMANY; **Underwater Plasma and Glow Discharge Electrolysis (Liquid Electrode) for Polymer Surface Modification**

F. J. Guild and B.R.K. Blackman; Department of Mechanical Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ; **Air-plasma Pre-treatment for Promotion of Thermoplastic Adhesion**

PLASMA PROCESSES II: APPLICATIONS

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Claus-Peter Klages, Alena Hinze and Michael Thomas; Institut für Oberflächentechnik, Technische Universität Braunschweig, Bienroder Weg 53, D-38108 Braunschweig, GERMANY; **Atmospheric-Pressure Plasma Amination of Polymer Surfaces**

Masukuni Mori; Mori Consultant Engineering, 36-1 Shinmeikuruwa Kaimel, Ichinomiya, Aichi 494-0001, JAPAN; **Modification of Wool fibers by Atmospheric Pressure Plasma Treatment**

Ulrike Schulz, Fraunhofer Institute of Applied Optics and Precision Engineering, 07745 Jena, GERMANY; **Plasma Modification of Polymers for Optical Applications**

Hyuk Yu; Department of Chemistry, University of Wisconsin, Madison, Wisconsin 53706; **Plasma Treatment of Hydrocarbon Polymers & Post-treatment Dynamics of Surface Polarity**

RADIATION/ SURFACE CHEMICAL MODIFICATION

Thomas Bahners and Eckhard Schollmeyer; Deutsches Textilforschungszentrum Nord-West e. V., Adlerstr. 1, 47798 Krefeld, GERMANY; **Photo-initiated Inter-Linking of Coatings on Textiles and Other Polymer Substrates**

M. Masudul Hassan, Marco Mueller and Manfred H. Wagner; Technical University of Berlin, Institute of Material Science and Technology, Polymertechnik/ Polymerphysik, Fasanen Str. 90, D-10623, Berlin, GERMANY; **Improvement of Mechanical Performance of Hybrid Seaweed/Rice Straw Polypropylene Composite: Effect of Maleic Anhydride**

F.J. Xu, S.J. Yuan, G. L. Li, K.G. Neoh and **E.T. Kang**; Dept. of Chemical and Biomolecular Engineering, National University of Singapore, Kent Ridge, SINGAPORE 119260; **Surface Functionalization via Controlled Radical Polymerizations**

Takaomi Kobayashi; Department of Chemistry, Nagacka University of Technology, 1603-1 Kamitomioka, Nagaoka, Niigata, JAPAN; **Surface Modification of Polymer Textiles by Thermally Dried Ozone**

D. Schaubroeck, J. De Baets, E. Schacht and A. Van Calster; Centre for Microsystems Technology (CMST)/ELIS, IMEC, Ghent University, Technologiepark 914A, BE-9052 Ghent -Zwijnaarde, BELGIUM; **Chemical Modification of a Photo Definable Epoxy Resin to Improve Adhesion with Electroless Copper**

M. Razdan, A. Entenberg, T. Debies, B. Parekh, P. Rai, and **G. A. Takacs**; Department of Chemistry, Center for Materials Science and Engineering, Rochester Institute of Technology, Rochester, NY 14623; **Surface Oxidation of Polyimides with UV Photo-oxidation in the Absence of Ozone**

NOVEL APPROACHES

F. Griffon, C. Delval and P. Hoffmann; EPFL, Station 17, Lausanne VD, 1015 SWITZERLAND; **Hot-Embossing: a Novel Technique for the Replication of Superhydrophobic Polymer Samples.**

Alexander Stadnick and **Grigoriy Kyryk**; Ukrrosmetall Concern, International Institute, 6 Kursky Avenue, Sumy 40020, UKRAINE; **New Ways of Drawing Metal Films on Polymeric Materials**

Thomas Luxbacher; Anton Paar GmbH, Anton-Paar-Strasse 20, A-8054 Graz, AUSTRIA; **Activation and Targeted Modification of Polymer Surfaces Assessed by Streaming Current Measurement**

Erhan Piskin; Hacettepe University, Beytepe, Ankara, TURKEY; **Self-Assembling of Molecules at the Surface**

Susan B. Sinnott; Department of Materials Science and Engineering, University of Florida, Gainesville, FL, 32611-6400; **Selective Chemical Modification of Polymer Surfaces through Low-Energy Ion-Beam Deposition**

Thomas Strunkus; Ruhr University Bochum, D-44780 Bochum, GERMANY; **Ion Modifications of Metal/Polymer Interfaces**

Zhi-Kang Xu; Key Laboratory of Macromolecular Synthesis and Functionalization (Ministry of Education), Department of Polymer Science & Engineering, Zhejiang University, Hangzhou 310027, CHINA; **Surface Engineering of Microporous Polypropylene Membranes**

K. Zuo, B.R.K. Blackman, J.G. Williams and H. Steininger; Department of Mechanical Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ, UK; **Toughening Research of Thermoplastics Modified by Surface Treated Nano-Particles**

This symposium is being organized by MST Conferences under the direction of Dr. K. L. Mittal, Editor, Journal of Adhesion Science and Technology (JAST) and in collaboration with Prof. Douglas Gardner of the University of Maine, Orono. It is planned to publish the proceedings of this symposium in the Journal of Adhesion Science and Technology, edited by the conference chairman Dr. Mittal. Please notify the conference chairman of your intentions to present a paper as early as possible. An abstract of about 200 words should be sent by **March 15, 2009** to the conference chairman by any of the following methods:

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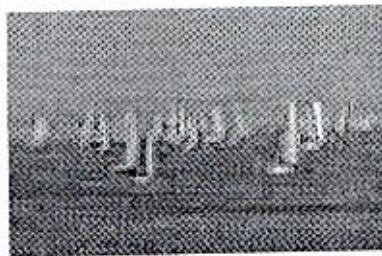
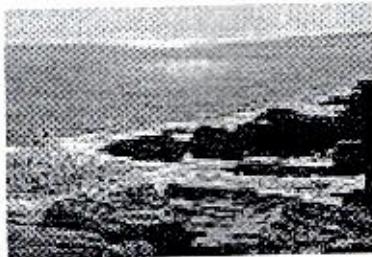
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JULY 12-15, 2009: SEVENTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION: RELEVANCE TO ADHESION

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SHORT COURSE ON APPLIED ADHESION MEASUREMENT METHODS

JULY 10 and 19, 2008: Associated with these symposia MST gives a short course on adhesion measurement methods. Since nearly all of the MST symposia have some relation to adhesion phenomena, the ability to quantify the adhesion of one material layer to another is clearly one of the unifying themes. This course is designed to mesh with the topical symposia by presenting an overview of the most useful adhesion measurement techniques which are being used to evaluate the **PRACTICAL ADHESION** of coatings. Emphasis will be given to methods which can be carried out in a manufacturing environment as well as in the lab and which give results that are directly relevant to the durability and performance of the coatings. The effects of material elastic properties and residual stress are considered as well as other external influences which affect coating adhesion.

How You Will Benefit From This Course:

- Understand advantages and disadvantages of a range of adhesion measurement techniques.
- Gain insight into mechanics of adhesion testing and the role of intrinsic stress and material properties
- Learn optimal methods for setting adhesion strength requirements for coating applications.
- Learn how to select the best measurement technique for a given application.
- Gain perspective from detailed discussion of actual case studies of product manufacturing and development problems.

A complete syllabus of the short course is available at:

www.mstconf.com/AdhesionShortCourse.pdf

SHORT COURSE ON DURABILITY OF ADHESIVE JOINTS AND COMPOSITES

JULY 11, 2009: When you make an adhesive joint or a composite as part of some device or product there is always the concern of the durability of the joint bond or the strength of the filler/matrix adhesion. Whether the

product is something as prosaic as a cereal box or as high tech as a jet aircraft, the consequences of failure can range anywhere from an annoying nuisance to the endangerment of lives. Thus this course will give an overview of the technology and tools available for evaluating beforehand the expected performance of adhesive joints and composites subjected to the environmental and load conditions under which they must survive.

How You Will Benefit from this Course:

Understand advantages and disadvantages of a range of test methods for adhesive joints and composites.

Gain insight into mechanics of adhesion testing and the role of material properties

Explore the full range of phenomena affecting composite and joint reliability including: adhesion to substrate, thermal-mechanical properties of adhesive and matrix binder materials and the effect of residual stress.

Review most important non-destructive inspection methods for discovering flaws in joint formation and composite structure

Gain perspective from detailed discussion of actual case studies of product manufacturing and development problems

A complete syllabus of the short course is available at:

www.mstconf.com/JointDurabilityV2.pdf

Audience: Both of the above short courses are tailored to meet the needs of scientists and professional staff in R&D, manufacturing, processing, quality control/reliability involved with adhesion aspects of coatings, laminate structures, composite materials or adhesive joining processes.

Level: Beginner to Intermediate

Prerequisites: Elementary background in chemistry, physics or materials science.

Duration: 1 day

Registration fee: \$595: Includes course notes, handouts and a copy of the newly published handbook and reference volume: **ADHESION MEASUREMENT METHODS: THEORY AND PRACTICE** (CRC Press, 2006).

CANCELLATIONS: Registration fees are refundable, subject to a 15% service charge, if cancellation is made by **June 20, 2009**. **NO** refunds will be given after that date. All cancellations must be in writing. Substitutions from the same organization may be made at any time without penalty. MST Conferences reserves the right to cancel any of the symposia or the short course if it deems this necessary and will, in such event, make a full refund of the registration fee. No liability is assumed by MST Conferences for changes in program content.

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1 3

2 4

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INTERNATIONAL PUBLICATIONS

ISI-Indexed Journal

- **H.S. Salapare III**, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, "Low-energy hydrogen ion shower treatment (LEHIS) of polytetrafluoroethylene (PTFE) materials", *Appl. Surf. Sci.* 255 (2008) 2951-2957.

Book Chapter

- **H.S. Salapare III**, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, "The porosity and wettability properties of hydrogen ion treated polytetrafluoroethylene," in *Contact Angle, Wettability, and Adhesion*, Volume 6, Kash L. Mittal, editor (VSP-Brill, 2009), In Press.

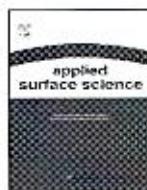
LOCAL PUBLICATIONS

Local News Features On Salapare's Research/Local Journal

- **H.S. Salapare III**, G.Q. Blantocas, V.R. Noguera, H.J. Ramos, Low-energy hydrogen ion shower (LEHIS) treatment of polytetrafluoroethylene (PTFE) materials, *Research News on PISIKA* Vol. 2 Issue 1, ISSN 1908-7640, October 2008, pp. 10-11.

Local Proceedings

- **H. S. Salapare III**, G.Q. Blantocas, V.R. Noguera, and H.J. Ramos, "Fourier transform infrared spectroscopy (FTIR) characterization of low energy hydrogen ion shower (LEHIS) treatment of polytetrafluoroethylene (PTFE) materials", Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 5, October 2008, p.17.
- **H. S. Salapare III**, G.Q. Blantocas, V.R. Noguera, and H.J. Rainos, "Wetting dynamics model of hydrogen ion treated polytetrafluoroethylene (PTFE) materials", Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 5, October 2008, p.10.
- **H. S. Salapare III**, G.Q. Blantocas, E.V.B. Lagsa, V.R. Noguera, and H.J. Ramos, "Effects of low energy hydrogen ion shower (LEHIS) treatment on the optical property and thickness of polytetrafluoroethylene (PTFE) materials", Proceedings of the 26th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 5, October 2008, p.13.
- **H. S. Salapare III**, A.M. Ulano, H.V. Lee Jr., G.Q. Blantocas, V.R.M. Daria, V.R. Noguerra, M.A.C. Camacho, and H.J. Ramos, "Optical Characterization of Hydrogen Ion Treated Polytetrafluoroethylene (Teflon[®]) Materials", Proceedings of the 25th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 4, October 2007, p.21.
- **H. S. Salapare III**, J.J.E. Palay, R. Kekim, G.J. Perez, and C.M.Y. Blanca, "Dynamic Contact Angle Measurements on Various Fabric Surfaces Using a Simple Optical Vision System.", Proceedings of the 25th Samahang Pisika ng Pilipinas Physics Congress, ISSN 1656-2666 Vol. 4, October 2007, p.9.



1

2 **Low-energy hydrogen ion shower (LEHIS) treatment of 3 polytetrafluoroethylene (PTFE) materials**

4 **H.S. Salapare III*, G.Q. Blantocas, V.R. Noguera, H.J. Ramos**

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ABSTRACT

The wettability and optical transmittance properties of hydrogen ion treated polytetrafluoroethylene (PTFE) materials were evaluated using contact angle, laser irradiation, scanning electron microscopy (SEM), and Fourier transform infrared spectroscopy (FTIR) tests. The materials were processed using low-energy hydrogen ion shower (LEHIS) produced by a gas discharge ion source (GDIS). The duration of treatment and ion shower energy were varied to determine their effects on the PTFE specimens. Mass spectrometry showed the ion shower constituents to be H^+ and H_2^+ species. Within the bounds of the discharge conditions, flux density for the H_n^+ beam measured a minimum of 0.06 A/m^2 and a maximum of 0.25 A/m^2 . Both one- and two-way analysis of variance were employed to assist in the interpretation of the empirical data. Results showed that treatment using lower plasma discharge currents (I_d) improved material hydrophobicity with contact angles measuring a high of 115° while higher I_d resulted in enhanced hydrophilicity reducing contact angles down to 61° . Transmittance and wettability were found to correlate, i.e., a surface made more wettable became optically transmissive allowing as much as 99% signal transmittance. Conversely, a surface made more hydrophobic reduced light leakage to as low as 60%. As the material showed increased surface striations, its optical transmittance, wettability, and surface tension also increased. With no observable shifting of the IR-absorption peaks, the surface modification was essentially morphological in character.

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1. Introduction

8 Since way back in the past century, polytetrafluoroethylene
9 (PTFE) or more commonly known as Teflon has gradually
10 developed to become the seminal material in numerous applica-
11 tions. By virtue of its incredibly versatile characteristics, its
12 potential use in a modern technological society appears limitless—
13 ranging from electrical and electronics, food packaging and
14 processing, biomedical, chemical and mechanical to agricultural
15 and aeronautical applications. Despite its obvious merits, PTFE is
16 not without problems in certain usage. Nevertheless, the ease with
17 which the surface attributes of PTFE can be manipulated without
18 altering its bulk composition suggests that the logical focus should
19 be towards tuning PTFE surface to suit a particular application.
20 Surface modification allows for the change and improvement of

the property of a material, consequently, making the processed material more useful in various aspects [1–3]. There is already an enormous body of work on surface modification methods of PTFE. Some of these techniques utilize flame [4], chemical [5], grafting [6–7], corona discharge [8], low-pressure plasma [9–11], and UV exposure [12]. This work presents the surface treatment of PTFE using low-energy hydrogen ion shower (LEHIS) irradiation.

21 PTFE is a pliable material and is resistant to high heat; it has
22 been used as a reflective layer for back-light illumination mounted
23 behind miniaturized flat panel displays. One problem using PTFE as
24 a reflector is that it permits a small amount of light leakage via
25 optical transmittance [13]. It is one of the objects of this
26 contribution to establish the viability of LEHIS treatment to
27 address such light leakage problem. Reduced optical leakage
28 should improve the brightness of flat compact video screens
29 employing PTFE reflective layers. In general, the current study
30 wishes to ascertain the following: (i) viability of LEHIS to surface
31 modify PTFE utilizing relatively short treatment times yet
32 producing significantly high-throughput, (ii) the mechanism of
33

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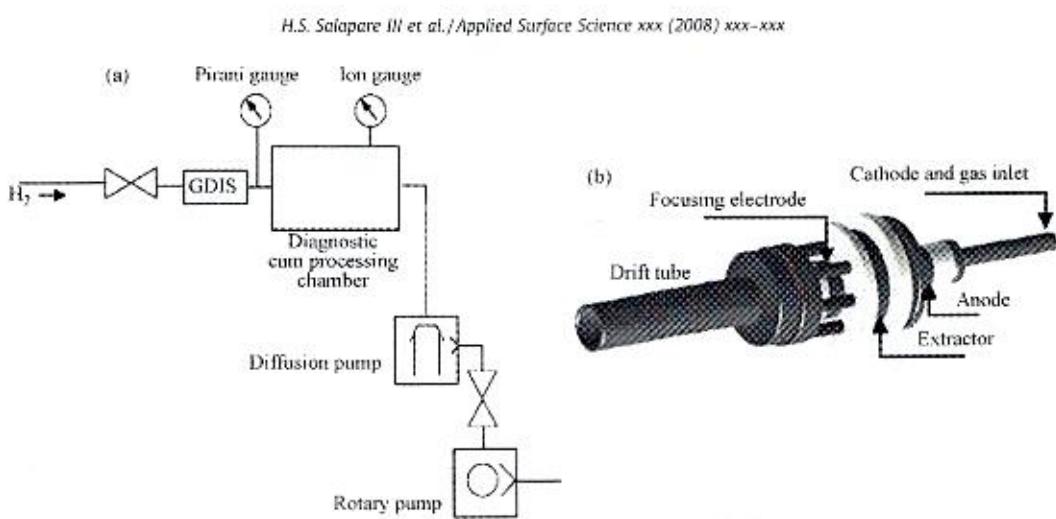


Fig. 1. Illustrations of the experimental setup. (a) Schematic diagram of the overall facility. (b) 3D figure of the GDIS.

40 surface modification as to whether it is physically or chemically
 41 based, or perhaps a combination of both, and (iii) the association
 42 between wettability and light leakage. The effectiveness of LEHIS
 43 as a surface modifier is assessed through contact angle measure-
 44 ments, scanning electron microscopy (SEM), Fourier transform
 45 infrared spectroscopy (FTIR), and optical transmittance.

46 2. Experimental setup and methodology

47 Clean and blow-dried PTFE samples measuring 1 cm × 2 cm are
 48 irradiated using LEHIS of a gas discharge ion source (GDIS) system.
 49 Fig. 1(a) shows the schematic diagram of the experimental setup
 50 and Fig. 1(b) presents a 3D figure of the GDIS. It has a compact
 51 discharge region of volume 0.8 cm³ and an exit aperture of 2.0 mm
 52 in diameter. The extraction and focusing electrodes are grounded
 53 to ensure a diffused ion shower configuration. The GDIS fits a
 54 standard 70 mm knife-edge flange coupled to the diagnostic
 55 chamber whose volume is about 2400 cm³. The system is
 56 evacuated by a 10.16-cm oil diffusion pump coupled to an 8-
 57 m³/h rotary pump. Complete details of the facility are described in
 58 [1] and [14,15]. The pressures inside the chamber are monitored
 59 using Pirani and ionization gauges. The facility is evacuated up to a
 60 base pressure of 1.0×10^{-6} Torr. The total hydrogen gas filling
 61 pressure is kept at 3 mTorr for all the experimental runs. Plasma is
 62 produced when a potential difference, V_d , is applied across the
 63 discharge region. The PTFE samples are placed on a holder
 64 positioned 70 mm downstream from the entrance port of the
 65 processing chamber. This is the position determined to give
 66 maximum ion current density. Processing times of 15 and 30 min
 67 are considered. There are 13 test groups, each with three replicates.
 68 One group consisting of untreated samples and the remaining 12
 69 groups made up of treated specimens. The treatment conditions
 70 are summarized in Table 1. The irradiation time and discharge
 71 conditions (V_d = discharge voltage, I_d = discharge current) are
 72 varied for each group.

73 3. Results and discussion

74 3.1. Ion-beam characterization

75 The charged particle species of the ion shower are determined
 76 using a cast steel mass spectrometer (CSMS). The design and
 77 operational characteristics of the device are reported in [14].
 78 Typical hydrogen ion peaks detected by the CSMS for I_d = 1, 2, and
 79 3 mA are shown in Fig. 2(a). Signal intensities are plotted against

the scanning magnetic field. A detachable Faraday cup, 1 cm in
 80 diameter is placed at the same spot as the sample holder to
 81 measure the total beam current. Fig. 2(b) shows the ion flux
 82 density for different discharge conditions registering a high of
 83 0.25 A/m² and a low of 0.06 A/m².

84 3.2. Contact angle measurement

85 The treated and untreated samples are subjected to contact
 86 angle test using an Intel[®] Play[™] QX3[™] Computer Microscope. The
 87 absorption of water droplet by a particular sample is recorded at a
 88 rate of one frame for every 5-s interval. For each sample, the time
 89 evolution of the contact angle is recorded at three different sites.
 90 Hence, the contact angle for a single time frame is actually a mean
 91 value, averaged over three different points on the sample.

92 Contact angle measurements as a function of time for some
 93 representative samples are shown in Fig. 3. Wettability is
 94 quantified by fitting the wetting model used in [16] to actual
 95 data. The model is expressed mathematically as

$$\frac{d\theta}{dt} = -k\theta \quad (1)$$

96 where θ is the contact angle between the supporting solid surface
 97 and the tangent to the drop-shape of the liquid, and k being the
 98 change rate constant or the quantity that describes the angle's
 99 temporal recession in units of per second. Rising values of k
 100 signifies increasing surface wettability. k is sensitive to data
 101 fluctuations and its values are normally small in the order of 10^{-3}
 102 to 10^{-1} . Therefore a difference of 10^{-3} between the k -values of

Table 1
Summary of experimental parameters

Treated group	Irradiation time (min)	Discharge voltage, V_d (kV)	Plasma discharge current, I_d (mA)
1	30	1.3	2
2	30	1	1
3	15	1.3	2
4	15	1	1
5	30	1.4	3
6	15	1.4	3
7	30	0.7	0.5
8	15	0.7	0.5
9	30	1.2	1.5
10	15	1.2	1.5
11	30	1.35	2.5
12	15	1.35	2.5

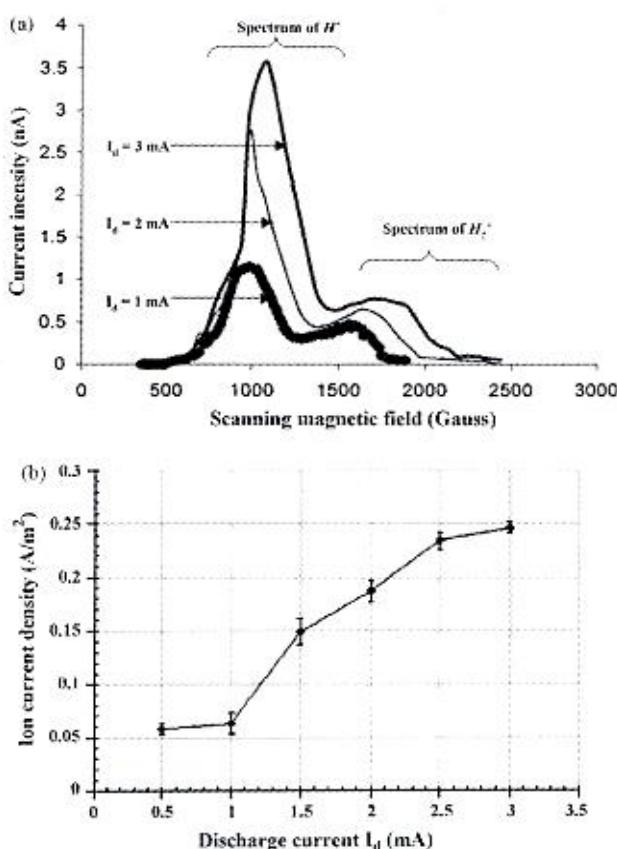


Fig. 2. (a) Typical mass spectra of LEHIS at varied plasma discharge currents. (b) Ion flux density for different discharge currents.

different samples is exceedingly significant given that numerical variations even as small as this may establish whether a surface is wettable or otherwise. The wetting model expresses the fact that the time rate of change of the contact angle has a direct functional relationship to its instantaneous value. When a liquid droplet is placed on a surface, in addition to forming a contact angle at the solid surface, penetration together with liquid spreading occurs. Therefore the contact angle of any material is never static; it will recede over time in accordance with Eq. (1).

It is observed that as the liquid's drop-shape flattens out over time, some uncertainties in the measurement process arise. That is,

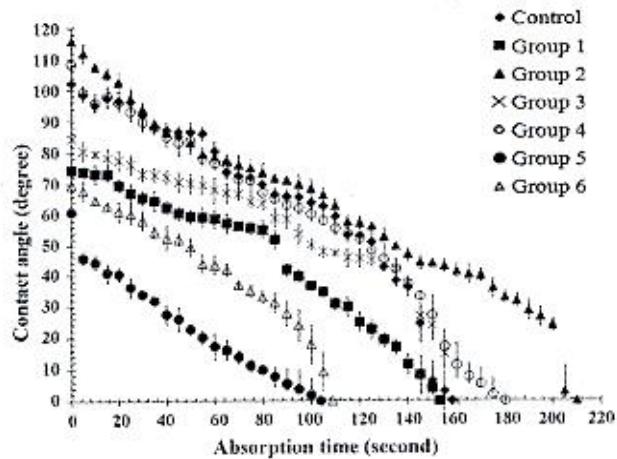


Fig. 3. Temporal recession of the contact angles for some representative samples.

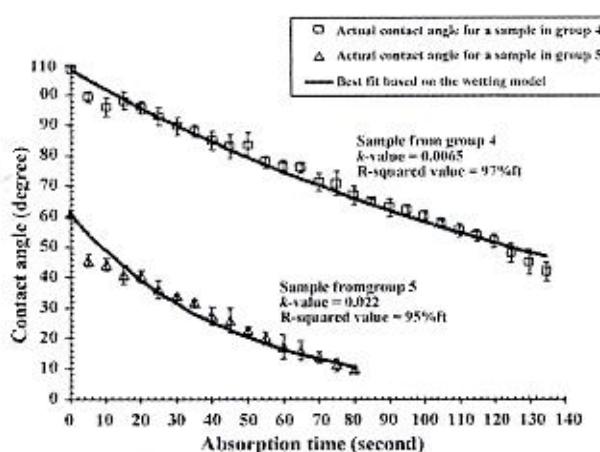


Fig. 4. Typical numerical constructs of Eq. (1) (wetting model) fitted against empirical data. The time rate equation of the wetting model is made to fit actual contact angle data of samples belonging to groups 4 and 5.

as the contact angle approaches zero, measurement error increases. For this reason, when using Eq. (1), data sets above the 95th percentile are discarded. Fig. 4 illustrates typical numerical constructs of Eq. (1) fitted against empirical data. In this illustration, the wetting model is solved to closely match actual contact angle data of representative samples belonging to group 4 and group 5. Calculations of the goodness index of fit between experiment and theory employing the R-squared method [17], show a lower bound of 90% and an upper bound of 99%. The control group, groups 2, 4, 7, and 8, show lower mean k-values. Lower k-values denote longer moisture absorption time, i.e., their representative samples are more hydrophobic. These are specimens irradiated by lower energy hydrogen ion showers (i.e., $I_d \leq 1$ mA). In contrast, groups 1, 3, 5, 6, 9, 10, 11, and 12 consisting of samples exposed to higher energy ion showers (i.e., $I_d \geq 1.5$ mA) came out with higher mean k-values indicative of specimens with hydrophilic qualities. A rule of thumb to describe wettability characteristics is simply to look at the initial contact angle (α), the 90° angle being the baseline that separates the hydrophilic and hydrophobic regimes [18]. A liquid is said to wet a solid surface if $\alpha < 90^\circ$ and is non-wetting if $\alpha > 90^\circ$. Fig. 5 shows the computed k-values plotted against the samples' α -angles. The plot shows two distinct regions: a hydrophobic region where $\alpha > 90^\circ$ occupied by the low energy and control groups with lower k-values and a

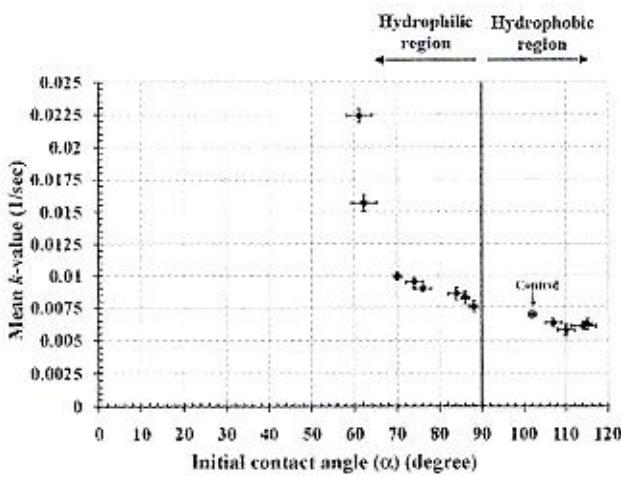


Fig. 5. A plot of k-values (wettability) against the samples' initial contact angles α .

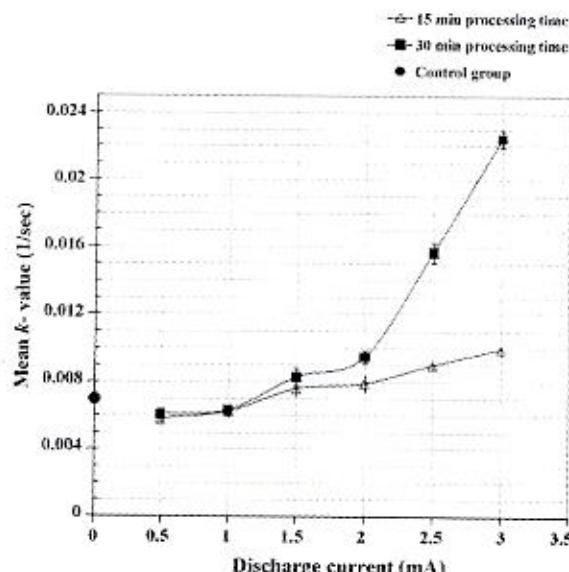


Fig. 6. A plot of the average k -value against discharge current at 15 and 30-min processing times.

hydrophilic region where $\alpha < 90^\circ$ occupied by the higher energy groups with higher k -values.

A two-factor analysis of variance (ANOVA) [19] is employed to examine the dependence of wettability (k) on I_d and exposure time (t). In this test, I_d and t represent the two factors providing the sources of variation for the response variable k . The probability values (P -value) of I_d , t , and their interaction on k are all found to be below 0.05. The conclusion drawn is that both discharge and time parameters affect the wettability of the treated materials. Fig. 6 shows that k generally rises (i.e., the material increases its affinity for water) as discharge currents and processing times are increased. However, a low plasma discharge ($I_d \leq 1$ mA) results in a marginal improvement of hydrophobicity as k falls from an average of 0.007 (for the control group) to about 0.006 for groups 2, 4, 7, and 8. The data from these groups are subjected to a one-way ANOVA using the time parameter as the source of variation. Results indicate that for low discharge, the processing times of 15 and 30 min appear to have no significant effects on their hydrophobicity (P -value > 0.05). Referring to the plots of Fig. 6, the statistical interpretation is obviously correct as there is an overlapping of data points in the low discharge regime ($I_d \leq 1$ mA, $v_d \leq 1$ kV). In contrast, higher discharges ($I_d \geq 1.5$ mA) result in enhanced affinity to water. The hydrophilicity of groups 1, 3, 5, 6, 9, 10, 11, and 12 (high-energy groups) is further improved using longer processing time, the average k -value peaks to 0.023 for group 5—the most hydrophilic processed using the highest beam energy at the longest treatment time. Numerous literatures have reported that the wettability of polymers can be enhanced by bombarding them with high-energy ions. Energetic ions incident on polymer samples cause surface heating effects which in turn, increase surface roughness. The increase in surface roughness is believed to be one of the reasons for increased hydrophilicity [20–23]. On the other hand, the cause of hydrophobicity by ion irradiation is not fully understood as yet. Reported in [24], the application of low discharge LEHIS on wood substrates led to similar surface inactivation effects. The present work seems to suggest that an essential condition for hydrophobicity is that the energy range of the irradiating ion-beam should be equal to or less than 1 keV. This is the threshold energy or the upper limit beyond which the processed surface will cross over to the hydrophilic

regime. Nevertheless, further studies are on-going using X-ray photoelectron spectroscopy to clearly describe the mechanism of hydrophobicity in polymeric materials.

3.3. Optical characterization

The optical characterization experiment investigates the transmittance of He-Ne laser light through the samples. Laser light from a He-Ne laser of wavelength 594 nm is directed onto the sample and the transmitted light is detected using a photodiode. Transmittance is then plotted against the discharge currents of the hydrogen beams used in processing the PTFE samples.

Transmittance may be regarded as a measure of light leakage through the sample. Seen in Fig. 7, samples irradiated by low-energy ion showers ($I_d \leq 1$ mA) show the least transmittance. These samples from groups 2, 4, 7, and 8 (low-energy groups), being the least wettable, give a lower bound of 60% mean transmittance which is an improvement of about 25% less light leakage compared to the control group. The opposite effect is seen for samples irradiated by higher energy beams. Group 5 gives the highest mean transmittance of 99% and is the most wettable as well.

3.4. SEM characterization

The substrates were coated with gold using a Jeol (JFC-1100) Fine Coat Ion Sputter. A Leica S440 scanning electron microscope (SEM) is used to determine the structure of the surface of the material.

Fig. 8 shows representative SEM images of the untreated and treated samples belonging to the different groups. The topographic view is viewed at 50k \times magnification while that of the cross-section at 1.5k \times . Samples from the low-energy groups ($I_d \leq 1$ mA) established earlier to be hydrophobic and less transmissive to laser irradiation show surfaces that are much smoother, more compact, and homogenous as seen in Fig. 8(b), which may explain why they exhibit reduced light leakage. Samples belonging to the high-energy groups ($I_d \geq 1.5$ mA) shown in Fig. 8(c) appear degraded; their surfaces show signs of damage somewhat akin to surfaces that have been striated. Literatures show that exposure to plasmas and ion irradiation significantly affect the optical characteristics of polymers [25–28]. These changes are brought about by a variety of factors such as increased polymeric cross-linking [29], carbonization [30],

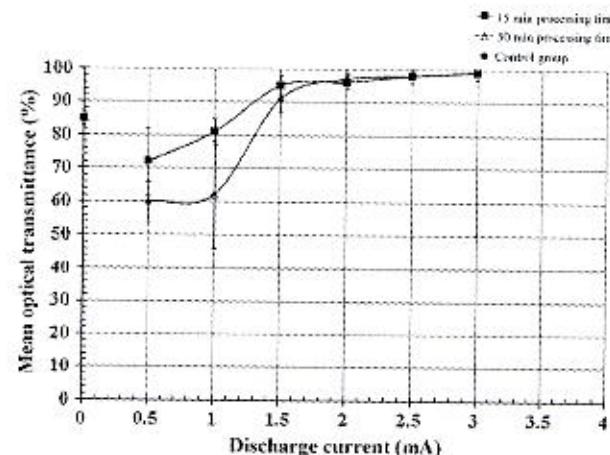


Fig. 7. The average % optical transmittance of He-Ne laser light through the samples.

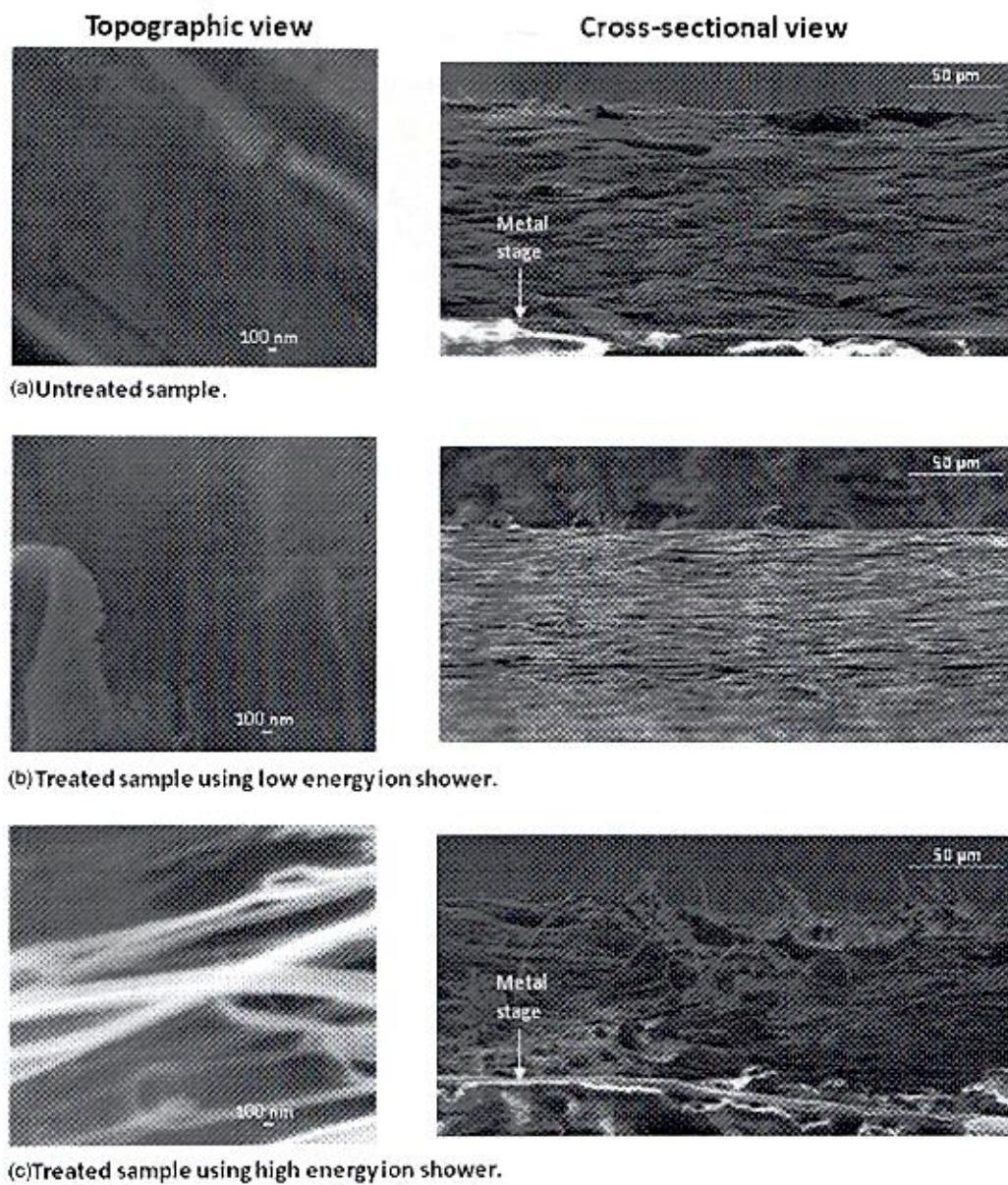


Fig. 8. (a) SEM image of a representative sample from the control group, (b) typical SEM image from the group processed at low discharge currents, $I_d \leq 1.0$ mA, beam energy ≤ 1.0 keV, and (c) typical SEM image from the group processed at higher discharge currents, $I_d \geq 1.5$ mA, beam energy ≥ 1.2 keV.

220 surface erosion forming spires and needles whose vertical
221 dimensions may range from tenths to hundreds of microns [31]
222 and alterations in refractive index due to structural modifications
223 [32]. Optical transmission is a very complex function and is
224 strongly dependent on the absorption coefficient and refractive
225 index of the substrate material; as well as the envelope of the
226 interference maxima and minima of the transmission spectra
227 [33]. For the samples under study, it is plausible that higher
228 energy ion bombardment leads to surface structural modification
229 in the form of increased striations and scissions allowing the
230 interference envelope function to attain maximum transmission
231 at 594-nm wavelength. Surface texturing of this kind wherein up
232 to 99% optical transmittance is achieved, occurs at ion flux density
233 of 0.25 A/m 2 ($I_d = 3$ mA). Fig. 9 presents the surface tension of the
234 samples calculated using a relation derived from Berthelot's rule

[34] and Young's equation of state [35] given by

$$\cos \alpha = -1 + 2 \sqrt{\frac{\gamma_s}{\gamma_w}} \quad (2)$$

where α is the initial contact angle, γ_s is the surface tension of the sample, and γ_w is the surface tension of water equal to 72.8 dyne/cm. Careful scrutiny of Figs. 8 and 9 reveal that rough surfaces, namely, those coming from the high discharge groups, have higher surface tensions. For samples coming from the low discharge groups, the surface tensions are lower.

3.5. FTIR characterization

A NEXUS 670 FTIR ESP with Nicolet Continuum Microscope is used for the chemical analysis of the PTFE samples. Reflective

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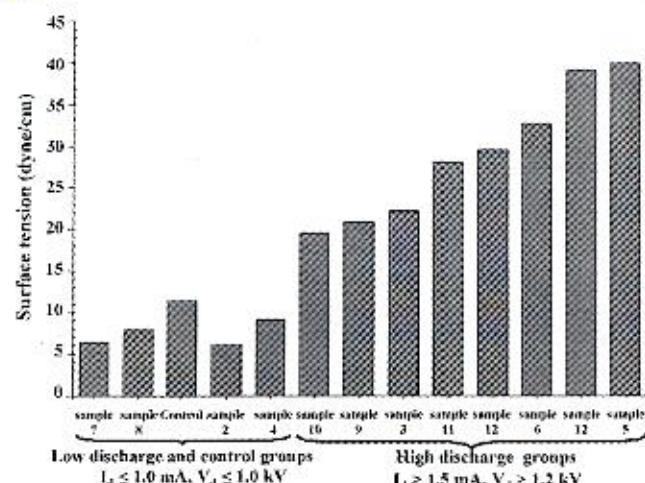


Fig. 9. Surface tension plots of the different groups.

mode IR spectroscopy is used on the samples that are mounted on flat gold-coated slides. The relative reflective spectra are then converted to IR relative absorbance spectra. Auto spectral baseline correction is performed for better peak

height comparison at specific wavenumbers in the absorbance mode.

Fig. 10(a) shows typical FTIR-spectra of group 2 samples and Fig. 10(b) shows typical FTIR-spectra of group 5 samples. High concentration of CF_2 bonds are observed in all samples in effect verifying these to be of PTFE materials. The strong absorption peaks observed at 1224 and 1155 cm^{-1} represent the asymmetric and symmetric stretches of $-\text{CF}_2$ functional groups, respectively. The peaks with smaller intensity at around 640 – 620 cm^{-1} are attributed to the chain stretching and wagging modes of the $-\text{CF}_2$ bond, and at 553 and 507 cm^{-1} , the bending and rocking modes are observed [36–39].

An upside to the surface modification process is that the physical changes do not affect the treated materials' bulk chemical composition since all specimens exhibit identical "molecular-fingerprints" with no observable shifts in wavenumber and peak sizes. Employing once more the factorial ANOVA, where in this case the variable of interest is the absorbance, yield test statistics greater than 0.05 for all absorption peaks across the whole spectrum. Both sources of variation, namely, the factors (i) processing time and (ii) discharge parameter, have no significant effects on absorbance. In addition, the interaction between these two factors is even lower. This finding leads to the hypothesis that the treatment may not involve any chemical reactions, and that any disparity in absorbance values may have arisen as a result of physical

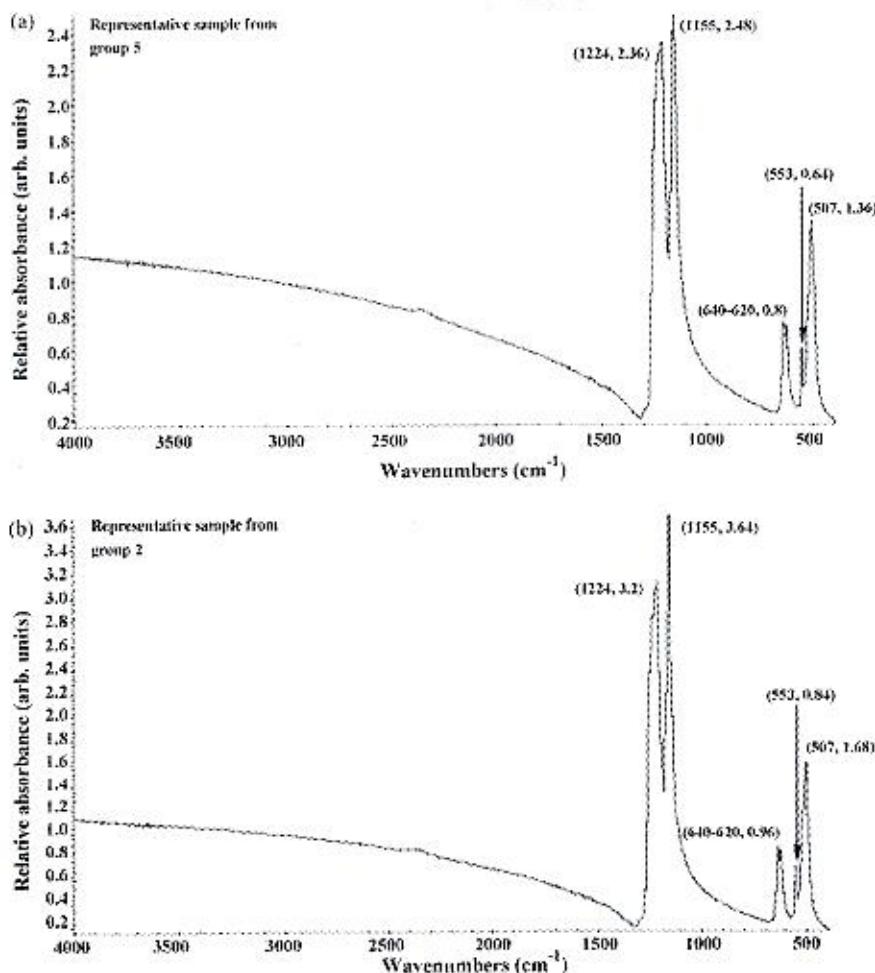


Fig. 10. (a) Typical FTIR-spectra of the samples from group 2. (b) typical FTIR-spectra of the samples from group 5. For brevity the "true zeroes" of the vertical and horizontal axes are not reflected. The intersection of the axes represents the coordinate (4000, 0.16).

276 changes. It is also highly unlikely that H_n^+ ions at this energy
 277 range (~ 1 keV) will bond with fluorocarbons. The modification
 278 process may be purely morphological in character.

279 4. Conclusions

280 The wettability and optical transmittance properties of hydro-
 281 gen ion treated PTFE materials were evaluated using contact angle
 282 measurements, laser irradiation, SEM, and FTIR tests. Depending
 283 on the kind of LEHIS treatment, two kinds of PTFE surfaces could be
 284 produced. Low discharge LEHIS produced hydrophobic, smooth,
 285 and less optically transmissive surfaces while high discharge LEHIS
 286 produced hydrophilic, striated, and light transmissive surfaces. A
 287 highly wettable PTFE would most likely be transmissive to light
 288 and a less wettable substance otherwise. If PTFE were to be used as
 289 a barrier to minimize the leakage of light, the material should be
 290 processed using LEHIS with discharge parameters not exceeding
 291 1 kV. This finding agreed with the results of [31] where spectral
 292 transmittance of polyimide decreased for all wavelengths after
 293 treatment by argon ion beam in this energy range. LEHIS of this
 294 intensity would be sufficient to texture the PTFE surface in a
 295 reasonably short time but with beam energy low enough to ensure
 296 the material maintained its physical integrity.

297 Infrared spectroscopy showed no change in peak wavenumbers
 298 and sizes; evidence that the surface modification process had no
 299 effect on the treated materials' chemical properties. Although
 300 empirical data pointed largely to a morphological modification,
 301 one cannot entirely discount chemical reactions on the surface
 302 induced by the irradiation process. Using X-ray photoelectron
 303 spectroscopy, further investigation to clarify this issue is in
 304 progress.

305 Acknowledgments

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 309 gratefully acknowledged.

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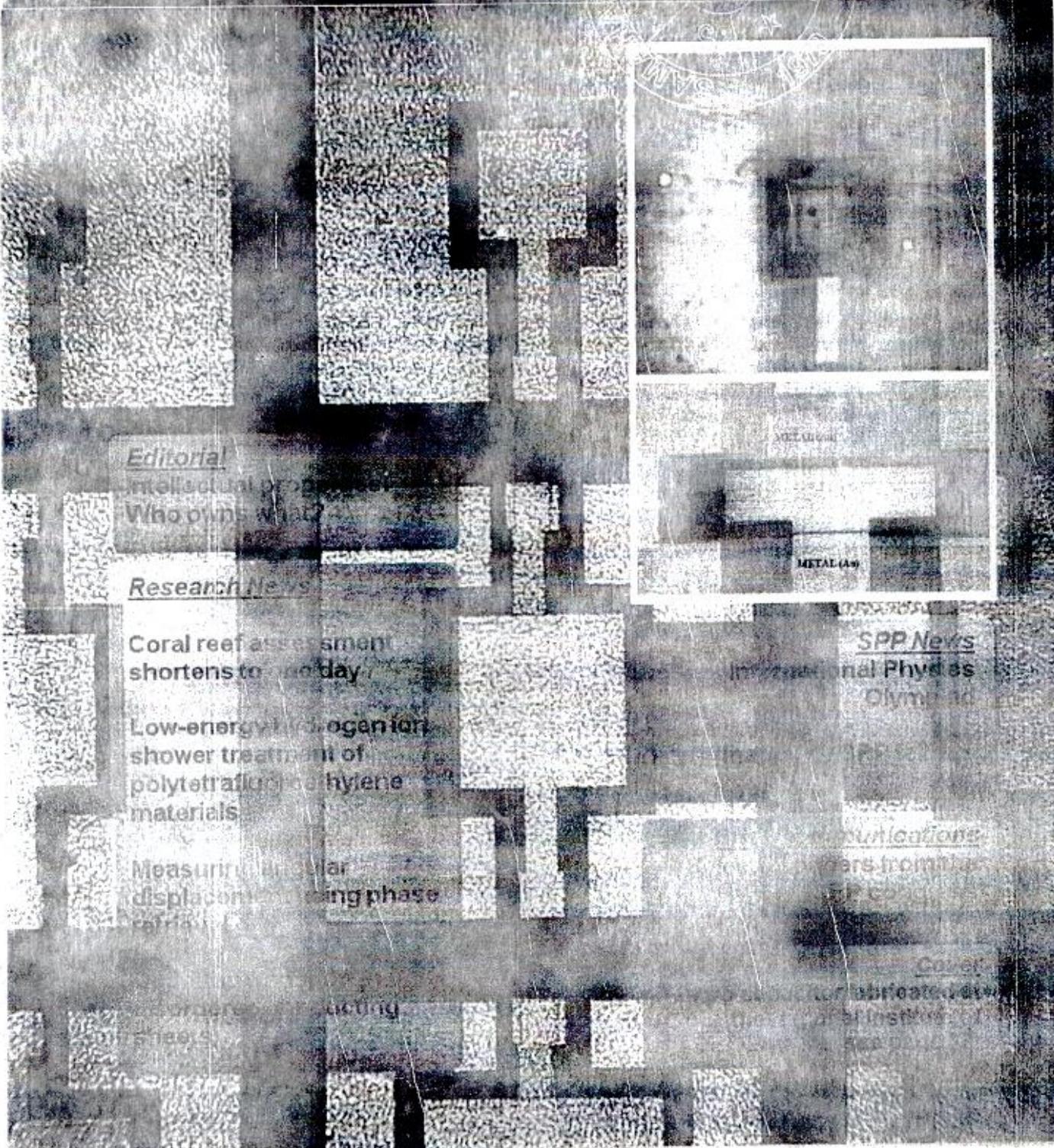
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Low-energy hydrogen ion shower treatment of polytetrafluoroethylene materials

Polytetrafluoroethylene (PTFE) or more commonly known as Teflon has gradually developed to become the seminal material in numerous applications. By virtue of its incredibly versatile characteristics, its potential

use in a modern technological society appears limitless- ranging from electrical and electronics, food packaging and processing, biomedical, chemical and mechanical to agricultural and aeronautical applications. The ease

with which the surface attributes of PTFE can be manipulated without altering its bulk composition suggests that the logical focus should be towards tuning PTFE surface to suit a particular application. Surface modification allows for the change and improvement of the property of a material, making the processed material more useful in various aspects.

A team of researchers composed of SPP members from the National Institute of Physics: Hernando Salapare III, Gene Blantocas, Virginia Noguera, and Henry Ramos demonstrated that PTFE properties could be modified by surface treatment using low energy hydrogen ion shower (LEHIS) irradiation¹. In contrast with other surface modification methods,²⁻⁴ LEHIS treatment is straightforward, dry and requires short processing times- proof of the viability and competitiveness of the method.

Depending on the treatment parameters employed, the processed PTFE manifested variations in optical and wettability properties. Results showed that treatment using lower plasma discharge currents improved material hydrophobicity with contact angles measuring as high as 115° while higher discharges resulted in enhanced hydrophilicity reducing contact angles down to 61°. Optical transmittance and wettability were found to correlate, i.e., a surface made more wettable became optically transmissive allowing as much as 99% signal transmittance. Conversely, a surface made more hydrophobic reduced light leakage to as low as 60%. As the material showed increased surface irregularities, its optical transmittance, wettability, and surface tension also increased. With no observable shifting in the samples' IR-absorption peaks, the surface modification was essentially morphological in character.



The research team: (from left to right) Hernando Salapare III, Gene Blantocas, Virginia Noguera, Henry Ramos (all are SPP members).

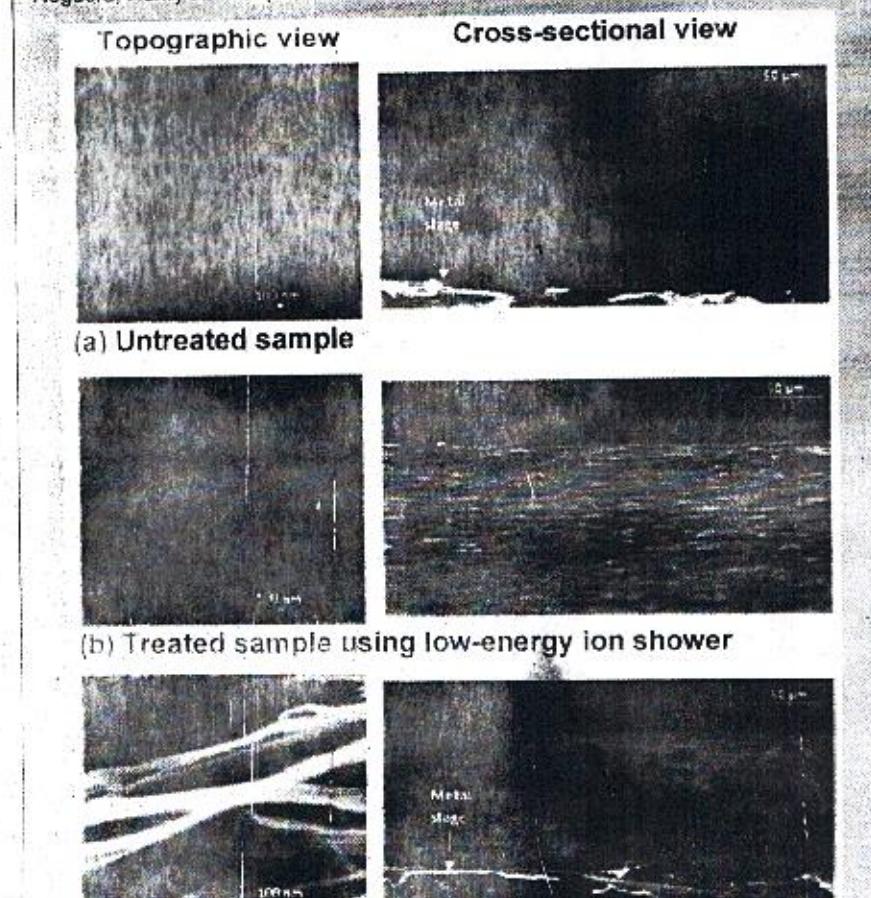


Figure 2.1. SEM images of representative PTFE samples. a) untreated (b) treated at low discharge currents, $I_d \leq 1.0\text{mA}$, beam energy $\leq 1.0\text{KeV}$, and (c) treated at higher discharge currents, $I_d \geq 1.5\text{mA}$, beam energy $\geq 1.2\text{KeV}$.



PROCEEDINGS OF THE SAMAHANG PISIKA NG FILIPINAS

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that depend on electrical conductance which may be erroneous due to the electrolytes present in the epidermis.

SPP-2008-018: Wetting dynamics model of hydrogen ion treated polytetrafluoroethylene (PTFE) materials
HS Salaparac¹, HJ Ramos, VR Noguera, GQ Blantocas
Nat Inst of Physics, Univ of the Philippines Diliman, QC

The wetting dynamics model of hydrogen ion treated polytetrafluoroethylene (PTFE) materials was determined. PTFE materials were irradiated using low energy hydrogen ion shower materials generated by a Gas Discharge Ion Source (GDIS). A contact angle test was used to characterize the effect of treatment. There is a significant difference between the contact angle measurements and the size of the dose used as determined by R-squared value of wetting dynamics model. Results also show that treatment using lower (1 kV) and higher (2 kV) fluence also resulted in enhanced hydrophilicity while higher (4 kV) resulted in enhanced hydrophobicity.

SPP-2008-020: Fabrication of Polycaprolactone Nanofibers through Electrospinning

JB Zerrudo¹, EA Florida, MR Amada²
¹Inst of Mathematical Sci & Phys, Univ of the Philippines Los Baños
²Philippine High School for the Arts, National Arts Center, Los Baños

Polymer nanofibers with diameters ranging from 200 to 400 nm were successfully fabricated via the electrospinning process. Scanning electron microscope was used to verify the existence of nanofibers. From SEM images the mean diameter of electrospun PCL nanofibers was found to be 366 nm. Uniform nanofibers were also observed from the electrospun PCL. Structural characterization using Fourier Transform infrared spectroscopy was used to determine its chemical structure.

SPP-2008-025: Enhancement of the Oleophilicity of Recycled Polypropylene by UVA Irradiation and Mechanical Abrasion

**JG Bugisa, EJ Florada,
¹Inst of Math, Sci & Phys, Univ of the Philippines Los Baños**

The effect of surface modification on the oleophilic property of recycled polypropylene (PP) was investigated. Surface modification was done by UVA irradiation, mechanical abrasion, and combined through UVA irradiation, mechanical abrasion, and combined through UVA irradiation and abrasion. The change in oil adhesion property of the surface was determined through Contact Angle Measurement. Mechanical abrasion increased the contact angle of the surface. UVA irradiation increased the contact angle only up to a critical time of irradiation (six minutes) for all the samples. Beyond this time, contact angle and roughness diminished.

SPP-2008-031: Modifying the Spectral Distribution of White Light via Stress Birefringence in a Transparent Elastomer

**JG Sen, EO Go, B Chan
¹Phys Dept, Ateneo de Manila Univ, Loyola Heights, QC**

This study investigates how the spectral distribution of white light changes as uniform stress is applied to a transparent elastomer. The behavior of the transmission intensities for different wavelengths was monitored as the sample was stretched. It was noticed that the intensity of the transmitted light through the sample for both white LED and incandescent light behaved similarly, increasing to a certain point and then decreasing as more stress was applied. It was further noticed that only a certain wavelength of light was transmitted at a certain amount of stress. Hence, this study may aid in the design of an optical device based on transparent elastomers.

SPP-2008-032: Strain in epitaxially lifted off GaAs bonded on Gold probed via Raman spectroscopy

**MJ Defensor, RB. Jaculbia, AS Somintac, AA Salvador
¹Nat Inst of Physics, Univ of the Philippines Diliman, QC**

Raman spectroscopy was utilized to investigate spot heating induced strain in epitaxially lift-off GaAs bonded on Gold. Gold mesh contacts were deposited on top of the GaAs film via electroplating prior to separating the film from their host substrate through the epitaxial lift-off technique. Raman spectroscopy shows that the LO phonon peak

of GaAs shifts to lower wavenumbers by as much as 4cm^{-1} for power density of $40,000\text{W/cm}^2$. This suggests that the GaAs film experiences tensile strain caused by the large disparity in thermal expansion coefficient of GaAs and Gold. Results show that a significantly larger amount of strain is introduced by laser heating of GaAs/Au films compared to heating at 500°C for GaAs grown on Silicon.

SPP-2008-035: Synthesis of Anodic Aluminum Oxide (AAO) From Aluminum Thin Film Deposited via RF Magnetron Sputtering
**RG Dizon, R Loberertos, J Bugne, D Taguba, O Valdez,
¹A Somintac**

Nat Inst of Physics, Univ of the Philippines Diliman, QC

Anodic Aluminum Oxide (AAO) was synthesized by anodizing thin film aluminum, with thickness of approximately 200nm , deposited on a silicon substrate via RF magnetron sputtering. Two-step anodization process using 0.3 Molar oxalic acid solution at applied potential of 40 volts was able to show high nanopore density and nearly ordered nanopore arrangement. Etching time with 5% phosphoric acid was varied in order to control nanopore diameter. The morphologic and physical characterizations of the alumina film samples were carried out by Scanning Electron Microscope (SEM).

SPP-2008-037: Numerical analysis of image wavelength down conversion using FD method

GG Manahan, WO Garcia

Nat Inst of Physics, Univ of the Philippines Diliman, QC

Image transfer from the laser wavelength to another through stimulated Raman scattering is numerically studied. The SRS wave equations are solved using two-dimensional finite difference (FD) method. The stimulated down converted images are found to be highly dependent on the laser input power and Raman gain. With FD technique, the converted images are found to be in good correspondence with the laser image.

SPP-2008-038: Three-dimensional dynamic stereo imaging microscopy using LCD projector illumination

LC Buñó, O Tarun, CY Blanca

Nat Inst of Physics, Univ of the Philippines Diliman, QC

We present low-cost three-dimensional (3D) microstereomicroscopy using a microscope coupled to an LCD projector light source. The polarization states of green and magenta displayed by the projector are mutually perpendicular which enables simultaneous color and polarization separation of the stereogram taken at two different perspectives. The use of polarized goggles visualizes the transparent samples in 3D which can be extended to simple anaglyph imaging using red-green color filters. The image contrast is then increased using dark oblique illumination patterns which can readily be changed using simple slideshow transition allowing real-time 3D visualization in real-time with no image processing and moving parts.

SPP-2008-039: Mobility Enhancement of a High Electron Mobility Transistor via External Strain

**KM Omambac, EA Prieto, JD Azares, RB Jaculbia, CF Baldo III,
¹AA Salvador**

Nat Inst of Physics, Univ of the Philippines Diliman, QC

The effect of external strain in the growth of High-Electron Mobility Transistor was investigated. The layer was grown by Molecular Beam Epitaxy at elevated temperature (690°C). High resolution X-ray diffraction of the grown layer revealed that Indium diffused into the Gallium Arsenide (GaAs) substrate. Hall measurements at 10K showed that there was an increase in the mobility due to strain. Reflectivity measurements at 10K of the As-grown epilayer showed the splitting of the heavy-hole (HH) - light-hole (LH) bands, indicating that the layer was strained. The separation was about 2.6meV at 10K and broadening of the PL peak in the 1.516eV was observed. The increase in mobility was attributed to change in the effective mass of the electron in the conduction band when the HH - LH bands were separated.

SPP-2008-124: Laser scanning two-photon fluorescence microscopy with a virtual pinhole
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²James Clark Ross Natl. Aust. Australia

We conducted and evaluate the performance of a two-photon fluorescence microscope with a virtual pinhole. Instead of using a single photodiode detector to render a 2PF image, we detect a wide-field image using a multi-channel pixelated array detector. As proof-of-concept, we used a conventional digital CCD camera to function as the wide-field detector. The virtual pinhole is implemented by selecting a region of interest in the wide-field digital image and setting the pixel values outside the region to zero. The virtual pinhole removes scattered signals resulting to improve contrast and the visibility of details masked by scattered signals. The optical sectioning capability of the system was also shown.

SPP-2008-128: Fluorescence experiments with dual-state chlorophyll immobilized by silicone
MJ Renovales, RA Guerrero
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The distinct effect of Syloid-184 on the spectral characteristics of chlorophyll is presented. Spectral data of different concentrations of chlorophyll and chlorophyll-adsorbed elastomer excited by a laser were collected. The spectra of two states of chlorophyll are remarkably different from each other. It is assumed that the adsorbed chlorophyll-doped elastomer is weakly ($\sim 0.1\text{ nm}$) covalently linked to chlorophyll in solution. When the chlorophyll solution was sprayed on glass and polystyrene, the fluorescence peak wavelength of the chlorophyll-adsorbed elastomer is away from the two others (± 5.5 by 8.0 nm). These results show that incorporation of chlorophyll in Syloid-184 presents the possibility of further using this material.

SPP-2008-130: Varying Geometrical Structures of Tin Oxide Nanomaterial Grown on Silicon (100) Substrate
A Co, S Sowl, A Ladines, R De los Reyes, N Alcantara, GC Santos, R Quiroga
¹Phil. Inst. State Polytechnic Laboratory, De La Salle University, Manila

Nano scale materials were grown on Silicon substrate using *Hydrogen Induced Physical Growth Technique*. Optimum results were obtained at a temperature of 1200°C and at a deposition time of 3 hours. Scanning Electron Microscope and Energy Dispersive X-Ray Spectrometry were employed to characterize the synthesized materials. SEM has indicated that the products consisted of nanoscale (~ 10 nm) nanoballs, nanowires, nanochips, nanorods, nanorings, and nanofins with preferred orientation and without crosslinks. The as-grown materials were then compared to SiO₂ nanomaterials grown without a substrate. The nanorods and nanowires coming from the quartz tube are random in direction compared to those grown on Silicon substrates although the same growth technique was used.

SPP-2008-135: Propagation Properties of Truncated Bessel Beams Retrieved From Volume Holograms
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Truncated Bessel Beams are vertically or horizontally half-blocked Bessel beams generated by obstructing half of the intensity profile. We report the storage of such beams in a photorefractive LiNbO₃ crystal via volume holography. Captured images show that a truncated Bessel beam recorded after a volume hologram exhibits non-diffraction up to an average distance of 75 cm. The reconstructed half-blocked Bessel beam can reconstruct a full reconstruction after encountering an aperture. Furthermore, we prove its capability to recover the pre-existing intensity profile of the central maximum, although to a lesser extent, than of a complete Bessel beam.

SPP-2008-137: Strengthen needles and optical activity in Manila Bay
A. Flores, J. A. Diaz
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One component of Manila bay was isolated and housed in glass slides using different methods. The samples were characterized and birefringence was observed using a microscope with crossed polarizers. Optical activity was also described through the rotation of polarizer and analyzer and transmittance measurements.

SPP-2008-143: Polycaprolactone (PCL) Polyethylene Oxide(PEO)/*Iota*-Carageenan(iCAR) Nanofibrous Scaffolds
S Lago III¹, TB Manguerra¹, M Amada², B Basilia¹

¹Philippine High School for the Arts, Nat Arts Center, Laguna
²Materials Science Div. Industrial Tech Development Inst

Polycaprolactone/Polyethylene Oxide/*Iota*-Carageenan nanofibrous scaffold was produced using electrospinning. Scanning Electron Microscopy was used to characterize the morphology of the samples and Fourier Transform Infrared Spectroscopy (FTIR) was used to identify the resulting functional groups present in the samples. An *in vitro* treatment using Simulated Body Fluids (SBF) was used to evaluate the biodegradability of the samples over a 24-hour period. Morphology reveals the relation between tip to collector distance and the relation between ratio concentrations of the reaction with diameter of the electrospun fibers.

SPP-2008-147: Effects of low energy hydrogen ion shower (LEHIS) treatment on the optical and thickness properties of polytetrafluoroethylene (PTFE) materials

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²PerkinElmer Optoelectronics Philippines, Inc., Cabuyao, Laguna

The optical and thickness properties of polytetrafluoroethylene (PTFE) materials treated by low energy hydrogen ion shower (LEHIS) of a Gas Discharge Ion Source (GDIS) are explained using scanning electron microscopy (SEM) and ellipsometry characterizations. Results show that as the discharge current is decreased, the PTFE materials thicken as indicated by the increase in the index of refraction, density and from its SEM cross sectional view. The thickness of the material reduces the transmittance of light to the sample to as low as 0%.

SPP-2008-153: Comparative experiments between human and holographic pattern recognition in solving Sudoku number puzzles

JC Chua, RA Guerrero

Dept of Physics, Ateneo de Manila Univ., Loyola Heights, QC

The study aims to characterize human pattern recognition and holographic process using 4x4 Sudoku puzzles. This was achieved by comparing results from human pattern recognition surveys and volume holographic correlation experiments. Recognition intensity for the surveys and experiments was assumed to be 1/ (time for solving) and reconstructed intensity, respectively. Results indicate similarities between the two recognition systems.

SPP-2008-159: Synthesis of TiAlN on stainless steel substrate using a magnetized sheet plasma source

MS Villamayor, LD Rosario, C Lim, A Bañas, H Ramos

Nat Inst of Physics, Univ. of the Philippines, Diliman, QC

A magnetized sheet plasma ($13 \times 20 \text{ cm}^2$ with a few millimeter thickness) source was used for the deposition (no substrate heating and biasing) of titanium aluminum nitride (TiAlN) on stainless steel substrates. Titanium and aluminum plates placed above SmCo magnets (2.2 kG) were sputtered by argon plasma produced at plasma current of 4 A and a discharge potential of 70 V under a total gas filling pressure of $9 \times 10^{-3} \text{ Torr}$. Reactive nitrogen gas is then fed to the system in N_2/Ar ratios of $1:2$, $1:3$, $1:5$, $1:8$, and $1:10$ all at $4 \times 10^{-3} \text{ Torr}$ gas filling pressure.

SPP-2008-183: Intragrain-dominated AC susceptibility responses of optimally doped $\text{La}_{2-x}\text{Sr}_x\text{CuO}_{4-\delta}$

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Diliman, QC

Improvement in the high frequency performance of spiral waveguide structures in the Condensed Matter Physics group at UPD is as compared to previously reported results in waveguides [1]. This is achieved through thicker gold contact pads and no electrochemical plating. The reduction of μ_{eff} and the ratio of the resist current, observed in the increase of the current density, is shown in figure 1.

Rm 205 (1) 10:30 AM - 12:00 PM

- SPP-2008-150:** Design and fabrication of DC planar cyclotron using concentric annular ceramic magnets
JC Vergara¹, IB Culaba²

¹Ug, Dept of Mndern State Inst of Sci & Tech, Butuan City
²Physics, Ateneo de Manila Univ, Loyola Heights, QC

A high-current sputtering system was previously developed [E. J. Urtia and I. B. Culaba, Fisika 1(1), pp. 30-32, 2007] using two sets of neodymium magnets. In this present work, a new magnetic field configuration is presented using two annular concentric magnets. The glow discharge profile is symmetrical to the Paschen curve and the current-voltage characteristic. This configuration produced highly symmetric radial plasma near the target surface, which will facilitate the introduction of cathodizers.

SPP-2008-151: Fourier transform infrared spectroscopy (FTIR) characterization of low energy hydrogen ion shower (LEHS) treatment of polytetrafluoroethylene (PTFE) materials
MS Salazar¹, GQ Blintucos, MR Noquera, HJ Rainas

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The physical and chemical properties of hydrogen ion treated polytetrafluoroethylene (PTFE) materials are evaluated using Fourier transform infrared spectroscopy (FTIR) test. The materials are processed using low energy hydrogen ion shower (LEHS) produced by a Gas Discharge Ion Source (GDIS). The duration of treatment and ion shower energy are varied to determine their effects on the PTFE specimens. Short treatment times of 15 and 30 minutes are used with plasma discharge current (I_d) varied at intervals of 0.5 mA. The surface modification is essentially morphological as there is no significant shift of the IR-absorption peaks for all the samples.

SPP-2008-152: Detection of Counterfeit Philippine Currency via LIBS
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Laser induced breakdown spectroscopy (LIBS) was used to determine the elemental composition of magnetic and non-magnetic coins made by smelting. The metal alloy, arm coins were analyzed by LIBS using Al pulse via Nd-YAG laser at 1064 nm as the excitation source. An sole Fe peak at 572.4 nm is not present only in several of the coins. The presence of iron in the magnetic alloys. LIBS can be used as a non-destructive technique in detecting synthetic counterfeit coins from non-magnetic ones.

SPP-2008-019: Terahertz absorption measurements of small peptides and proteins
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Absorption cross section was obtained for amino acids L-alanine and glycine, and peptides di-L-alanine di-glycine, tri-L-alanine, and tri-glycine using terahertz time domain spectroscopy (THz-TDS). Power law characteristics of reduced absorption cross section was observed for all of the biomolecules whose exponent is -2 for amino acids then decreases its value as the peptide chain increases in length. This shows the harmonic behavior of the low frequency vibrations of amino acids as well as the extent of anharmonic coupling of vibrational modes when the peptide chain is increased.

- SPP-2008-118:** Vacuum ultraviolet fluorescence from $\text{Nd}^{3+}:\text{LaF}_3$ excited by 290-nm femtosecond pulses

MM Cadatal^{1,3}, Y Furukawa², M Pham^{1,3}, E Estacio³, N Sarukura³, K Fukuda^{4,5}, T Suyama⁴, A Yoshikawa⁵, F Salto⁵

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We present the vacuum ultraviolet fluorescence from a Czochralski method-grown $\text{Nd}^{3+}:\text{LaF}_3$. Emission spectra resulting from excitation by 290-nm femtosecond pulses of a Ti:sapphire laser and by 157 nm pulses of a F_2 laser show that the luminescence spectral and temporal characteristics are similar for both excitation cases. Laser emission in the $\sim 1\text{eV}$ region may be achievable by pumping with existing ultraviolet solid-state lasers.

Rm 205 Complex Systems 2

- SPP-2008-057:** Polarity-based growth model of budding yeast

RB Cabral, MT Lim

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We model the colony growth of budding-type yeast through its polarity property coupled with the diffusive metabolites (growth inhibitor) and nutrients (growth activator) in a two-dimensional medium. We observed 'blob-like' to 'dendritic' morphological patterns as we varied nutrient concentration and growth inhibition factor in the colony. We found that the distal budding mechanism is responsible for the formation of fingers at the growth front of the colony. On the other hand, the proximal budding mechanism explains impeded growth in the presence of high metabolite concentration, even in the presence of a growth-inducing high nutrient concentration.

- SPP-2008-082:** Dual scaling law in human area perception of concentric circles

ET Legara, IA Crisolgo, AG Longjas, CP Monterola

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Understanding how humans perceive objects may unravel psychophysical laws that allow us to gain mastery of issues involving various cognitive phenomena. Here, we conduct an area-space task using circle as precent. We show that when the stimuli are smaller than the reference area A of the circle, individuals tend to underestimate the perceived area. On the other hand, overestimation is observed for the regime where the stimuli are greater than A. The psychophysical relationship between the perceived area and the stimulus is obtained and shown to obey Stevens' law. However, contrary to prevalent idea that a single diagnostic Stevens' exponent (γ) exists for every psychophysical phenomenon, our results indicate conclusively scale duality. For stimuli less than A, $\gamma = 1/1$ while, for stimuli greater than A, $\gamma = 1/7$. The existence of two scaling exponents in a single psychophysical experiment is a

Fourier transform infrared spectroscopy (FTIR) characterization of low energy hydrogen ion shower (LEHIS) treatment of polytetrafluoroethylene (PTFE) materials

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Abstract

The physical and chemical properties of hydrogen ion treated polytetrafluoroethylene (PTFE) materials are evaluated using Fourier transform infrared spectroscopy (FTIR) test. The materials are processed using low energy hydrogen ion shower (LEHIS) produced by a Gas Discharge Ion Source (GDIS). The duration of treatment and ion shower energy are varied to determine their effects on the PTFE specimens. Short treatment times of 15 and 30 minutes are used with plasma discharge current (I_d) varied at intervals of 0.5 mA. The surface modification is essentially morphological as there is no observable shifting of the IR-absorption peaks for all the samples. © 2008 Samahang Pisika ng Pilipinas

Keywords: 81.30.Hd, 68.35.bm, 61.80.-x, 82.80.Nj

1. Introduction

Surface modification of polymer materials has been of great interest in most researches for the past years because of its importance in the field of materials science, electronics and biomedical physics. Surface modification technology allows for the change and improvement of the property of a material and in consequence making the material more useful in different aspects [1].

There are different ways on how surface modification happens. An energetic ion is needed to interact with the surface of the material to initiate the modification of the surface [2]. Surface modification maybe due to any of the following processes [3]: (a) particles may be reflected and probably neutralized during the process, (b) the impact may cause the target to eject electrons (secondary emission) or atoms (sputtering), (c) particles may be trapped into the target (ion implantation, electron trapping), (d) impact may cause structural rearrangements of the surface varying from point defects to grow more defects such as dislocations, changing crystal lattice and other high order phenomena, (e) impact could promote some chemical modification of the surface if either the ion or original gas is chemically reactive. Internal and external plasma parameters may also affect the kind of surface modification that may happen in a material.

There are different characterization techniques that can determine the change in the surface of the material, in this study Fourier transform infrared spectroscopy (FTIR) is used to characterize the surface modification of a polytetrafluoroethylene (PTFE) material by a low energy hydrogen ion shower (LEHIS) treatment of a gas discharge ion source (GDIS) system.

In general, the current study wishes to ascertain the mechanism of surface modification as to whether it is physically or chemically based, or perhaps a combination of both.

2. Methodology

Clean and blow-dried PTFE of size 1 x 2 cm are irradiated using LEHIS of a gas discharge ion source (GDIS) system. Figure 1(a) shows the schematic diagram of the experimental setup and Figure 1 (b) presents a 3-D figure of the GDIS. Complete details of the facility are described in [1] and [4-5]. The pressures inside the chamber are monitored using Pirani and ionization gauges. The facility is evacuated up to a base pressure of 1.0×10^{-6} Torr. The total hydrogen gas filling pressure is kept at 3 mTorr for all the experimental runs. Plasma is produced when a potential difference, V_d , is applied across the discharge region. The PTFE samples are placed on a holder positioned 70 mm downstream from the entrance port of the processing chamber. This is the position determined to give maximum ion current density. Processing times of 15 and 30 minutes are considered. There are thirteen test groups, each with three replicates. One group consisting of untreated samples and the remaining twelve groups made up of treated specimens. The treatment conditions are summarized in

Table 1. The irradiation time and discharge conditions (V_d =discharge voltage, I_d = discharge current) are varied for each group.

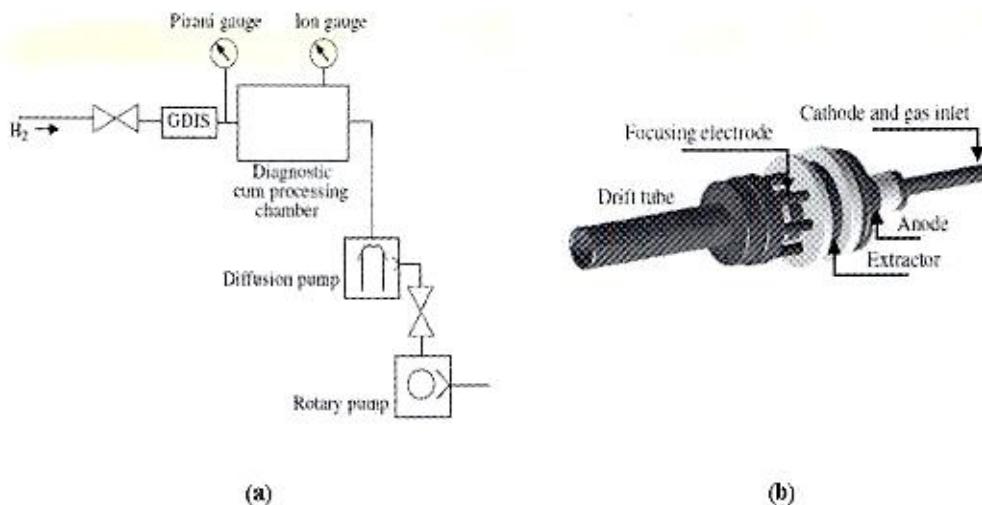


Figure 1. (a) Schematic diagram of the experimental setup and (b) the gas discharge ion source.

Table 1. Summary of irradiation time, discharge conditions, and extraction current of the Teflon® samples.

Treated Group	Irradiation time (min)	Discharge voltage, V_d (kV)	Plasma discharge current, I_d (mA)
1	30	1.3	2
2	30	1	1
3	15	1.3	2
4	15	1	1
5	30	1.4	3
6	15	1.4	3
7	30	0.7	0.5
8	15	0.7	0.5
9	30	1.2	1.5
10	15	1.2	1.5
11	30	1.35	2.5
12	15	1.35	2.5

3. Results and Discussion

A NEXUS 670 FTIR ESP with Nicolet Continuum Microscope is used for the chemical analysis of the PTFE samples. Reflective mode IR spectroscopy is used on the samples that are mounted on flat gold-coated slides. The relative reflective spectra are then converted to IR relative absorbance spectra. Auto spectral baseline correction is performed for better peak height comparison at specific wavenumbers in the absorbance mode.

Figure 2 shows typical FTIR-spectra of the samples, in particular, those of groups 2 and 5. High concentration of CF_2 bonds are observed in all samples in effect verifying these to be of PTFE materials. The strong absorption peaks observed at 1224 and 1155 cm^{-1} represent the asymmetric and symmetric stretches of $-\text{CF}_2$ functional groups, respectively. The peaks with smaller intensity at around 640 - 620 cm^{-1} are attributed to the chain stretching and wagging modes of the $-\text{CF}_2$ bond, and at 553 and 507 cm^{-1} , the bending and rocking modes are observed [6-9]. Exactly the same IR-signatures were found for the untreated group and the 12 treated groups which imply that the LEHIS process maintains the integrity of the PTFE material.

An upside to the surface modification process is that the physical changes do not affect the treated materials' bulk chemical composition since all specimens exhibit identical "molecular-fingerprints" with no observable shifts in wavenumber and peak sizes. Employing once more the factorial ANOVA, where in this case the variable of interest is the absorbance, yield test statistics greater than 0.05 for all absorption peaks across the whole spectrum. Both sources of variation, namely, the factors (i) processing time and (ii) discharge parameter, have no significant effects on absorbance. In addition, the interaction between these two factors is even lower. This finding leads to the hypothesis that the treatment may not involve any chemical reactions, and that any disparity in absorbance values may have arisen as a result of physical changes. Mass spectrometry shows the ion shower constituents to be H^+ and H_2^+ where the monatomic ion is the dominant species [10]. It is also highly unlikely that H_n^+ ions at this energy range (~ 1 keV) will bond with fluorocarbons. In reference with the contact angle measurements and SEM images of the samples in [10], the modification process is purely morphological in character.

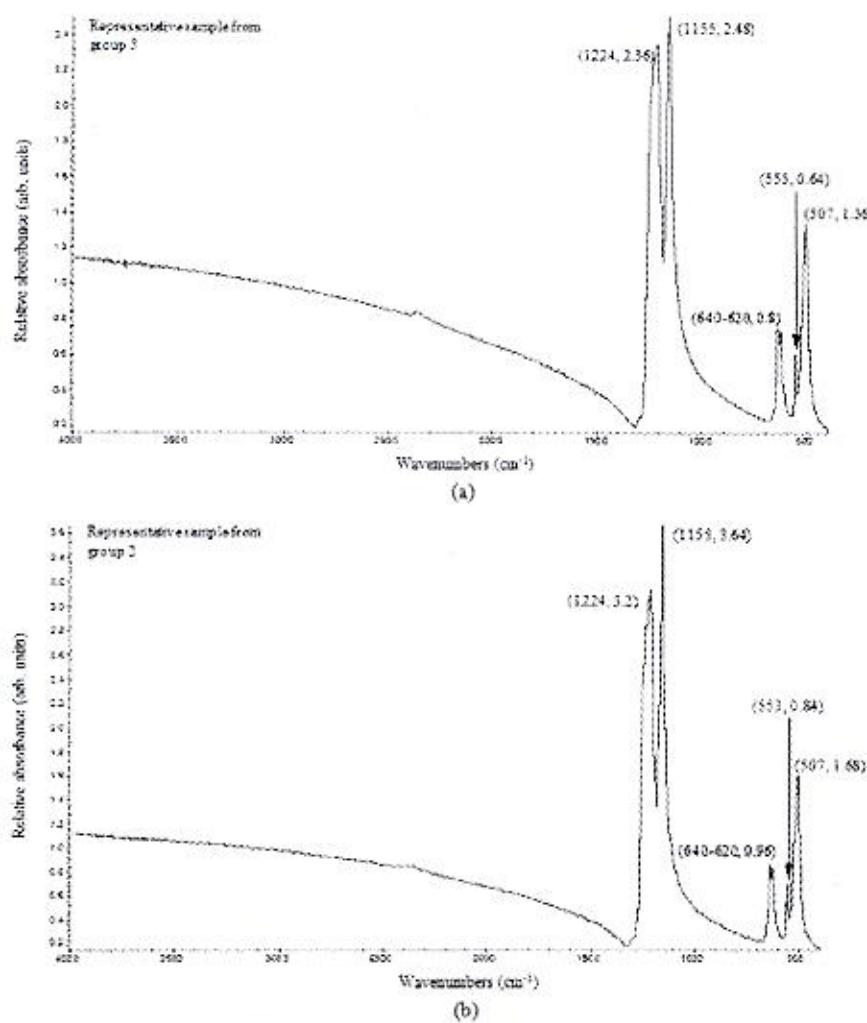


Figure 2: Typical FTIR-spectra of a representative sample from (a) group 5 and (b) group 2.

4. Conclusions and Recommendations

The physical and chemical properties of hydrogen ion treated PTFE materials were evaluated using FTIR tests. Infrared spectroscopy shows no change in peak wavenumbers and sizes; this was an evidence that the surface modification process has no effect on the treated materials' chemical properties. Although empirical data point largely to a morphological modification, one cannot entirely discount chemical reactions on the surface

induced by the irradiation process. Using x-ray photoelectron spectroscopy, further investigation to clarify this issue is in progress.

Acknowledgement

The financial support from the Department of Science and Technology (DOST) – Philippine Council for Advanced Science and Technology Research and Development (PCASTRD) is gratefully acknowledged. The authors also thank Gil Nonato Santos of De La Salle University for the FTIR facility.

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Effects of low energy hydrogen ion shower (LEHIS) treatment on the optical property and thickness of polytetrafluoroethylene (PTFE) materials

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Abstract

The optical and thickness properties of polytetrafluoroethylene (PTFE) materials treated by low energy hydrogen ion shower (LEHIS) of a Gas Discharge Ion Source (GDIS) are explained using scanning electron microscopy (SEM) and ellipsometry characterizations. Results show that as the discharge current is decreased, the PTFE materials thickens as indicated by the increase in the index of refraction, density, and from its SEM cross sectional view. The thickening of the material reduces the transmittance of light to the sample to as low as 60%. © 2008 Samahang Pisika ng Pilipinas

Keywords: 07.60.Fs, 68.35.bm, 61.80.-x

1. Introduction

Polytetrafluoroethylene (PTFE) is a pliable material and is resistant to high heat; it has been used as a reflective layer for back-light illumination mounted behind miniaturized flat panel displays. One problem using PTFE as a reflector is that it permits a small amount of light leakage via optical transmittance [1]. It is one of the objects of this contribution to establish the viability of LEHIS treatment to address such light leakage problem. Reduced optical leakage should improve the brightness of flat compact video screens employing PTFE reflective layers. PTFE material will be treated using low energy hydrogen ion shower (LEHIS) of a gas discharge ion source (GDIS) facility. In general, the current study wishes to ascertain the association between the change in the index of refraction and light leakage. This paper would also look into the relationship of the change in the thickness and the change in density of the material. The effectiveness of the LEHIS process in changing the optical and thickness properties of PTFE materials is assessed through ellipsometry, optical transmittance, and SEM tests.

2. Methodology

PTFE materials are treated using low energy hydrogen ion shower (LEHIS) of a gas discharge ion source (GDIS) system. Complete details of the facility and procedure are described in [2-6]. There are seven test groups, each with three replicates. One group consisting of untreated samples and the remaining six groups made up of treated specimens. The treatment conditions are summarized in Table 1. The irradiation time and discharge conditions (V_d =discharge voltage, I_d = discharge current) are varied for each group. A Leica S440 Scanning Electron Microscope (SEM) and a VASE M-44 ellipsometer (J. A. Woolam Co.) are used to characterize the untreated and treated samples.

Table 1. Summary of irradiation time and discharge conditions of the PTFE samples.

Treated Group	Irradiation Time (minutes)	V_d (kV)	I_d (mA)
1	30	1.30	2.0
2	30	1.08	1.0
3	15	1.30	2.0
4	15	1.08	1.0
5	30	1.37	3.0
6	15	1.37	3.0

3. Results and Discussion

The optical transmittance experiment on the PTFE samples was already done in [3]. It showed that samples irradiated by low energy ion showers ($I_d \leq 1$ mA) have the least transmittance. These samples from groups 2 and 4 (low-energy groups) give a lower bound of 60% mean transmittance which is an improvement of about 25% less light leakage compared to the control group. The opposite effect is seen for samples irradiated by higher energy beams. Group 5 gives the highest mean transmittance of 99 %. Groups 2 and 5 are considered in this paper since they are the least transmissive and the most transmissive, respectively.

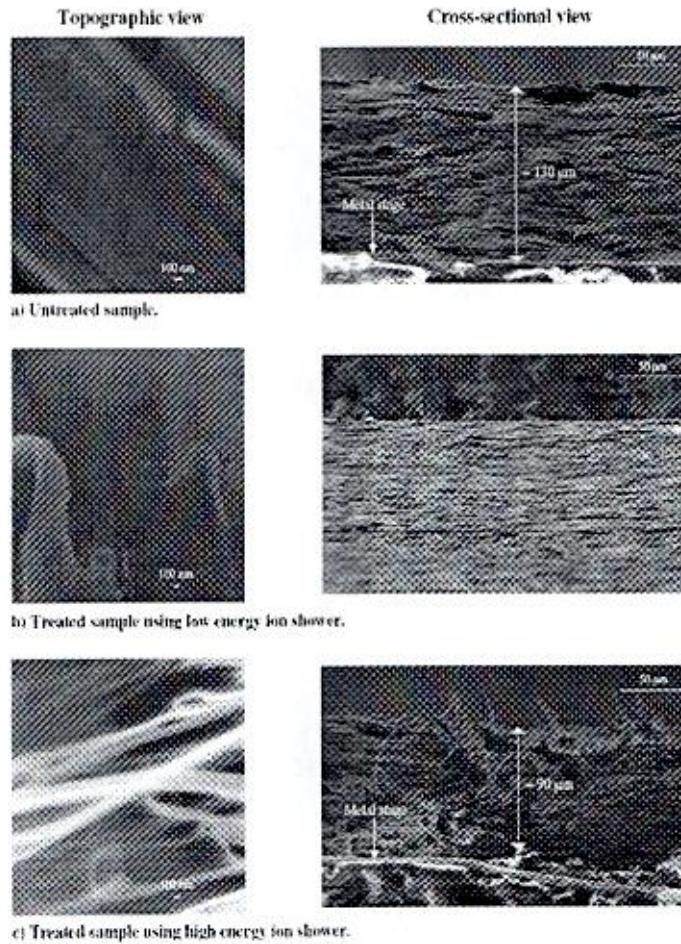


Figure 1: (a) SEM image of a representative sample from the control group, (b) typical SEM image from the group processed at low discharge currents, $I_d \leq 1.0$ mA, beam energy ≤ 1.0 keV, and (c) typical SEM image from the group processed at higher discharge currents, $I_d \geq 1.5$ mA, beam energy ≥ 1.2 keV.

Figure 1 shows representative SEM images of the untreated and treated samples belonging to the different groups. The topographic view is viewed at 50kX magnification while that of the cross-section at 1.5kX. Samples from the low energy groups ($I_d \leq 1$ mA) established earlier to be less transmissive to laser irradiation show surfaces that are much smoother, more compact, and homogenous as seen in Figure 1(b), which may explain why they exhibit reduced light leakage. Samples belonging to the high energy groups ($I_d \geq 1.5$ mA) appear degraded; their surfaces show signs of damage somewhat akin to surfaces that have been striated. It is also observed in Figure 1(c) that their cross-sections have significantly thinned out by several tens of microns compared to the thickness of the control. Many researches show that exposure to plasmas and ion irradiation significantly affects the optical characteristics of polymers [6-10]. The changes in the optical properties of these materials are caused by any of the following: increased polymeric cross-linking [11], carbonization [12], surface erosion forming spires and needles whose vertical dimensions may range from tenths to hundreds of microns [13] and alterations in refractive index due to structural modifications [14]. Optical transmission is a very complex function and is strongly dependent on the absorption coefficient and refractive index of the substrate material; as well as the envelope of the interference maxima and minima of the transmission spectra [15]. It is

plausible that higher energy ion bombardment leads to surface structural modification in the form of increased striations and scissions allowing the interference envelope function to attain maximum transmission at 594 nm wavelength [6]. The thinning effect and the observed striations on the surface account for their higher optical transmittances. Beer-Lambert law supports this argument since the thinner the sample, the higher the transmittance or the thicker the sample, the higher absorption. The optical transmittance in % as described by the Beer-Lambert law is

$$T = P/P_0 = e^{-\varepsilon bc} \quad (1)$$

where P and P_0 are the power of the incident light and that after the material, respectively, ε is the concentration of absorbing species in the material, b is the path length of the sample which is also the thickness, and c is the absorption cross section. Again with Beer-Lambert Law, as density is increased, transmittance should decrease.

Figure 2 shows the plot of the index of refraction as a function of wavelength (nm). The index of refraction of samples treated with low discharge current is higher than those of the index of refraction of samples treated with high discharge current for the whole spectrum of light. High index of refraction indicates that the density of the material is also high [16]. This would imply that the samples treated with low discharge current has a low density as compared with samples treated with high discharge current.

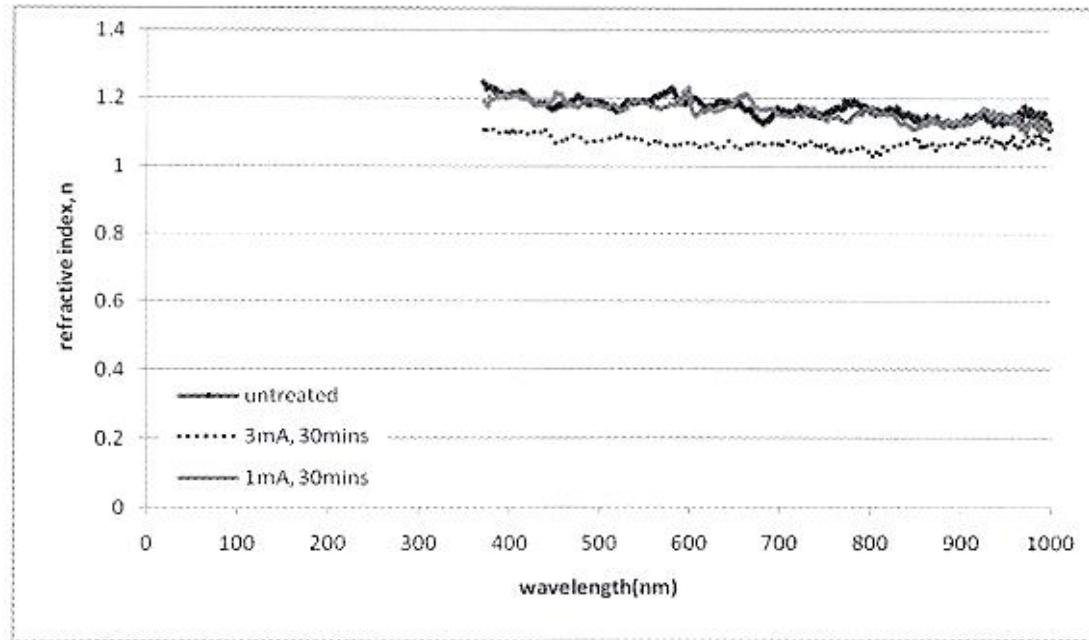


Figure 2: Plots of wavelength (nm) versus refractive index n for some representative samples.

In order to relate the optical transmittance with density, the wavelength equal to 594 nm in Figure 2 must be the only wavelength to consider since it is the same wavelength of light used in the optical transmittance experiment. The index of refraction for this wavelength of the untreated, 3mA treated, and 1 mA treated samples are 1.19, 1.07, and 1.22, respectively. When the discharge current is decreased, the PTFE material thickens as indicated by the increase in the index of refraction and from its SEM cross sectional view. The thickening of the material reduces the transmittance of light to the sample to as low as 60%. This is due to the increase in the density of the material as exhibited by the increase in the index of refraction. This is also supported by the Beer-Lambert Law. The density and the index of refraction of the material changed due to the air gaps created by the striations as seen from the SEM images.

4. Conclusions and Recommendations

The optical properties of hydrogen ion treated PTFE materials are evaluated using laser irradiation, SEM, and ellipsometry tests. Depending on the kind of LEHIS treatment, two kinds of PTFE surfaces could be produced. Low discharge LEHIS produced smooth, thicker, highly dense, and less optically transmissive surfaces while high discharge LEHIS produced striated, thinner, less dense, and light transmissive surfaces. A PTFE material with high index of refraction would most likely be less transmissive to light. If PTFE were to be used as a barrier to minimize the leakage of light, the material should be processed using LEHIS with discharge

parameters not exceeding 1 kV. This finding agreed with the results of [13] where spectral transmittance of polyimide decreased for all wavelengths after treatment by argon ion beam in this energy range.

Acknowledgement

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Wetting dynamics model of hydrogen ion treated polytetrafluoroethylene (PTFE) materials

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Abstract

The wetting dynamics model of hydrogen ion treated polytetrafluoroethylene (PTFE) materials was determined. PTFE materials are processed using low energy hydrogen ion shower (LEHIS) produced by a Gas Discharge Ion Source (GDIS). A contact angle test is used to characterize the effect of treatment. There is a high correlation between the contact angle measurements and the wetting dynamics model used as determined by R^2 -squared value of 90% and above. Results also show that treatment using lower I_d improved material hydrophobicity while higher I_d resulted in enhanced hydrophilicity. © 2008 Samahang Pisika ng Pilipinas

Keywords: 81.30.Hd, 68.35.bm, 61.80.-x, 68.08.Bc

1. Introduction

Polytetrafluoroethylene (PTFE) or more commonly known as Teflon is becoming the shaping material in many technological applications. Because of its flexible characteristics, it has a wide range of use from electrical and electronics, food packaging and processing, biomedical, chemical and mechanical to agricultural and aeronautical applications. In spite of its many applications, PTFE still has problems in certain usages. By simply modifying the surface of PTFE, some of these problems can be solved since surface modification allows for the change and improvement of the property of a material, consequently, making the processed material more useful in various aspects [1], [2], [3]. Many researches have been done on the surface modification of PTFE. The modification of the PTFE surface is determined by the change in its wettability (i.e. whether the surface is changed from being hydrophilic to hydrophobic, or vice versa). Previous research on the surface treatment of PTFE using low energy hydrogen ion shower (LEHIS) irradiation showed the viability of LEHIS to surface modify PTFE utilizing relatively short treatment times yet producing significantly high throughput [4].

In general, the current study wishes to ascertain the behavior of the change of contact angles in time which is not discussed in the previous study on PTFE [4]. Determining the wetting dynamics model of the system would allow us to explore other possible uses of PTFE. The effectiveness of the wetting model will be determined through the R^2 value from the plot of the experimental contact angles and the plot of the wetting dynamics equation.

2. Methodology

PTFE samples are treated using LEHIS of a GDIS system. Complete details of the facility and procedure are described in [1] and [4-6]. There are thirteen test groups, each with three replicates. One group consisting of untreated samples and the remaining twelve groups made up of treated specimens. The treatment conditions are summarized in Table 1. The irradiation time and discharge conditions (V_d =discharge voltage, I_d = discharge current) are varied for each group.

The contact angle measurement is described in [4] and [7]. For each sample, the time evolution of the contact angle is recorded at three different sites. Hence, the contact angle for a single time frame is actually a mean value, averaged over three different points on the sample.

3. Results and Discussion

Temporal recessions of the contact angles for some representative samples are shown in Figure 1. Wettability is quantified by fitting the wetting dynamics model used in [8] to actual data. The model is expressed mathematically as

$$\frac{d\theta}{dt} = -k\theta \quad (1)$$

where θ is the contact angle between the supporting solid surface and the tangent to the drop-shape of the liquid, and k being the change rate constant or the quantity that describes the angle's temporal recession in units of per second. The increase in the value of k signifies increasing surface wettability. k is sensitive to data fluctuations

and its values are normally small in the order of 10^{-3} to 10^{-1} and a difference of 10^{-3} between the k values of different samples is exceedingly significant given that numerical variations even as small as this may establish whether a surface is wettable or otherwise. The wetting dynamics model implies that the time rate of change of the contact angle has a direct link to its instantaneous value. When a liquid is dropped on a surface, it forms a contact angle at the solid surface and penetration happens while the liquid is spreading. The contact angle of any material is never static; it will recede over time in accordance with Eq. (1).

Table 1. Summary of irradiation time and discharge conditions of the PTFE samples.

Treated Group	Irradiation time (min)	Discharge voltage, V_d (kV)	Plasma discharge current, I_d (mA)
1	30	1.3	2
2	30	1	1
3	15	1.3	2
4	15	1	1
5	30	1.4	3
6	15	1.4	3
7	30	0.7	0.5
8	15	0.7	0.5
9	30	1.2	1.5
10	15	1.2	1.5
11	30	1.35	2.5
12	15	1.35	2.5

In using Eq. (1) data sets above the 95th percentile are discarded because as the contact angle approaches zero, measurement error increases. Figure 2 shows the typical numerical constructs of Eq. (1) fitted against empirical data of representative samples belonging to group 4 and group 5. The relationship between the experiment and the theory is described using the R-squared method [9] and it shows a lower bound of 90% and an upper bound of 99%. The control group, groups 2, 4, 7, and 8, show lower mean k values which means that longer moisture absorption time are more hydrophobic. Samples from these groups are irradiated at $I_d \leq 1$ mA. In contrast, groups 1, 3, 5, 6, 9, 10, 11, and 12 which are exposed to $I_d \geq 1.5$ mA have higher mean k values which means that they are more hydrophilic.

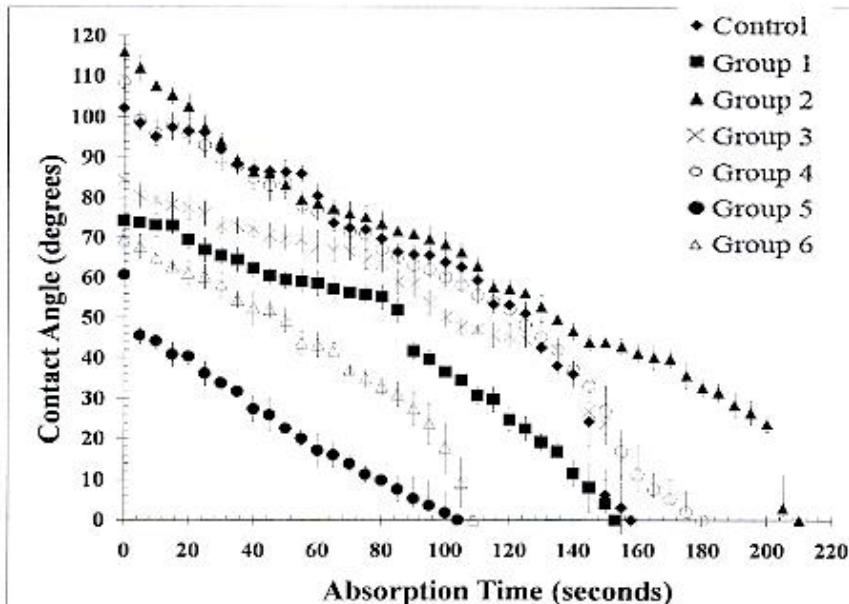


Figure 1: Temporal recession of the contact angles for some representative samples.

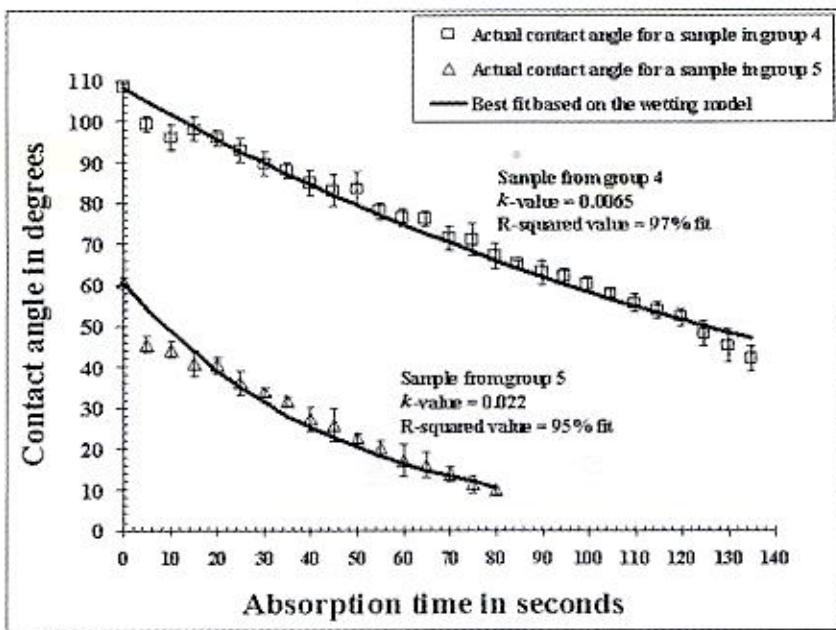


Figure 2. Typical numerical constructs of Eq. (1) (wetting model) fitted against empirical data.

In determining the relationship between wettability (k) on I_d and exposure time (t), two-factor analysis of variance (ANOVA) [11] is used. In this test, I_d and t represent the two factors providing the sources of variation for the response variable k . The probability values (P-value) of I_d , t , and their interaction on k are all found to be below 0.05. It is determined that both discharge and time parameters affect the wettability of the treated materials. This also means that as k is increased, discharge currents and processing times are also increased. However, a low plasma discharge ($I_d \leq 1$ mA) results in a marginal improvement of hydrophobicity as k falls from an average of 0.007 (for the control group) to about 0.006 for groups 2, 4, 7, and 8. The data from these groups are subjected to a one-way ANOVA using the time parameter as the source of variation. Results indicate that for low discharge, the processing times of 15 and 30 minutes appear to have no significant effects on their hydrophobicity (P-value > 0.05).

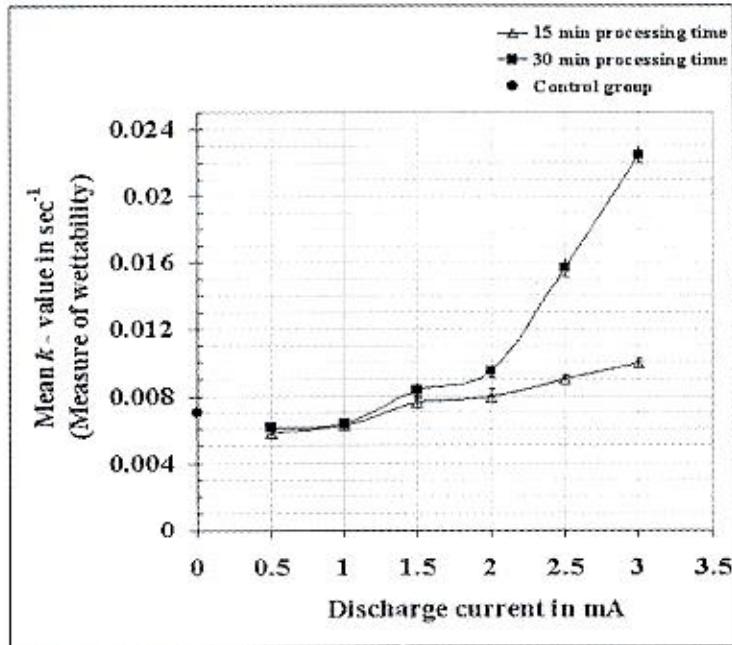


Figure 3: A plot of the average k -value against discharge current at 15 and 30 min processing times.

Using Figure 3, we can say that the statistical interpretation is correct because of the overlapping of data points in the low discharge region. In contrast, higher discharges resulted in enhanced affinity to water. The

hydrophilicity of groups 1, 3, 5, 6, 9, 10, 11, and 12 (high-energy groups) is further improved using longer processing time, the average k value peaks to 0.023 for group 5- the most hydrophilic processed using the highest beam energy at the longest treatment time. Numerous literatures have reported that the wettability of polymers can be enhanced by bombarding them with high energy ions. Energetic ions incident on polymer samples cause surface heating effects which in turn, increase surface roughness. The increase in surface roughness is believed to be one of the reasons for increased hydrophilicity [12-14]. On the other hand, the cause of hydrophobication by ion irradiation is not fully understood as yet. The application of low discharge LEHIS on wood substrates led to similar surface inactivation effects [15]. The present work seems to suggest that an essential condition for hydrophobication is that the energy range of the irradiating ion-beam should be equal to or less than 1 keV. This is the threshold energy or the upper limit beyond which the processed surface will cross over to the hydrophilic regime. Nevertheless, further studies are on-going using x-ray photoelectron spectroscopy to clearly describe the mechanism of hydrophobication in polymeric materials.

4. Conclusions

The wetting dynamics model of hydrogen ion treated polytetrafluoroethylene (PTFE) materials was determined. The contact angle measurement highly correlates with the wetting dynamics model since the R^2 squared value was above 90%. Results also show that the k -value or the measure of wettability increases as the discharge current is increased. Two kinds of PTFE surfaces can be produced depending on the kind of LEHIS treatment used. Low discharge LEHIS produces hydrophobic surfaces while high discharge LEHIS produces hydrophilic surfaces.

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The financial support from the Department of Science and Technology (DOST) - Philippine Council for Advanced Science and Technology Research and Development (PCASTRD) is gratefully acknowledged.

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Development of a simple 2.45 GHz microwave plasma with a repulsive double hexapole configuration

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A simple and inexpensive 2.45 GHz microwave plasma source with a repulsive double hexapole configuration is described and characterized. In this work, the operation of the source is shown to be flexible in terms of electron density, electron temperature, and plasma uniformity even at low-pressure (approximately millitorr). It allows for easy control of the electron temperature (2–3.8 eV) and density ($\sim 10^9$ – 10^{10} cm $^{-3}$) by removing either of the two hexapoles or by varying the separation distance between the two hexapoles. Characterization was done via information gathered from the usual Langmuir probe measurements for electron temperature and density. The source makes a resonant surface with its repulsive double hexapole magnetic configuration providing an additional longitudinal confinement near the walls midway between the two hexapoles. Magnetic field maps are presented for varying double hexapole distances. Power delivery for various settings is also presented. © 2008 American Institute of Physics. [DOI: 10.1063/1.2987694]

I. INTRODUCTION

Microwave-generated plasma devices are preferred over other types of plasma sources because these sources do not need electrodes nor filaments. The task of replacing or cleaning these fragile parts is avoided. More importantly, the plasma is free from impurities that can come from the sputtering or evaporation of these parts during operation. Microwave plasma is finding many applications in various fields. One of its major applications is in electron cyclotron resonance (ECR) ion sources, which are used for the production of multiply-charged ions needed in atomic, nuclear, fusion, and high-energy physics researches.^{1,2} It has been widely used for material science applications such as ion implantation into semiconductor devices, deposition of diamond thin films, and growth of hard coatings.^{3–5} Studies have shown its environmental applications such as for decontamination of chemical and biological warfare agents and abatement of perfluorinated compounds.^{6,7}

It is well known^{1,2,8,9} that there are different modes of energy transfer from the microwave to the gas load, such as oscillatory, resonant, and surface-wave modes. In the oscillatory mode, the microwave causes the oscillation of free electrons, which in turn collide with neutral particles to induce a plasma discharge. This mode operates even in the absence of a magnetic field but it requires pressures between some minimum (few millitorrs) and maximum values (several millitorrs) depending on the chamber dimensions. Production of a discharge at very low pressures becomes difficult due to very low frequency of collisions. Too high

pressures also hinder plasma ignition because the electrons collide very often, which prohibits buildup of their energy. The resonant mode can operate even at low pressures but requires an appropriate applied magnetic field. The electrons gyrate about the magnetic field lines with the cyclotron frequency. If the frequency of the microwave is equal to the electron's cyclotron frequency, the transfer of energy from the microwave to the electron is large, a phenomenon called ECR. For a microwave frequency of 2.45 GHz, the magnetic field required for resonance is 875 G. The electron density produced by the oscillatory and resonant modes is limited by a maximum value called the critical density, which is $\sim 7 \times 10^{10}$ cm $^{-3}$ for an unmagnetized 2.45 GHz microwave plasma. This upper limit is due to the fact that an electromagnetic wave cannot penetrate the core of the plasma but only a fraction of the surface called the skin depth or penetration depth, because the plasma is a conducting body. However, microwave sources can still reach densities greater than the critical density in the surface-wave mode. Since the skin depth is large enough for the microwave to extend one to a few centimeters into the discharge, forming an evanescent surface wave, the plasma can be excited to produce an "overdense" plasma. This mode of operation is enhanced when the plasma is bound by another conductor to form a waveguide between the surface of the plasma and the conductor.

Several designs of microwave plasma devices for industrial applications exist and are described in literature.^{1–3,8} They can be categorized into three, namely, permanent magnet, hybrid, and superconducting sources. Permanent magnet sources utilize permanent magnets to produce the magnetic field for ECR operation. Hybrid sources use a combination

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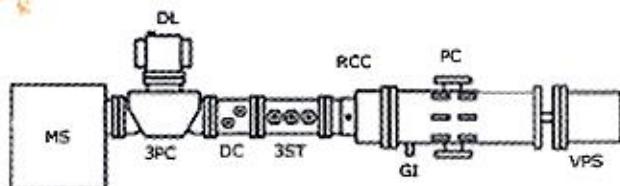


FIG. 1. Schematic of the microwave plasma device composed of the microwave source, waveguide system, and the plasma chamber. MS=microwave source; 3PC=three-port circulator; DL=dummy load; DC=directional coupler; 3ST=three-stub tuner; RCC=rectangular-to-cylindrical converter; GI=gas inlet; PC=plasma chamber (with magnets); and VPS=vacuum pump system.

of permanent magnets (usually hexapole) and solenoid coils, which provide radial and axial magnetic confinements, respectively. Superconducting sources make use of superconducting coils and hexapoles. Permanent magnet sources are relatively simpler to construct and cheaper to operate compared to the others. The most common design of permanent magnet source has six permanent magnets only (hexapole), but others use more magnets, even reaching up to 24 poles, to create a wide-area and uniform plasma.¹⁰ The lack of coils for axial confinement in permanent magnet sources results to losses in the plasma; however, there are designs that create axial confinement using permanent magnets only.

In this paper, the operation of a simple and inexpensive 2.45 GHz microwave plasma source with repulsive double hexapole is described and characterized. The main objective is to develop an all-permanent magnet microwave plasma source with good characteristics in terms of flexibility of application, uniformity of plasma, and ease of operation. The incorporation of a repulsive double hexapole magnetic configuration using 12 permanent bar magnets can produce an additional longitudinal confinement near the walls between the pair of hexapoles, aside from the resonant surface that it makes. The design also allows for versatility of application and control of plasma parameters by removing either of the two hexapoles or varying the separation distance between the two hexapoles. It will be shown that the device is able to produce a wide-area uniform plasma, which is vital for its intended future applications, such as uniform thin film deposition and uniform plasma processing of surfaces and materials. The device is described in detail in Sec. II. The methodology and characterization procedures are discussed in Sec. III. Section IV includes the results of the characterization, magnetic field maps, and power delivery of the source. Section V concludes this paper.

II. MICROWAVE PLASMA SOURCE

The microwave plasma source is composed of the microwave source, waveguide system, and plasma chamber. The cw microwave source is a magnetron taken from a commercial microwave oven rated at 2.45 GHz, 1.5 kW, powered by a high voltage power supply that is half-wave rectified and housed in a stainless steel box with two fans for cooling.

The waveguide system is composed of several components (three-port circulator, bidirectional coupler, three-stub tuner, *E*-plane 90° bend, rectangular-to-cylindrical mode converter, and dummy load) connected as shown in Fig. 1.

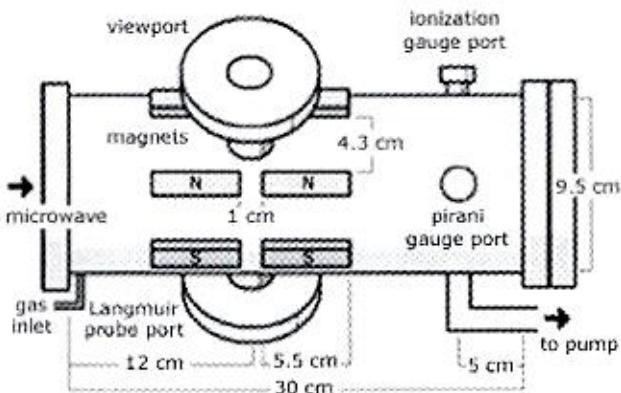


FIG. 2. Schematic of the plasma chamber and its dimensions.

The three-port circulator directs the microwave from the magnetron to the actual load in the plasma chamber, and then directs any reflected microwave to the dummy load. The variable three-stub tuner is used for impedance matching between the source and the actual load to optimize the power delivery. The rectangular-to-cylindrical mode converter transforms the microwave between its rectangular and cylindrical modes and a built-in converter stick can adjust coupling.

The microwave from the mode converter enters the plasma chamber via a borosilicate glass port. The plasma chamber, shown in Fig. 2, is a cylindrical stainless steel pipe with a volume of 2126 cm³. A view port is positioned about 12 cm away from the entry point of the microwave. Repulsive double hexapole magnetic configuration is formed using 12 Sm-Co permanent magnets ($1 \times 1 \times 5.5$ cm³ each, ~1500 G on the surface). In each hexapole, the six magnets are positioned with alternating poles around the chamber. The two hexapoles are positioned in a way that two adjacent magnets along the axial direction have the same pole; thus, the name repulsive double hexapole. This configuration not only provides a magnetic field for resonant mode operation but creates a longitudinal trap near the walls midway between the two sets of hexapoles.

The dummy load houses two connected glass tubes where water continuously flows to absorb the microwave power reflected by the actual load to the dummy load. The water is supplied by a recirculating chiller that controls the temperature and flow rate at 4.3×10^{-5} m³/s.

III. EXPERIMENTAL PROCEDURE

Chamber was evacuated down to a base pressure of $\sim 10^{-5}$ Torr using an oil diffusion pump backed up by a rotary pump. Argon gas was fed into the chamber using a mass-flow controller, setting its filling pressure to 10 mTorr. Pressure was monitored using Pirani and ionization gauges.

The plasma parameters under four different magnetic field configurations were determined, namely, (i) no magnet, (ii) with only the hexapole “near” the microwave entry, (iii) with only the hexapole “far” from the microwave entry, and (iv) with the “double” hexapole.

Several settings for the stub tuners were tried to determine an optimum setting that gives good plasma parameters.

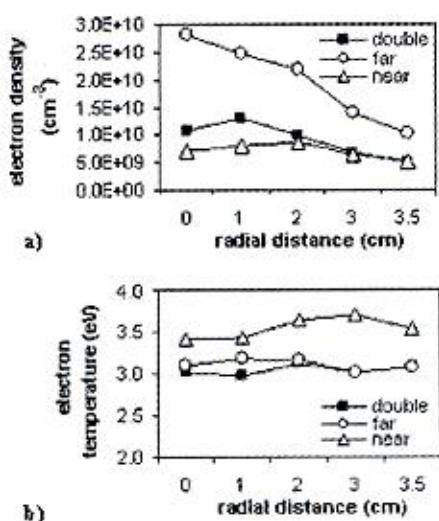


FIG. 3. Radial profile of the electron density and electron temperature in a 10 mTorr argon plasma with double, far, and near hexapole configurations. Stub setting is (111) and power absorbed is 85 W.

For example, the $(\frac{1}{4} \frac{1}{4} \frac{1}{4})$ stub setting means that the middle stub is completely pulled out while the two stubs at opposite sides are pulled out by $\frac{1}{4}$ of its length. In other words, the middle stub is not inserted into the waveguide and $\frac{3}{4}$ of the length of the two other stubs is inserted.

The separation distance between the two repelling double hexapoles was also varied from 0 to 3 cm to determine its effect on the plasma parameters. Two shielded cylindrical single Langmuir probes were used to determine the electron density and electron temperature along the radial and axial directions. A single Langmuir probe of exposed tip 2 mm and diameter 0.6 mm was inserted in a port between the two sets of hexapoles for radial measurements perpendicular to the axis of the chamber. Another single Langmuir probe of exposed tip 3 mm and diameter 0.5 mm was inserted along the axis of the chamber for axial measurements. Axial probe measurements were taken at different positions along the axis of the chamber (i.e., z -axis). But radial probe measurements were obtained at different positions along a cross-sectional plane exactly between the two sets of hexapoles (i.e., along the $z=0$ plane). Measurements of the forward and reverse microwave power were taken at the bidirectional coupler using a Gerling GA3007 power monitor. The magnetic field of the system was calculated numerically using finite difference method. The contour plots, field maps, and field magnitudes under different magnetic configurations were simulated.

IV. RESULTS AND DISCUSSION

In the presence of the double hexapole magnets, argon discharge was created even for low pressures, which is a characteristic of resonant (ECR) mode of microwave discharge. However, without any magnet, argon discharge is not possible for pressures less than 80 mTorr. This is expected for oscillatory mode microwave discharge that ignites only between a minimum and maximum gas-filling pressures.

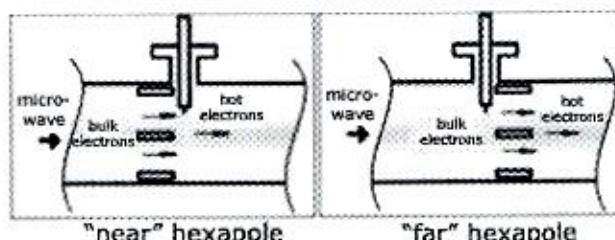


FIG. 4. Schematic of the filtering effect of the hexapole magnets on the electrons. Comparison of the near and far hexapole configurations.

Another observation in the experiment is that with no magnet and with a radial Langmuir probe inserted in the chamber, there is no argon discharge even with a high gas-filling pressure of 200 mTorr. This means that the minimum pressure for an oscillatory mode microwave discharge increases in the presence of the radial Langmuir probe. This is consistent with the idea that the minimum pressure increases as the dimension of the cavity decreases. In this study, the insertion of the radial Langmuir probe at a distance of about 12 cm from the entry port of the microwave (see Fig. 2) decreases the effective dimension of the cavity, thereby increasing the minimum pressure for a microwave discharge. Moreover, the presence of the conducting probe alters the microwave fields making it more difficult to get high enough empty cavity microwave field strengths to ignite the plasma.

Figure 3 shows the variation in the electron density and electron temperature with the radial distance from the center of the cylindrical chamber as determined by the radial Langmuir probe for different magnetic configurations. It shows that with the double hexapole, the electrons have a nearly uniform energy of ~ 3 eV along the $z=0$ plane. The radial density profile can be further explained by the loss of electrons on the wall.

With the far hexapole only, the electron density is high and the electron temperature is low, signifying that the cold bulk electrons are at the probe position. But with the near hexapole only, the hot tail electrons are at the probe position, as indicated by the low electron density and high electron temperature. This is brought about by the filtering effect of

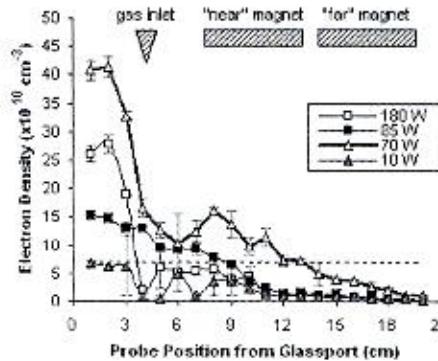


FIG. 5. Axial profile of the electron density in a 10 mTorr argon plasma with double hexapole configuration under different power deliveries to the chamber. The dashed line indicates the critical density of $\sim 7 \times 10^{10}$ cm⁻³. The relative positions of the gas inlet and two sets of hexapoles are also indicated above. Stub settings are $(\frac{1}{4} \frac{1}{4} \frac{1}{4})$, (111), $(\frac{1}{2} \frac{1}{2} \frac{1}{2})$, and $(\frac{1}{2} \frac{1}{2} \frac{1}{4})$ with corresponding power deliveries of 180, 85, 70, and 10 W, respectively.

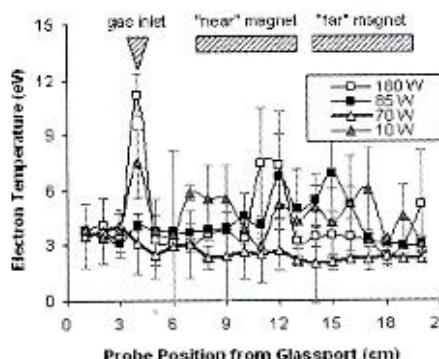


FIG. 6. Axial profile of the electron temperature in a 10 mTorr argon plasma with double hexapole configuration under different power deliveries to the chamber. The relative positions of the gas inlet and two sets of hexapoles are also indicated above. Stub settings are $(\frac{1}{2} \frac{1}{2})$, $(1 \frac{1}{1})$, $(\frac{1}{2} \frac{1}{2})$, and $(\frac{1}{2} \frac{1}{2})$ with corresponding power deliveries of 180, 85, 70, and 10 W, respectively.

the hexapole, wherein electrons from one side of a hexapole find it difficult to pass to the other side, as illustrated in Fig. 4.

These results demonstrate the flexibility of the device with a magnetic configuration that can be easily varied to obtain low- to high-energy and low- to high-density electrons to suit various application requirements. A configuration with the near hexapole magnets only can also be used to produce a highly uniform plasma with a relatively large diameter of at least 7 cm.

The axial profile of the electron density and temperature measured by the axial Langmuir probe under various power settings are shown in Figs. 5 and 6. The locations of the two sets of hexapoles, separated by 1 cm from each other, and the gas inlet are indicated at the top. It can be seen that there is a very high electron density near the glass port. This decreases with the axial distance from the glass port. It is expected that most of the plasma electrons are generated in the region where the microwave first meets the neutral gas, and this is within the 4 cm region from the glass port up to the gas inlet (see Figs. 2 and 5). It is evident from the axial profile of the density that there is an overdense plasma (exceeding the critical density of $\sim 7 \times 10^{10} \text{ cm}^{-3}$ marked as dashed horizontal line in Fig. 5) that exists in the region near the glass port. This is consistent with the fact that a 2.45 GHz microwave has a maximum penetration depth of about 5 cm for these values of density.¹ Furthermore, it can also be seen that the region between the two sets of repelling hexapoles, which includes the $z=0$ plane where the radial profiles of density and temperature were measured, has a density less than the critical density. This indicates that a major part of the $z=0$ plane of the chamber is relatively shielded from the microwave. The electron temperature is relatively uniform along the axis of the plasma chamber as seen in Fig. 6. It should also be mentioned here that the power delivered to the chamber does not vary with the change in position of the axial Langmuir probe; thus, keeping a constant power for a particular stub tuner setting.

The average electron density and average electron temperature of the argon plasma at the $z=0$ plane under different stub tuner settings are shown in Fig. 7 (filled and unfilled

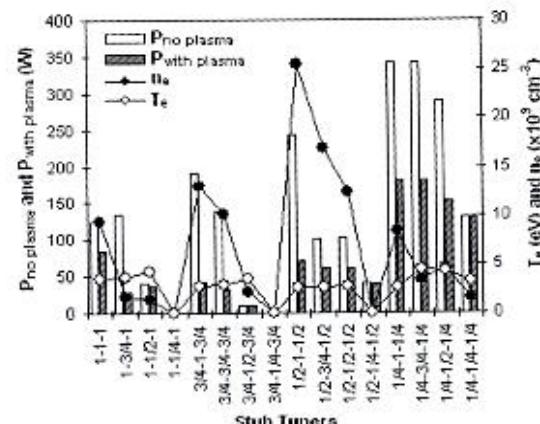


FIG. 7. Average of the radial electron density n_e (filled circles) and average radial electron temperature T_e (unfilled circles) of a 10 mTorr argon plasma at the $z=0$ plane of the plasma chamber under different stub tuner settings. Also shown are the net microwave power delivered to the plasma chamber with a 10 mTorr argon plasma $P_{\text{with plasma}}$ (filled columns) and power delivered without any gas or plasma load $P_{\text{no plasma}}$ (unfilled columns). Separation distance of the double hexapole is 1 cm. No plasma is generated in the settings $(\frac{1}{2} \frac{1}{2})$, $(\frac{3}{4} \frac{3}{4})$, and $(\frac{1}{2} \frac{1}{2})$. Power measurements have a maximum uncertainty of 11.5%.

circles, respectively) with the repulsive double hexapole separated by 1 cm. The $(\frac{1}{2} \frac{1}{2})$ setting gives the highest value of average electron density ($\sim 2.5 \times 10^{10} \text{ cm}^{-3}$) while the $(\frac{1}{2} \frac{1}{2})$ setting results to the highest average electron temperature ($\sim 4.3 \text{ eV}$).

The net power delivered to the chamber with a 10 mTorr argon plasma for different stub tuner settings is also shown in Fig. 7 (filled columns), wherein the maximum uncertainty in the power measurements due to effect of standing wave in the directional coupler is 11.5%. The magnetron supplied an average power of 628.98 W with a variance of 8.51% to the plasma chamber with a maximum power delivery of 180 W. It is expected that the electron density generally increases with the average power absorbed by the plasma. This idea is consistent with the results in Fig. 7 (compare filled circles and filled columns) in most of the stub tuner settings, except for the cases of $(\frac{1}{4} \times \frac{1}{4})$. This apparent inconsistency may be explained by noting that the large power at $(\frac{1}{4} \times \frac{1}{4})$ settings was not actually absorbed by the argon plasma, as supported by Fig. 7 (unfilled columns), which shows the net power absorbed by the plasma chamber without any neutral gas or plasma load. The $(\frac{1}{4} \times \frac{1}{4})$ settings deliver large power because of possible matching with other dielectrics present in the system such as the glass port and air in the waveguide.

The electron temperature is relatively constant within the limits of uncertainty, which is mostly due to a constant electron-neutral collision frequency at a constant pressure of 10 mTorr. In general, however, it can be seen that the settings giving higher mean electron densities correspondingly give slightly lower mean electron temperatures. For instance, the $(\frac{1}{2} \frac{1}{2})$, $(\frac{1}{2} \frac{1}{2})$, $(\frac{3}{4} \frac{3}{4})$, and $(\frac{1}{2} \frac{1}{2})$ settings have the highest electron densities but they result to the lowest electron temperatures. For this system, the absorption of the microwave power occurs near the glass port where the neutral gas is injected (see Fig. 5). The plasma species created near the glass port then diffuse toward the $z=0$ plane of the chamber,

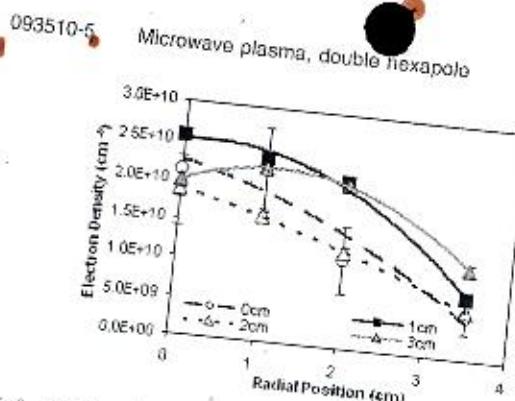


FIG. 8. Radial profile of the electron density of a 10 mTorr argon plasma under different separations of two sets of hexapoles. Stub setting is $(\frac{1}{2} \frac{1}{2})$ and power absorbed is 70 W.

where the radial Langmuir probe is located. The higher the electron density in the glass port region, the higher the number of argon ions produced in the plasma. As the electrons diffuse from the glass port region toward the $z=0$ plane, their energy is effectively lowered by interactions with the positive argon ions in the plasma. This process explains why the central region has slightly lower electron temperature when the electron density is higher. It should be clarified that although the electron-neutral collision frequency is much higher than the electron-ion collision frequency at a pressure of 10 mTorr, the slight increase in electron-ion collision frequency is the cause of the slight decrease in electron temperature.

The results suggest using the $(\frac{1}{2} \frac{1}{2})$ setting for future applications that would require high electron densities. The average electron temperature of about 2.5 eV is practically sufficient for several applications.

The plasma parameters for different separations of two hexapoles under a stub setting of $(\frac{1}{2} \frac{1}{2})$ are summarized in Figs. 8 and 9. The electron density decreases radially primarily because of ambipolar diffusion and the magnetic confinement along the radial direction created by the double hexapole configuration (see Figs. 10 and 11). Furthermore, the radial gradient of the magnetic field decreases as the separation of the two hexapoles increases, as shown in Fig. 11. Hence, the radial confinement is smallest for the 3 cm separation. Electron density depends on the separation distance of the two hexapoles. Results indicate that the electron

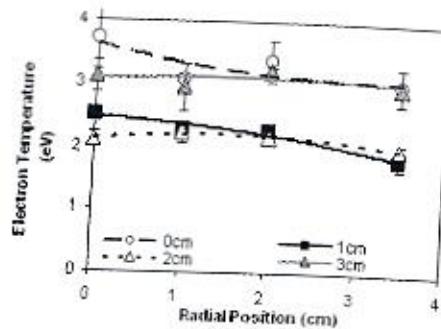


FIG. 9. Radial profile of the electron temperature of a 10 mTorr argon plasma under different separations of two sets of hexapoles. Stub setting is $(\frac{1}{2} \frac{1}{2})$ and power absorbed is 70 W.

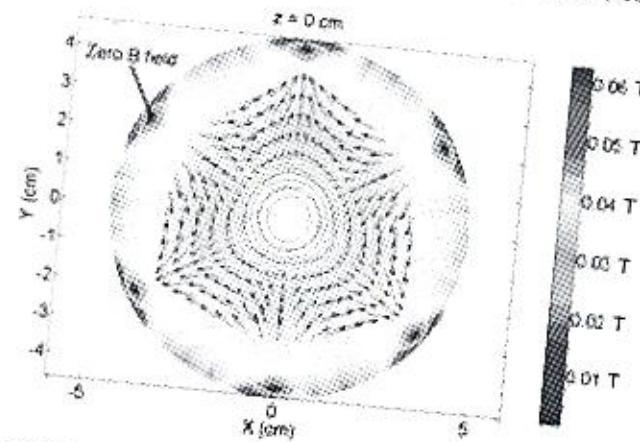


FIG. 10. (Color online) Contour plot and field map of the magnetic field at the center ($z=0$ plane) of the double hexapole. Separation distance of the double hexapole is 1 cm.

density is highest for 1 cm hexapole separation with 2.5×10^{10} cm⁻³ at the center, and is reduced to 7.7×10^9 cm⁻³ near the chamber wall.

Electron density is also high for the 3 cm separation of hexapoles because the longitudinal magnetic confinement near the chamber wall is better than in other separation distances, as verified by the plots of magnetic field magnitudes near the wall (Fig. 12). Electrons near the wall move longitudinally toward the $z=0$ plane (i.e., between the two hexapoles) due to the longitudinal gradient of the magnetic field. These electrons distribute throughout the $z=0$ plane due to the radial gradient of the magnetic field as earlier pointed out.

Figure 9 shows that the electron temperature is practically uniform along the radial direction for the same separation distance between the two hexapoles. But electron temperature varies for different separation distances. For instance, the electron temperature is high (about 3 eV) for 0 and 3 cm hexapole separations and it is low (about 2 eV) for 1 and 2 cm separations.

Electron temperature is high for 3 cm separation since the electrons near the wall region find their way to the $z=0$ cm plane easily due to the great longitudinal gradient of

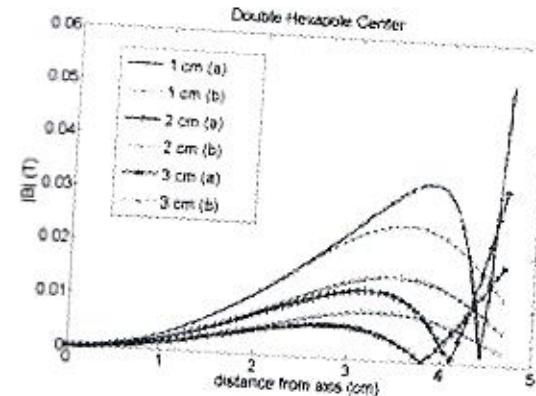


FIG. 11. (Color online) Radial profile of the magnetic field for different separation distances of the two hexapoles (1, 2, and 3 cm) taken at $z=0$ plane. Curves: (a) along the vertical of Fig. 10 and (b) 30° from the vertical of Fig. 10.

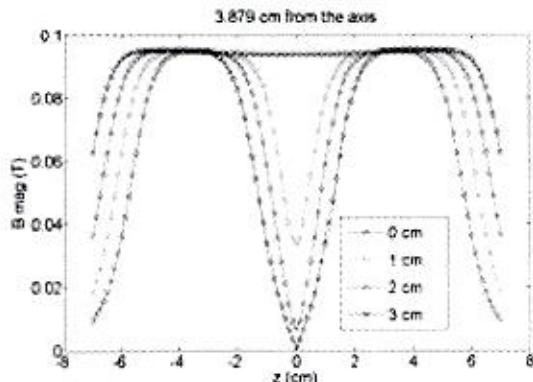


FIG. 12. (Color online) Longitudinal profile of the magnetic field magnitude for different separation distances of the two hexapoles (0, 1, 2, and 3 cm) taken at 0.9 cm near the chamber wall.

the magnetic field. Then, these electrons distribute throughout the $z=0$ plane due to the small radial gradient of the magnetic field. But those electrons coming from near the wall are actually energetic due to the nearby resonant zone (see Fig. 13), thus resulting to a high electron temperature for the 3 cm separation.

The change in the radial position of the radial Langmuir probe alters the microwave power delivered to the chamber by 23% as shown in Fig. 14, although practically it is almost constant within the range of the uncertainties in the power measurements as shown by the error bars. But the important thing to note here is that these power readings do not vary with the change in the separation of the two sets of hexapoles. The power delivered is independent of the magnetic configuration; thus, having a constant power setting for the data shown in Figs. 8 and 9.

All these results suggest using 1 cm separation for the two repelling hexapoles for applications requiring high elec-

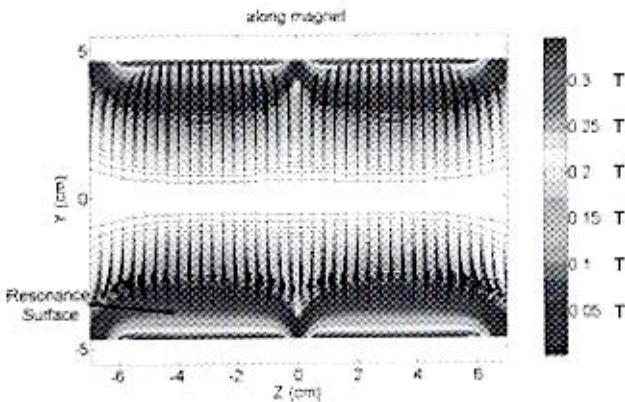


FIG. 13. (Color online) Contour plot and field map of the magnetic field along the length of the chamber. Separation distance of the double hexapole is 1 cm. The resonant surface of 875 G is approximately 1 cm from the wall.

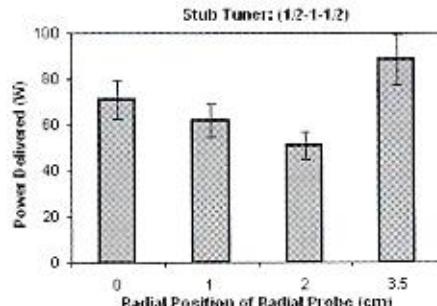


FIG. 14. (Color online) Microwave power delivered to the plasma chamber with a 10 mTorr argon plasma under different radial positions of the radial probe. Stub setting is $(\frac{1}{2}-1-\frac{1}{2})$. Average power is 68 W with 23% variation.

tron density and uniformly low-energy plasma. But a 3 cm separation must be used when uniformly high-energy plasma is needed.

V. CONCLUSION

The results prove that the developed simple 2.45 GHz microwave plasma source with the variable repulsive double hexapole configuration provides the flexibility for low- to high-energy and low- to high-density electrons, as well as a wide-area uniform temperature plasma for various applications.

ACKNOWLEDGMENTS

This work was supported by the Philippine Council for Advanced Science and Technology Research and Development (PCASTRD) of the Department of Science and Technology and by the Office of the Vice-Chancellor for Research and Development (OVCRD) of the University of the Philippines. One of the authors (R.B. Tumlos) also wishes to acknowledge the support of the University of the Philippines Manila through the Centennial Professorial Chair awarded in 2008.

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AC Susceptibility measurements were taken for three doped $\text{La}_2\text{Sr}_x\text{CuO}_{4+\delta}$ (LSCO) samples with $x=0.14, 0.16, 0.18$, fabricated using identical temperature and annealing profiles. Susceptibility data is dominated by its intragranular response, which was confirmed using their corresponding harmonic susceptibilities. SEM reveals that at $x=0.14$ the material is fused, thereby eliminating intergrain interaction – corresponding to susceptibility that is purely intragranular. At $x=0.16$ and $x=0.18$ grain boundaries are present, but not causing significant loss such that the intragranular losses still has greater magnitude.

SPP-2008-187: Role of Hydrogen in the Ionization and Enhancement of Argon Ions in a Microwave Plasma

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The effect of adding hydrogen gas in a microwave-induced argon plasma was studied using optical emission spectroscopy (OES) to determine the role of the hydrogen gas in the ionization and enhancement (increase of excited and ionized plasma species) of argon atoms. Spectroscopy data from the visible optical emission of the argon plasma gathered from the experiment were analyzed. Neutral and ion species (argon and hydrogen) in the plasma were identified using the Table of Line Spectra of Elements and the NIST Atomic Transition Probability Table of the CRC Handbook of Chemistry and Physics. The OES spectrograph analysis of the argon plasma showed a vast species of excited argon atoms (ArI). The excited state of hydrogen, H_2^+ , was also evident when hydrogen gas is added to the plasma. The electrons, e^- , of the excited hydrogen atoms provide the impact electrons to produce argon ions (ArII or Ar^+) and probably higher order ions (ArIII or Ar^{+2}) by electron impact process on already excited or already ionized argon atoms. This study will pave the way to better understanding of the microwave plasma source used in the experimental results.

SPP-2008-188: Plasma treatment of Pine Wood (*Pinus kesiya*) using Glow Discharge Ion Source (GDIS)

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Pine wood (*Pinus kesiya*) samples were treated using low energy hydrogen ion shower. A compact gas discharge ion source (GDIS) was used to produce the hydrogen ions. The pine wood samples were exposed with the hydrogen ion beam with a discharge current from 1mA to 4mA with 3 mTorr gas filling pressure. The changes on the properties of plasma treated pine wood were investigated in contrast to untreated samples using wettability tests and flame test. Two types of thin wood sample were plasma treated: longitudinal (samples cut perpendicular to the tree growth rings) and cross-sectional (samples cut parallel to the growth rings). Different tests on a longitudinal sample such as water drop test, dye test and flame retardation test were conducted to investigate the wettability and flammability properties of the wood specimen. Wettability results showed that the treated sample absorbed water slower than the untreated sample. Plasma treatment retards the fire consumption of the wood. SEM results for the cross section sample showed opening of more pores and appearance of cracks. These results prove that low energy hydrogen ion shower is effective to enhance hydrophobicity and flame retardation.

SPP-2008-189: Light through a Novel Lens

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We investigate the propagation of light passing through a novel lens. Our lens is composed of a spherical lens with a protruding conical section. We determine intensity profiles of top hat light beams passing through this lens by the Split-Step algorithms. We compare these with those from a spherical lens and a conical lens. Our lens may find applications in imaging and microscopy.

SPP-2008-194: Optical emission spectroscopy of microwave induced CO_2 plasma

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The electrochemical decomposition of CO_2 into its elemental forms through CO_2 and $\text{CO}_2\text{-Ar}$ microwave induced plasmas is studied via optical emission spectroscopy. The active species present as well as the electrochemical processes that produce them have been identified. It has been shown that the microwave plasma device was able to achieve CO_2 decomposition with the existence of CO and C species. The optimum power for CO_2 conversion was determined from a set of powers used for CO_2 and $\text{CO}_2\text{-Ar}$ plasmas. It has also been shown that the addition of argon improved CO_2 decomposition.

SPP-2008-196: Surface Modification of ophthalmic CR-39 polymer lenses by low energy hydrogen ion shower (LEHIS) treatment

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A low energy hydrogen ion shower (LEHIS) was used for the surface modification of Allyl Diglycol Carbonate (CR-39) ophthalmic lens samples. To investigate the changes in the physical, chemical, and optical characteristics, scanning electron microscopy (SEM), atomic force microscopy (AFM), Fourier transform infrared spectroscopy (FTIR) with attenuated reflectance accessory (ATR), and transmittance measurements were performed on treated and untreated 6x6 mm² samples. After treatment, SEM showed a decrease in surface nanosized structures and a change in structure size homogeneity, which corresponds with surface morphology data obtained through AFM. FTIR-ATR results showed minimal change in chemical structure while transmittance measurements showed increased values.

SPP-2008-200: Hydrogen Ion Implantation of Acrylamide-bis in Gas Discharge Ion Source Plasma: Investigation of Conductivity using FTIR Analysis

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Acrylamide-bis was treated with hydrogen ion implantation thru a gas discharge ion source (GDIS). The samples were treated for 15 minutes at discharge currents of 2.5 mA, 3.0 mA, and 3.5 mA. Fourier transform infrared spectroscopy (FTIR) characterization was performed and results indicate stretching in the apparent bonds/peaks before and after treatment. Changes in the C-N and C-H bonds were also observed which causes electron deficiency in N. This deficiency suggests change in the materials' conductivity.

SPP-2008-207: Low Temperature Sintering of MgO-Doped ZrO₂ Ceramic

EB. Bognalbal¹ and AV. Amorsolo, Jr.

Dept of MMM Engg, Univ of the Philippines Diliman, QC

Zirconia ceramic doped with 9.7% mole MgO was synthesized by solid state method at 1300°C to 1500°C for 1 hour to 6 hours following a factorial experimental design. XRD analysis of sintered samples showed that the phases formed were dependent on sintering temperature. SEM and SMA results revealed microcracks and surface uplift in samples containing single monoclinic ZrO_2 phase. The grain size was observed to be dependent on sintering temperature and ZrO_2 phases formed. The hardness obtained by indentation method was found to be lower for samples sintered at 1300°C and 1400°C than for samples sintered at 1500°C due to the lower density contributed by microcracks in monoclinic ZrO_2 .

SPP-2008-209: Hydrogen Ion immersion implantation (HI) of aged polyaniline-emeraldine film using glow discharge ion source (GDIS)

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Deprotonated aged polyaniline-emeraldine film prepared thru oxidative polymerization was implanted with hydrogen ions using compact glow discharge ion source. H₂ gas was injected into the chamber at 7 sccm filling the chamber from a base pressure of 1.8×10^{-5} torr to 5.1×10^{-3} torr working pressure. FTIR analyses showed that hydrogenation caused a general red shift on the quinoid ring. Protonation was also observed by hydrogen implantation onto the imine. Also, increase in relative intensity was observed in H bonding suggesting successful implantation.

SPP-2008-213: Synthesis of Cadmium Oxide Nanostructures

L Tan, J Feraer, A Ladines, R De los Reyes, G Santos, N Quevada, R Quiroga

De La Salle Univ, Taft Ave., Malate, Manila

Cadmium Oxide nanomaterial have been successfully fabricated from the horizontal vapor phase growth at 200°C, and characterized by scanning electron microscopy (SEM) and Energy Dispersive X-ray (EDX). SEM image shows that the nanomaterial has a needle and rod-like structure of 15 microns length, with 100 nm tail end and tip size of 0.5 microns ideal for cantilever nanoprobe applications. EDX analyses indicate that these CdO nanomaterials crystallize in its original composition. The growth mechanism of the nanomaterial is also proposed as a solid-vapor-solid mechanism without a catalyst.

SPP-2008-214: Fabrication of Carbon Nanomaterial from Charcoal

J Feraer, L Tan, A Ladines, R De los Reyes, GN Santos, N Quevada, R Quiroga

De La Salle Univ, Taft Ave., Malate, Manila

In this study, a simple Physical Vapor Deposition (PVD) process we call Horizontal Vapor Phase Growth (HVPG) Method was used to grow carbon nanomaterial from activated carbon powder (charcoal). Scanning Electron Microscopy revealed that the carbon nanomaterial grew under high vacuum conditions ($=10^{-6}$ Torr) with a growth temperature of 1200°C for 6 hours. Energy Dispersive X-ray revealed the elemental composition of the nanomaterial as Carbon (35.3%); Oxygen (61.69%), with a minimal trace of Calcium (3.01%) suggesting a nominal contaminant has occurred during the synthesis process. The as grown product has a width of 50 nm and length of 50 μm.

SPP-2008-215: Simulation of Ion Trajectories in the Enhancement of TiN Deposition and TiCuN Synthesis in a Magnetized Sheet Plasma

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Ion trajectories for a Sheet Plasma Negative Ion Source (SPNIS) were simulated to show how the addition of Samarium-cobalt (Sm-Co) magnets at the base of the extraction chamber would increase the sputtering yield of Titanium (Ti) ions and neutrals and deposition rate of Titanium nitride (TiN). It is demonstrated that the resulting magnetic field would alter ion trajectories such that there would be an increase in the amount of ions hitting the target, resulting to an enhancement of Ti sputtering yield and TiN deposition rate.

SPP-2008-217: Thermal Analysis and Reaction Profile of SnO₂ Nanomaterial

R De los Reyes, E Rodulfo, N Quevada, GC Santos, R Quiroga

De La Salle Univ, Taft Ave., Malate, Manila

SnO₂ nanomaterial was synthesized using the non-catalytic horizontal vapor phase growth technique. The resulting nanostructured SnO₂ were then subjected to Differential Thermal Analysis (DTA) and

Differential Scanning Calorimetry (DSC) analysis to obtain its thermal properties such as its melting point, latent heat of fusion, exothermic peak temperature, thermal resistance, thermal conductance and specific heat capacity. The reaction profile was then obtained from the DSC measurements.

SPP-2008-218: X-Ray and UVA Irradiation of PAni-Emeraldine: A Comparative Study on the Vibrational Modes

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In this work, effects of x-ray and UV irradiation on the chemical structure of doped and undoped polyaniline emeraldine (PANI-E) films were explored using infrared spectroscopy. PANI films were deposited on SiO₂ by dry casting method. Results showed that nitrogen groups are involved in the red shifting of absorption bands after irradiation with UVA and X-ray. Also, it was observed that exposure of doped and undoped polyaniline film to these radiations blue shifted the aromatic CC and aliphatic CC conjugated bands. Blue shifting of CC bands implies higher energy requirement for polaronic migration to take place. The occurrence of aliphatic CC on one hand indicates decreased long chain conjugation. These affect the electrical property of PANI by lowering the intrinsic conductivity of the material.

SPP-2008-219: Synthesis of Titanium Copper Nitride Films on Cu and SS Substrates Using a Magnetized Sheet Plasma Negative Ion Source

MS Villamayor, AM Ulano, BT Suarez, HJ Ramos

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Titanium copper nitride (TiCuN) films were synthesized using a magnetized sheet plasma negative ion source (MSPNIS) with the addition of two Samarium-cobalt (SmCo) magnets at the base of the extraction chamber to enhance titanium sputtering. Two types of substrates for deposition were exposed to the plasma namely copper (Cu) and stainless steel (SS). X-ray diffraction analysis of the samples verified the presence of TiCuN and SEM results show that the surface morphology of the samples changed.

SPP-2008-231: Synthesis of ZnO nanowalls by an aqueous solution process

JA Lazo, CV Cruz, BG Singidas, RV Sarmago

Mat Sci & Engg Prog, Univ of the Philippines, Diliman, QC

Thru a solution process at relatively low temperatures (90-115°C), using aqueous zinc acetate solution as the precursor and liquid ammonia as both the complexing agent and the pH controller, zinc oxide nanowalls with thickness of 80-100 nm were successfully synthesized and deposited on glass substrates. The effects of processing conditions were studied and results showed that longer drying time increases the size of the ZnO nanostructures, drying temperature dictates its morphology, higher pH decreases the nanowall thickness, and higher growth precursor solution concentration lowers its density, i.e. the number of nanowalls per unit area of the substrate.

SPP-2008-233: Nanostructured ZnO Films on Silicon by Sol-Gel Spin-Coating

J. Diamante, J. M. Isidro, E. Magdaluyo, B. Singidas, R. Sarmago

Mat Sci & Engg Prog, Univ of the Philippines, Diliman, QC

Nanostructured film of zinc oxide with wurtzite crystal structure was successfully synthesized using sol-gel spin-coating technique with zinc acetate as a precursor material and PEG as surfactant. The size of the crystals in the film was found to decrease with annealing temperature and time. An average crystal diagonal length of less than 100 nm was achieved at 500°C for 30 and 60 minutes. The clustering of the crystals observed can be associated to the heterogeneous nucleation of the crystals.

DAY 3, 24 October, Friday

Harmonics was observed using FFT for both walks and a decrease in the difference between the dominant frequencies for the abnormal walk.

SPP-2008-120: Hitness of Original Pilipino Music can be predicted up to 92%

J Tugaff, L Venturina, CP Monterola,
Nat Inst of Physics, Univ of the Philippines Diliman, QC

In this work, musical features (e.g. pitch, tempo, and dynamic range) are extracted from Original Pilipino Music (OPM) released from 2004 to 2006 and are used to forecast hit songs. We show that a trained feed-forward NN can predict which songs would hit up to 92.3% regardless of musical genre. The accuracy is remarkable given that linear classifiers are just within the proportion chance criterion.

SPP-2008-131: A System for Determining Angular Tilt of a CCD and/or CMOS Image Sensor by Image Fourier Transform Analysis

J Escay, JR Asis
Design & Engg Dept, Integrated Microelectronics Inc., Muntinlupa City

We propose a system that makes use of a laser setup and a bar chart to determine the tilt of an image sensor. Fourier analysis is performed on sample images where the image sensor itself is used to determine overall sensor tilt. In comparison to other techniques such as SAM, the proposed technique is fast and non-destructive. The system was able to determine sensor tilt to 25% RMSE compared with an ideal or simulated setup. The system can be adapted and used as a quick Good/No Good test for industrial applications where it can have advantages being that the setup itself is simple and can easily be implemented in a production line.

SPP-2008-136: Speculation, efficiency, and competition in zero-sum minority game with mixed strategies

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A new mechanism of financial markets driven in the information efficient regime is presented in the minority game. We introduce a zero-sum wealth pay-off and mixed strategies in the minority game with dynamic capitals. With the zero-sum wealth pay-off, intermittent volatility clustering is found in between regions of absorbing states. The absorbing dynamics disappear when the agents are using mixed strategies. Our model is able to capture a range of stylized facts observed in real financial data such as clustering of volatilities, long-range volatility correlation, and fat tails in the distribution of returns. While it is found to be important in the recovery of stylized facts, mixed strategies does not guarantee a better market speculation and on the average agents using them are being outperformed by those who are not.

SPP-2008-146: Rational Solutions of a Class of Hydrodynamic Partial Differential Equations via the Variational Iteration Method

JC Imperio, JP Esguerra
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In this paper the variational iteration method (VIM) is applied to a class of partial differential equations, which include as special cases the Burgers, Korteweg-de Vries, and Kawahara-Korteweg-de Vries equations. A general form of exact rational solutions of these equations is obtained. This study highlights the simplicity and efficiency of the VIM. The rational solutions are obtained directly and in a straightforward manner.

SPP-2008-148: Adsorption of chromium(VI) for wastewater treatment by native sawdust

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Adsorption of chromium(VI) for wastewater treatment using native sawdust derived from hardwood tangule and softwoods palochina and coconut were investigated. Various parameters such as adsorbent surface area, adsorbent dose, adsorbate concentration, contact time, and pH were studied. Equilibrium was reached after 2 hours at a pH of 2. The Langmuir isotherm model was fitted with the adsorption data with

$R^2=0.978\pm0.008$. Softwoods were found to be better adsorbents, with higher maximum adsorption capacities for coconut (0.455) and palochina (0.444), than hardwood tangule (0.387). Results indicate that HCl-treated coconut sawdust is the most efficient adsorbent with the highest chromium removal of 74.53% at equilibrium.

SPP-2008-155: Statistical analysis of sports dynamics

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The dynamics of sports is statistically investigated. We propose correlation as a measure of predictability. An agent-based model is used to simulate the dynamics resulting to highly predictable game results. Different model parameters are tuned to predict the behavior of the game. Results from numerical data exhibit a good degree of predictability because of the high average correlation and low standard deviation in the rankings. We also match the model predicted rankings to a real data ranking and obtained a good degree of predictability. The difference in the dynamics of the selected individual and team sport is observed from real data using the model.

SPP-2008-158: A procedure for generating a random number sequence using at least seven individuals

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We verify through experimentation that humans, individually, cannot generate a random number sequence due to fatigue and inherent biases. Humans often neglect certain numbers and have tendencies to repeat or to avoid repeating particular pairs of numbers. We, however, demonstrate that the alternating sequence of numbers generated by seven or more individuals can produce a random series. The similarity between the relative frequencies of actual collective results and that of a random sequence are evaluated using Linfoot's criteria of Fidelity, Structural Content, and Correlation Quality.

SPP-2008-165: News Framing of Population and Family Planning Issues via Semantic Network Analysis

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Contentious political debates regarding the issues on population and family planning have been perennial over the past four decades. While its prominence in the public agenda varies depending on other national issues vying for public attention, its presence in policy and political agendas is constant. Here, computer based framing analysis is developed that examines the pattern of media coverage on the population issue in the country. The content of 146 articles sampled from 1988 to 2007 in Manila Bulletin is analyzed by creating a network of concept co-occurrences. The network shows small-world characteristics with a scale-free distribution, implying that the discussion of an article revolves around few central ideas. Moreover, cluster analysis of the network suggests three well-defined frame themes, namely: (1) Development Frame; (2) Maternal Health Frame; and (3) Framing by the Catholic Church. Our results support the thesis that the lack of progress in discussions about suitable population policies is due to the mismatched frames within which it is discussed.

SPP-2008-170: Removal of methyl red dye from aqueous solutions using coconut product sawdust by the process of adsorption

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The use of cheap and environment friendly adsorbents has been studied as possible alternative to commercially available adsorbents for dye removal from wastewater. This study investigates the potential use of coconut products sawdust, pretreated with formaldehyde and sulphuric acid, for the removal of methyl red from simulated wastewater. The effects of dye concentration, adsorbent dosage, pH, and contact time were studied. Results showed that adsorption percentages were observed to increase with lower concentrations of methyl red. Percentage of dye removal increased with the amount of adsorbent and the contact

Synthesis of Titanium Copper Nitride Films on Cu and SS Substrates Using a Magnetized Sheet Plasma Negative Ion Source

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Abstract

Titanium copper nitride (TiCuN) films were synthesized using a magnetized sheet plasma negative ion source (MSPNIS) with the addition of two SmCo magnets at the base of the extraction chamber to enhance magnetron sputtering. Two types of substrates for deposition were exposed to the plasma namely Cu and SS. X-ray diffraction analysis of the samples verified the presence of TiCuN and SEM results show that the surface morphology of the samples changed.

Keywords: magnetized plasmas (52.25.Xz), thin film structure and morphology (68.55.-a), Chemical Vapor Deposition (81.15Gh), $\text{TiN}|\text{Cu}$

1. Introduction

For decades, research on the production of thin-films has fueled the interest of researchers because of the uncommon properties these films possess. Thin films can be tailor made to meet the requirements needed in the manufacture of electronic and optical devices as well as hard coatings for industrial tools. Dispersion hardened super alloys can answer these needs. Copper dispersion hardened by TiN is useful in making lead frames and spot welding electrodes [Ref. 1].

Titanium nitride, a hard ceramic, is a popular choice for coating industrial tools because of its characteristic hardness, wear resistance and inertness [Ref. 2]. Synthesis of TiN films has been done using a sheet plasma negative ion source. It was found that synthesized films exhibit the stoichiometric TiN (200), TiN (220), TiN (311) and the nonstoichiometric Ti_2N (220) phases [Ref. 3]. A recent trend to further improve the properties of TiN films is the addition of other elements [Ref. 4,5,6]. Synthesized nanostructured films including super lattices and nanocomposites are found to enhance the hardness of TiN films [Ref. 7,8]. It was found by GM Matenoglou, et. al., that $\text{Ti}-\text{Cu}-\text{N}$ films produced by hybrid PLD process consisted of nanocrystalline TiN and amorphous Cu [Ref. 8]. TiCuN films are expected to have 42 GPa hardness [Ref. 6]. A maximum hardness of 42 GPa is evidently large compared to the 24.5 GPa exhibited by pure TiN.

In this study, a magnetized sheet plasma source is used to deposit TiCuN on copper and stainless steel substrates. Different characterization techniques are employed to describe the samples and to confirm the presence of TiCuN on the surface of the substrates. Properties of the samples will be compared with that of TiN.

This work is composed of four parts. Part 2 discusses the experimental methods employed and sample preparation, part 3 presents and explains the results and the paper is concluded in part 4.

2. Methodology

Figure 1 shows the schematic diagram of the Magnetized Sheet Plasma Negative Ion Source (MSPNIS). A slight modification is introduced into the system by placing two Sm-Co magnets with an effective area of $3 \times 4 \text{ cm}^2$ at the bottom of the extraction chamber. This is done to induce sputtering due to the attraction of the positive Argon ions responsible for the extraction of the metal targets. Modification of the machine led to the increase in the deposition rate for TiN synthesis due to the addition of the two magnets.

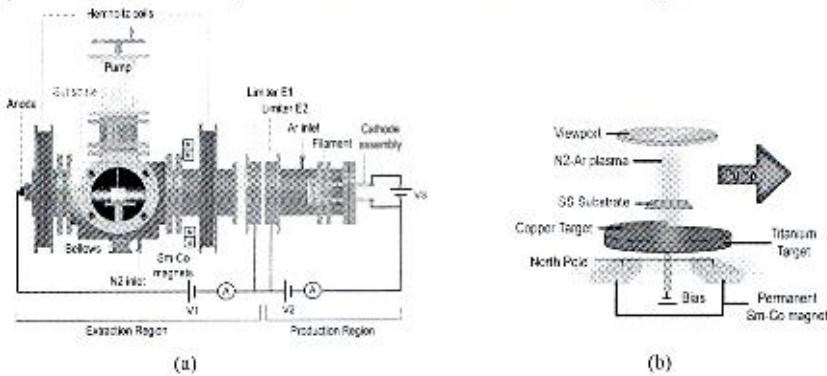


Figure 1. Schematic diagram of the (a)MSPNIS and (b)orientation of the targets and substrates.

Titanium (Ti) disc and a copper (Cu) half moon sheet placed at the base of the extraction chamber act as targets for sputtering. It is biased at -350 V. The said metals were sputtered by Argon plasma produced at a plasma current of 4A and at a discharge potential of 70V. This discharge potential is the potential between the cathode and the anode. Reactive nitrogen gas is fed into the system and is combined with the Argon gas in ratio 1:10 N₂-Ar. Total gas filling pressure is maintained at 40mTorr.

In this experiment, Cu and stainless steel are used as substrates. They are cut such that the exposed area for the Cu and SS is 1×2cm². The substrates are not biased (i.e. floating) and are attached to a stainless steel holder and placed above the target at a distance of 2cm. The arrangement of the targets and substrates are shown in Figure 2.

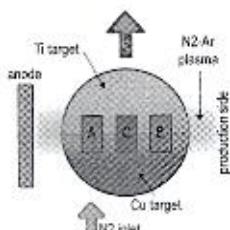


Figure 2. Orientation of the substrates with respect to the Cu and Ti targets. Substrate A and B are stainless steel and the one in between is copper, substrate C.

The system is evacuated to a base pressure of 20μTorr prior to ignition. The substrates have an exposed area of 1×2cm² each are scrubbed using Schleiffix™ Universal Cleaner, Grit 120 and wiped with methanol before subjected to ultrasonic cleaning. Before deposition, a 30-minute discharge clean was done using Argon plasma. Afterwards, the filling pressure was maintained at 9mTorr to induce target sputtering.

Deposited TiCuN film on the substrates is characterized using X-ray diffraction (XRD) and scanning electron microscopy (SEM). From XRD, the crystallographic structures of the samples are determined. SEM analysis of the samples shows their surface morphology.

Sterilization capabilities of the coated samples were also tested showing that TiCuN deposits are effective for bacterial lysing.

3. Results and Discussion

Two stainless steel substrates, sample A and B, were positioned near the anode and near the production chamber are shown in Figure 3. There is a great difference with the color deposited on each of the substrates. Sample A, the substrate near the anode, showed a dark blue shade while sample B exhibited a light yellow shade. The gray color on each sample's lower right area is covered with the sample holder therefore no deposition occurred in this location

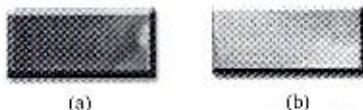


Figure 3. Stainless steel substrates exposed in N₂-Ar plasma with Ti and Cu targets for TiCuN deposition (a) Sample A is nearer to the anode and N₂ inlet with a dark blue deposit as compared to (b) sample B which is nearer to the production chamber with a light yellow deposit.

Shown in Figure 4 are the SEM results of untreated stainless steel (a), sample deposited with TiCuN positioned near the anode (b) and one also treated with TiCuN placed near the production chamber (c). The untreated sample was rough with trenches and voids, compared to its treated counterparts. Sample A near the anode exhibited a smoother, clearer surface, while sample B near the production chamber had parallel striations. This means that the deposition process is dependent on the position of the sample inside the extraction chamber. A separate simulation study supports this result. The study showed a higher Ti and Cu sputtering yield around sample A's position.

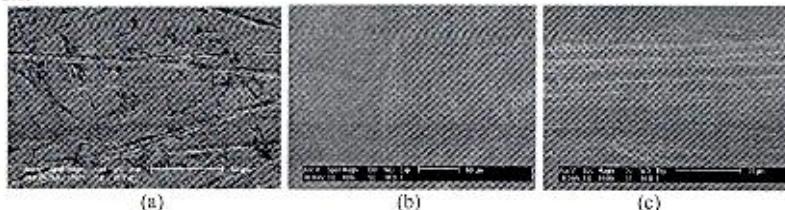


Figure 4. (a) Untreated stainless steel sample compared with (b) TiCuN deposited SS near the anode and N₂ inlet Sample A, and (c) TiCuN deposited SS near the production chamber Sample B.

An XRD plot of a TiN coated stainless substrate Ref. [3] is shown in Figure 5. The sample is coated using the same device—the sheet plasma negative ion source. The only difference between this study and the previous one [Ref. 3] is the placement of permanent magnets beneath the extraction chamber thus the name magnetized sheet plasma negative ion source.

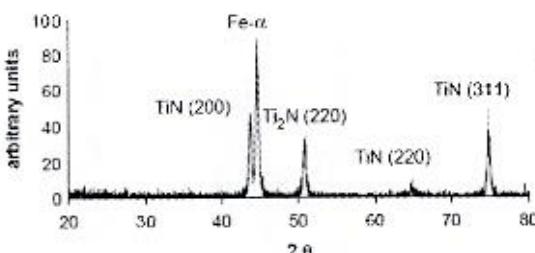


Figure 5. XRD spectrum of TiN coated stainless steel substrate from the paper of V.R. Noguera and H.J. Ramos Ref. [3]

Figure 6 shows the XRD spectrum of sample A. From the plot, the presence of TiN, TiCu_4 and Cu peaks is verified. Nitrogen is insoluble in Cu in both liquid and solid states so the deposited film does not show any XRD peaks for TiCuN .

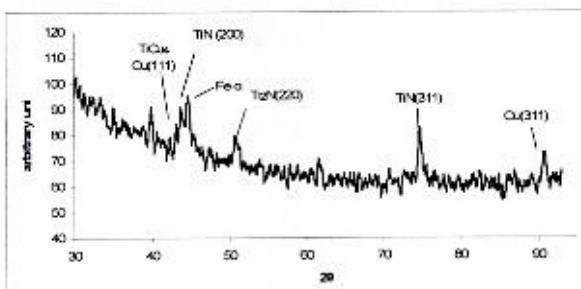


Figure 6. XRD spectrum of Sample A showing several TiN and Cu peaks.

Zooming in at the interval 40° - 50° , we verify the presence of peaks which are indicative of TiCu^4 , $\text{TiN}(200)$ and $\text{Fe-}\alpha$. Figure 7 shows a close up of this XRD plot.

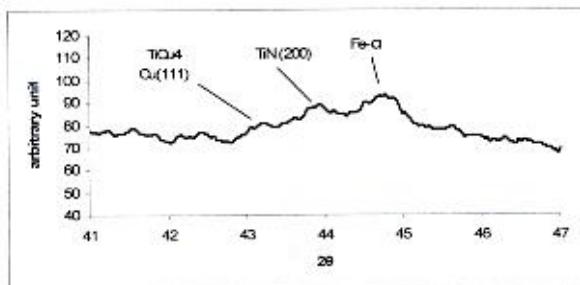


Figure 7. Magnified plot of Figure 5 showing the 3 peaks at interval 40° - 50°

In terms of visual analysis, Figure 8 shows the difference in the color of the treated and untreated side of copper substrate. The treated area has a gold shade and was found to be deposited with $\text{TiN}(311)$. The gold and bronze colors are indicative of the presence of TiN and Cu as verified by the XRD plot in Figure 9.



Figure 8. Treated copper substrate with TiN deposit Sample C. Note the difference of the color on both sides of the substrate. The right most side is unexposed to the plasma while the left side shows the presence of TiN.

Several Cu peaks are apparent in Figure 9 since the sample C is made of copper. The peaks correspond to Cu (111), Cu (200) and Cu (311).

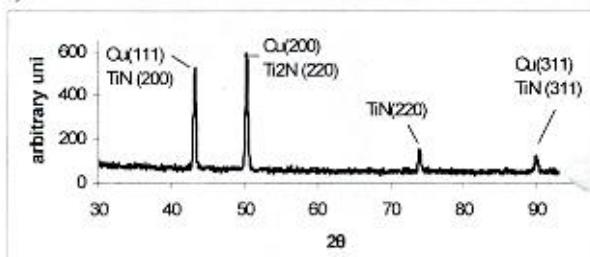


Figure 9. XRD spectrum of copper substrate Sample C.

4. Conclusions

From the SEM analysis of the samples, change in surface morphology is apparent. Stainless steel substrate sample A located away from the production chamber and near the gas inlet has a smoother surface compared with the stainless steel substrate sample B located near the production chamber. Thorough XRD examination confirms that both TiCuN and TiN films are present on the substrates. The smoother surface indicated that a thin film is deposited in the substrate. XRD results also show that the copper substrate/sample C has more defined Cu peaks compared with the two stainless steel substrates. This is because there is more Cu in sample C as compared to the other samples.

Comparing the XRD plot obtained with other published work, results were consistent with the expected outcome, with the exemption of some displaced peaks in the Cu substrate. This can be attributed to the strain obtained from using stainless steel substrate rather than a copper substrate.

The presence of TiN and TiCuN on both stainless steel and copper substrates proved the versatility the ion source as well as the great possibility of depositing TiN and TiCuN on both copper and stainless steel.

Acknowledgements

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Role of Hydrogen in the Ionization and Enhancement of Argon Ions in a Microwave Plasma

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Abstract

The effect of adding hydrogen gas in a microwave-induced argon plasma was studied using optical emission spectroscopy (OES) to determine the role of the hydrogen gas in the ionization and enhancement (increase of excited and ionized plasma species) of argon atoms. Spectroscopy data from the visible optical emission of the argon plasma gathered from the experiment were analyzed. OES data of the argon plasma showed a vast species of excited argon atoms (ArI). The excited state of hydrogen, H_a, was also evident when hydrogen gas is added to the plasma. The electrons of the excited hydrogen atoms provide the impact electrons to produce argon ions (ArII or Ar⁺) and probably higher order ions (ArIII or Ar²⁺) by electron impact process on already excited or already ionized argon atoms. This study will pave the way to better understanding of the microwave plasma source used in the experimental results.

Keywords: 52.25.Jm (Ionization of plasmas), 52.25.Os (Emission, absorption, and scattering of electromagnetic radiation), 52.27.-h (**Basic studies of specific kinds of plasmas**), 52.70.Kz(Optical (ultraviolet, visible, infrared) measurements)

1. Introduction

Optical emission spectroscopy (OES) is preferred by many plasma researchers over intrusive diagnostic devices such as Langmuir probe. OES is a non-invasive method used not only in analyzing important parameters such as electron temperature and electron density of the plasma being studied but also in understanding the elementary processes involved in the plasma. [1-4]. In this paper, glow discharge region of argon and argon-hydrogen gas mixture microwave plasma was analyzed using optical emission spectroscopy.

This study reports the role of hydrogen in the enhancement of the ionization of argon plasma using the microwave plasma source at the Plasma Physics laboratory of the National Institute of Physics. The optical emission spectra of pure argon plasma and argon-hydrogen gas mixture plasma were gathered and compared to determine the effect of the hydrogen gas on the enhancement of argon ions and possibly, in the production of multiply charged argon ions in the device.

2. Methodology

2.1 Discharge Production

The argon and argon-hydrogen plasmas were produced using the microwave plasma device at the Plasma Physics Laboratory of the National Institute of Physics. Figure 1 shows the schematic diagram of the ECR device used to produce the plasma. The details of the microwave plasma device have been described by previously papers which used the device [5]. The plasma chamber is evacuated to a base pressure of the order 10^{-5} Torr and was monitored by the ionization and Pirani gauges. Argon and hydrogen gas were supplied to the system using an MKS mass flow controller. A gas pressure of 10 mTorr was maintained throughout the experimental runs. The gas flow rate at 10 scem (standard cubic centimeter per minute) and microwave power at 180W were chosen for this study. These are the optimum parameters determined by the authors via OES which is discussed in another submitted paper.

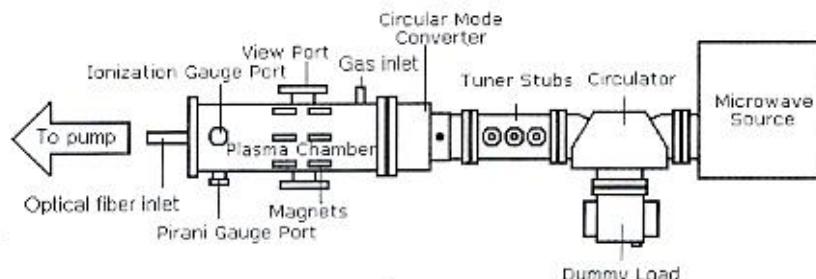


Figure 1. Schematic diagram of the microwave plasma device.

2.2 Spectroscopy Data

An optical fiber was used to guide the emission from the plasma to the spectrometer (JOBIN YVON) and the spectrograph was recorded using a silicon detector. The microwave plasma device has a built-in viewport for the spectroscopy data gathering. However, the initial spectral data gathered showed low emission signals because the plasma was not located exactly at the viewport. The authors positioned the tip of the optic fiber, which collects the optical emissions, as near to the plasma discharge as possible by inserting a glass tube into the plasma chamber through the optical fiber inlet (See Figure 1, left side of diagram). This resulted in a better emission signal of the plasma which was relayed to the spectrometer and recorded in a computer. Spectral profile scans were done in the range of 250-1000 nm. Figures 2 shows the spectral peaks for the argon in its excited state (ArI), and singly-ionized state (ArII). Based on the ionization probability for argon, the excited states (Ar I) are expected in the longer wavelength region (600-1000 nm) while argon ions (Ar II) are in the shorter wavelength region (250-400nm). Argon ions of higher ionization level are located above the ultraviolet region. Unfortunately, the spectrometer is not designed to scan the UV region. Hence, this study focused on ArI, ArII and ArIII plasma species that were observed experimentally. Figure 2 shows the argon spectral lines from the experiment.

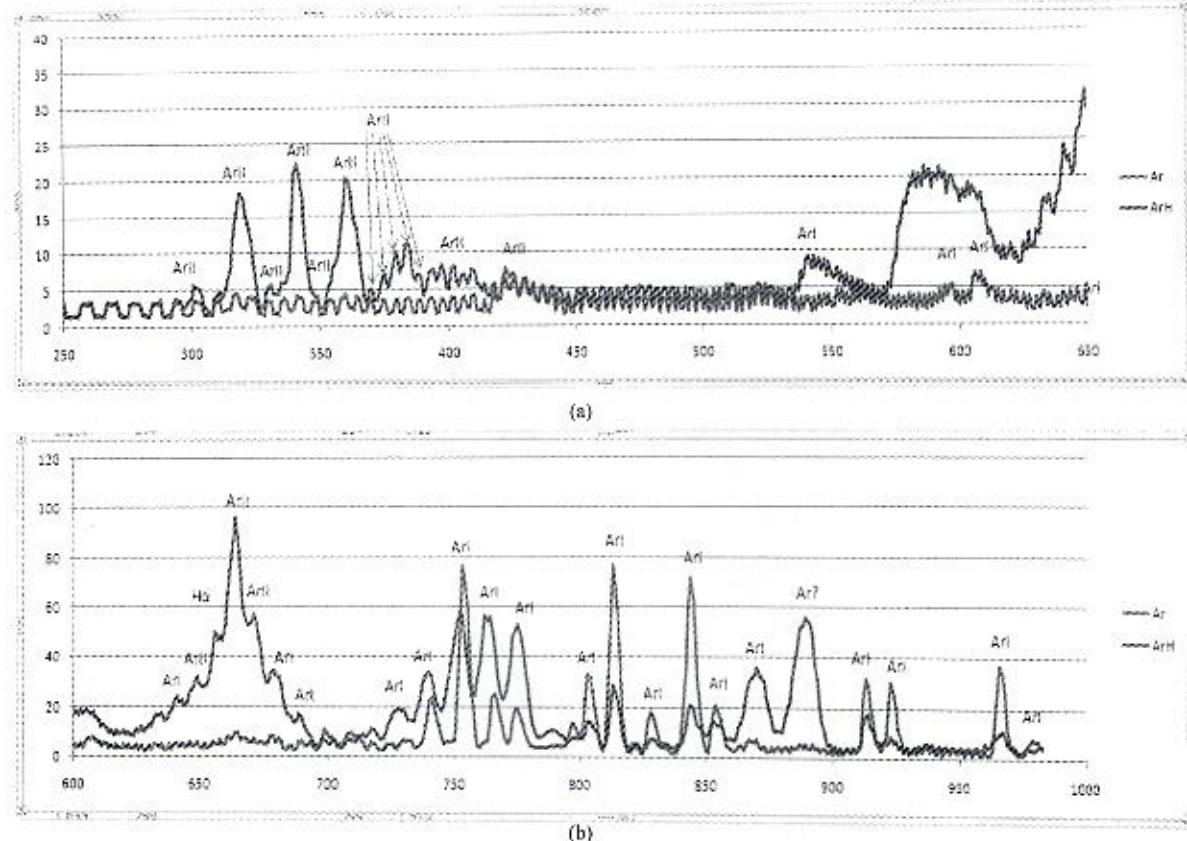


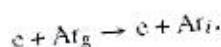
Figure 2. Spectrograph of the microwave argon plasma showing argon plasma with hydrogen gas (red line) and without hydrogen (blue line). (a) spectrograph scan from 250-650nm, (b) spectrograph scan from 600-1000nm. Spectrograph was divided into regions for better visual comparison.

Figure 2 shows the argon plasma with hydrogen gas (red line) and without hydrogen (blue line). Note the production of ionized states (ArII) at 300 to 450 nm wavelengths (Figure 2a) and at 600-700nm wavelengths (Figure 2b) when hydrogen gas is added to the plasma. Furthermore, note the increase or enhancement of some argon excited states (ArI) at some wavelengths between 700 to 1000nm .

3. Results and Discussion

For analyzing argon discharges, collisional-radiative (CR) models that include processes like ionization, electron impact excitation (and de-excitation) and spontaneous radiation are used. A simple CR model was proposed in ref [6] and will be used in the analysis of the microwave argon plasma. The simple model included the following reactions:

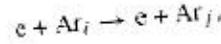
Excitation from ground state (Ar_g) to an excited state (Ar_i):



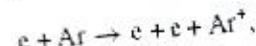
De-excitation from excited state (Ar_i) to ground state (Ar_g):



Electron impact transition between i^{th} and j^{th} excited states:



Electron impact ionization:



Spontaneous radiation:



The CR model suggests that ionization is mainly due to electron impact collision in the plasma while the observed optical emission spectra are due to excitation followed by spontaneous radiation then de-excitation. In Figure 2, it can be seen that the dominant species are the argon excited states (Ar_i). This means that with argon gas only in the plasma, excitation-spontaneous radiation-de-excitation process prevail in the plasma. However, with the addition of hydrogen in the argon plasma, ionized species are formed which means that hydrogen catalyses the electron impact ionization of the argon atoms while enhancing or increasing the excited state species of argon in some higher energy levels. In this case, the electrons in the above reactions were provided by the hydrogen gas. The H_α excited state is observed in the spectral data which verifies that the hydrogen electrons are the main source of impact electrons in the ionization process.

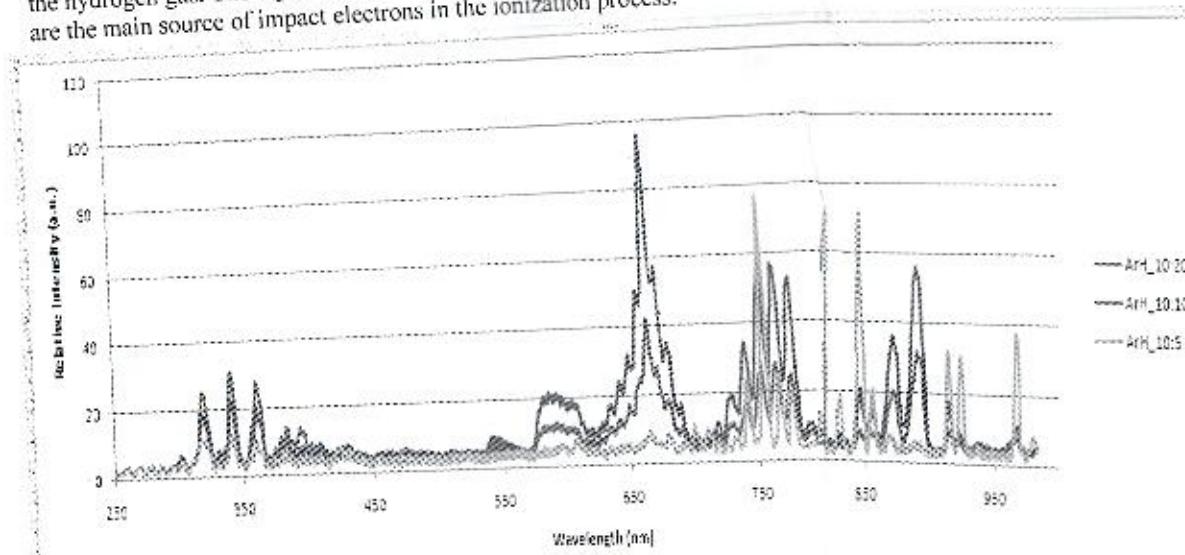


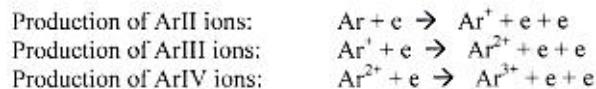
Figure 4. Spectrograph of the microwave argon -hydrogen plasma at different on-hydrogen gas ratios.

Spectral data was also gathered for argon-hydrogen plasma at microwave power of 180W at varying argon-hydrogen concentration ratio. The spectrograph in Figure 4 shows fitting details. It can be seen that argon II ions are produced and enhanced as the amount of hydrogen gas is added to the argon plasma. The number of excited argon states (Ar_i) are also enhanced as seen by the increase in the intensity of Ar_i emission in the 860-900nm region and in the 700-780nm region.

4. Conclusion

Hydrogen gas played an important role in the production of excited ionized states and in the enhancement or increase of ion species in the microwave argon plasma in study. The ECR device is unique in such a way that it elevates both the argon and hydrogen atoms in their excited states, Ar_i and H_α , respectively and then the plasma gases undergo simultaneous plasma processes discuss the CR model. In their excited

states, the hydrogen contributes the impact electrons (e) in the reactions while the argon atoms in their excited states undergo electron impact ionization to produce argon ions. This is easily understood as we realize that the hydrogen atom has a single electron that can be easily excited or dissociated from the hydrogen nucleus. And with the abundance of ArI excited state argon ions as evidenced in all the spectrographs, the hydrogen electron can cause impact collision with the electrons in these ArI argon atoms to produce argon ions. It is also then possible to produce higher order ionization by a series of impact ionization as follows:



It is probable that higher order argon ions, ArIII were present in the argon plasmas in the experiments. To verify this, it is recommended that a spectrometer or an OES sensor that can scan wavelengths above the UV region be used in further study.

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Optical emission spectroscopy of microwave induced CO₂ plasma

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Abstract

The electrochemical decomposition of CO₂ into its elemental forms through CO₂ and CO₂-Ar microwave induced plasmas is studied via optical emission spectroscopy. The active species present as well as the electrochemical processes that produce them have been identified. It has been shown that the microwave plasma device was able to achieve CO₂ decomposition with the existence of CO and C species. The optimum power for CO₂ conversion was determined from a set of powers used for CO₂ and CO₂-Ar plasmas. It has also been shown that the addition of argon improved CO₂ decomposition. © 2008 Samahang Pisika ng Pilipinas

Keywords: Optical emission spectroscopy, microwave plasmas, carbon dioxide decomposition

1. Introduction

The rapid rise of global temperatures over the past decades has been attributed from the increase of greenhouse gases in the atmosphere. More than half of these greenhouse gases are CO₂ [1]. Industrial sources of CO₂ in the atmosphere are fossil fuel based energy sources and industrial processes. The growing global warming awareness has pushed industrial processes to follow through with the elimination or reduction of CO₂ as by-products. With these challenges, there is a need for new technologies specifically a final end of pipe treatment facility that is capable of CO₂ abatement with more efficient methods, wider operational range, and lesser chemicals [2].

CO₂ decomposition can be achieved through thermal or electrochemical methods. Thermal methods require very high temperatures which increase reverse reaction rates. Electrochemical methods or specifically plasma treatment offers low temperature CO₂ decomposition via electron impact dissociation (nonequilibrium plasmas) or neutral gas heating (equilibrium plasmas). In comparison, electron impact dissociation is more efficient than neutral gas heating because less energy is required to increase the temperature of electrons compared to heavy ions for the collision induced dissociation [3]. Current nonequilibrium plasmas for CO₂ decomposition are radiofrequency plasmas [4], microwave plasmas [5], corona [6], dielectric barrier discharge [7], and glow discharge [8].

For the past years, the production of microwave plasmas has become cost effective with the use of commercial magnetrons as microwave sources and a tandem of permanent magnets for magnetic confinement in replacement of high power Helmholtz coils [9, 10]. However, there are not enough studies on CO₂ decomposition in microwave discharges. In this study, we demonstrate CO₂ decomposition with a microwave plasma device utilizing a 2.45 GHz commercial magnetron and a set of SmCo magnets in a double hexapole repelling magnetic configuration [11]. We focus on determining the active species generated in the CO₂ microwave discharge using optical emission spectroscopy. The active species would suggest the dominant chemical reactions present in the CO₂ microwave discharge, which would provide insights in significant plasma processes and parameters needed in optimizing the CO₂ decomposition. We also investigate the effect of increasing input power and adding argon as some studies have shown that they increase CO₂ conversion efficiency [4, 12, 13].

2. Methodology

The microwave plasma device used in this study is shown in Fig. 1(a) with the magnetic system shown in Fig. 1(b). It is composed of a microwave source, waveguide assembly, vacuum chamber, and pumping system. A detailed description of the components of the microwave plasma device is given in Refs. 9 and 10. The vacuum chamber is evacuated to a base pressure of 2×10^{-2} Pa and is monitored by ionization and Pirani gauges.

Industrial CO₂ (Ingasco, 99.99%) and argon gases are supplied to the system using an MKS mass flow controller. The CO₂ microwave discharge was generated at microwave power range of 20-160 W and a gas filling pressure of 6.5 Pa, respectively. For CO₂-Ar plasmas, the same power range was used with a gas ratio of 2:1 (CO₂:Ar).

Optical emission spectroscopy was implemented with JOBIN YVON spectrometer using a Si detector. An optical fiber was used to guide the emission from the plasma to the spectrometer. Spectral profile scans were done in the range of 250-1000 nm with an interval of 1 nm. The microwave plasma device has a built-in viewport for the spectroscopy data gathering; however, the initial spectral data gathered showed low emission signals because the plasma was not located near the end viewport. The authors positioned the tip of the optic fiber, which collects the optical emissions, as near to the plasma discharge as possible by inserting a glass tube into the plasma chamber through the optical fiber inlet [see Fig. 1(c)].

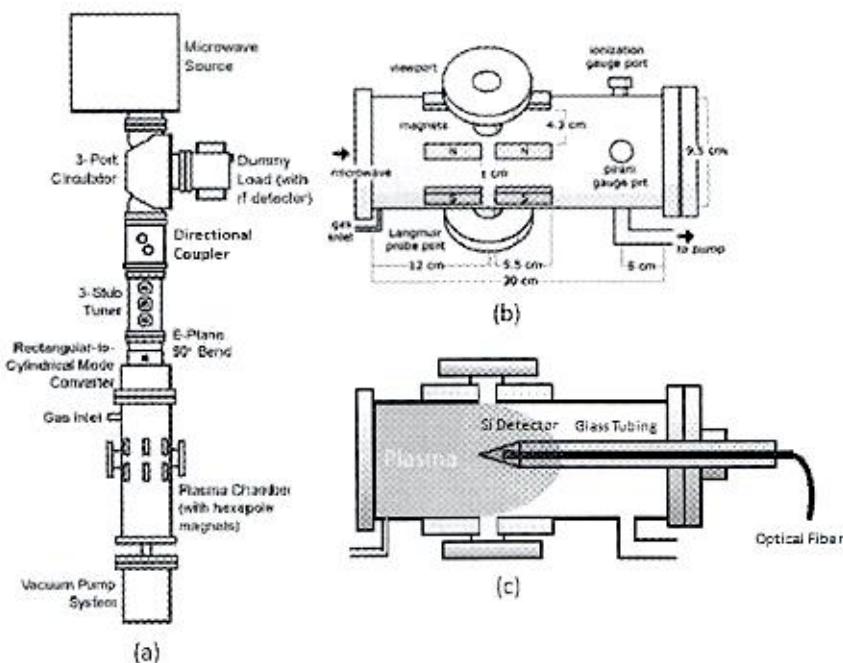


Figure 1. Schematic diagrams of the (a) microwave plasma device and (b) vacuum chamber. (c) Orientation of the optical fiber with the Si detector inside the vacuum chamber (side view cross section).

3. Results and Discussion

Sample images of the emission of CO₂ and CO₂-Ar microwave discharges are shown in Figs. 2(a) and 2(b), respectively. The typical spectroscopic emission measurements of CO₂ and CO₂-Ar microwave discharges are shown in Figs. 3(a) and 3(b), respectively.

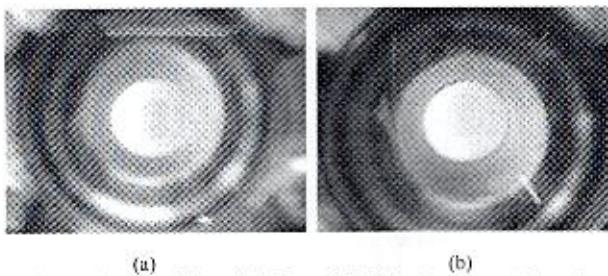
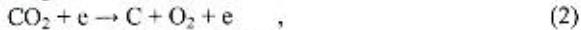


Figure 2. Images of the microwave induced (a) CO₂ and (b) CO₂-Ar plasmas taken at the viewport.

Some of the active species present in the CO₂ and CO₂-Ar plasmas are CO, C, C₂, O, and O₂ as seen from Fig. 3(a). With these species, we suggest the possible electron impact processes for the CO₂ plasma as follows:



The reaction for CO_2 -Ar plasma is

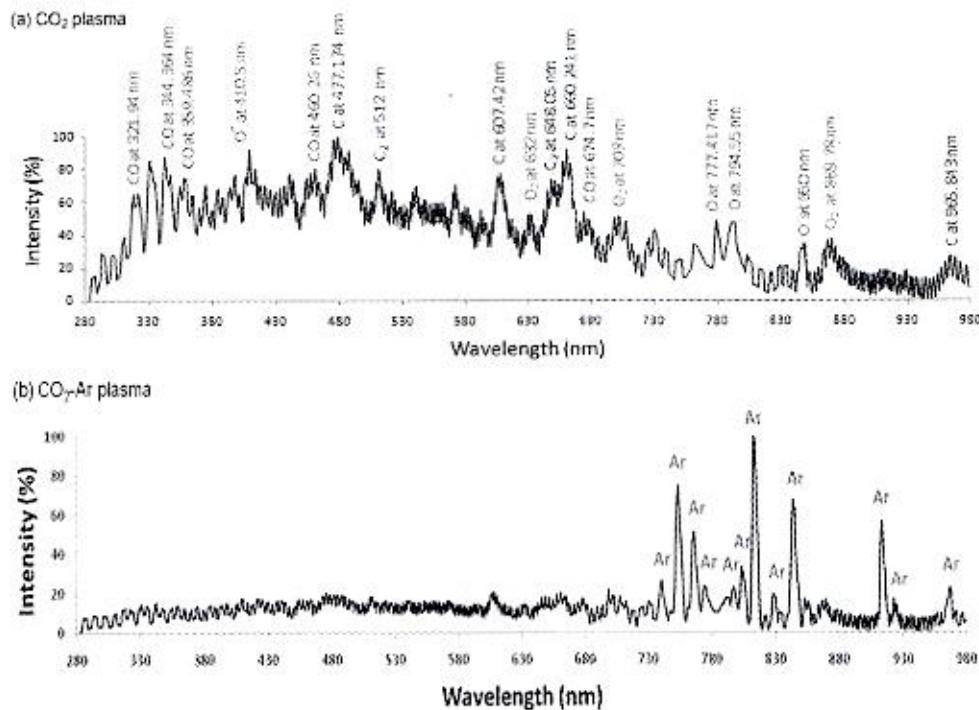


Figure 3. Typical emission spectra of microwave induced CO_2 and CO_2 -Ar plasmas. (a) Emission spectra of CO_2 microwave plasma for a power of 140 W and a gas filling pressure of 6.5 Pa. (b) Emission spectra of CO_2 -Ar microwave plasma for a gas ratio of 2:1 (CO_2 :Ar), power of 154 W, and gas filling pressure of 4.1 Pa.

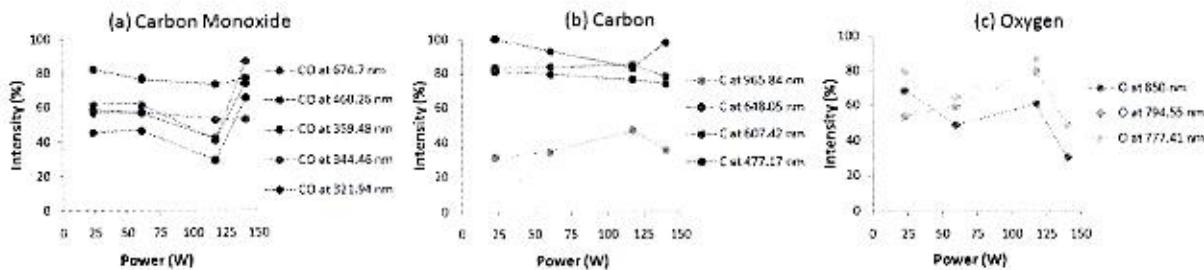


Figure 4. Comparison of intensity of emissions as a function of microwave power of the active species (a) CO, (b) C, and (c) O in the CO_2 plasma for a power range of 0-150 W and a gas filling pressure of 6.5 Pa.

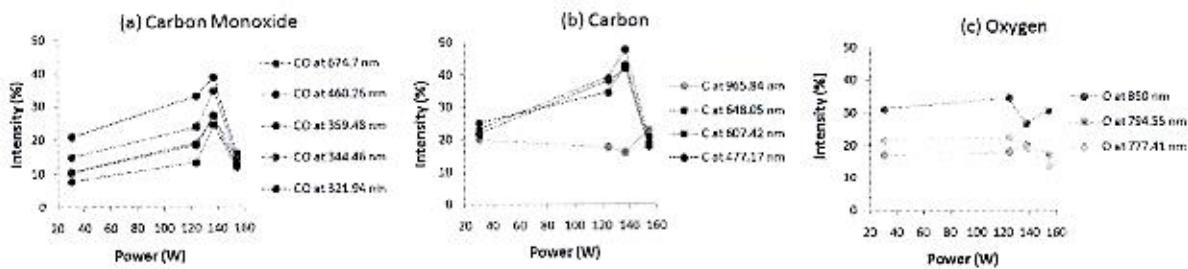


Figure 5. Comparison of intensity of emissions as a function microwave power of the active species (a) CO, (b) C, and (c) O in the CO_2 -Ar plasma for a power range of 0-160 W and a gas ratio of 2:1 (CO_2 :Ar).

We plot in Fig. 4 the emission intensities of the active species CO, C, and O in the CO₂ plasma versus microwave power. In our study, 117 W has the highest full conversion of CO₂ from a set of microwave powers used in CO₂ plasma production. We observe in the figure at 117 W that a decrease in the intensity (population) of CO species leads to an increase in the intensity (population) of some C and O species. A lower population of CO indicates that they have dissociated into C and O.

In Fig. 5, we plot the emission intensity of the same active species used in CO₂ plasma in terms of microwave power for CO₂-Ar plasma. In our study, 137 W has the highest full conversion of CO₂ from a set of microwave powers used in CO₂-Ar plasma production. The addition argon has increased the conversion of CO₂ into both CO and C unlike in the compromise in CO₂ plasma where CO population decreases with an increase in C and O populations. Argon acts an additional source of collision induced decomposition of CO₂. However, the addition of argon has increased the optimum power to 137 W which is may be due to an increased collision frequency.

4. Conclusions and recommendations

From optical emission spectroscopy, we have determined the active species present in CO₂ and CO₂-Ar plasmas as well as the electrochemical processes that produce them. It has been shown that the microwave plasma device was able to achieve CO₂ decomposition with the existence of CO and C species. From the results, we observe optimum powers for CO₂ decomposition from a set of powers used with CO₂ and CO₂-Ar plasmas. We have also observed that adding argon increased CO₂ decomposition. It is recommended that further studies should be done to understand the mechanism and determination of the optimum power in CO₂ and CO₂-Ar plasmas.

Acknowledgements

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Removal of methyl red dye from aqueous solutions using coconut product sawdust by the process of adsorption

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Abstract

The use of cheap and environment friendly adsorbents has been studied as possible alternative to commercially available adsorbents for dye removal from wastewater. This study investigates the potential use of coconut products sawdust, pretreated with formaldehyde and sulphuric acid, for the removal of methyl red from simulated wastewater. The effects of dye concentration, adsorbent dosage, pH, and contact time were studied. Results showed that adsorption percentages were observed to be higher at lower concentrations of methyl red. Percentage of dye removal increased as the amount of adsorbent and contact time was increased. Sulphuric acid treatment showed better performance compared to formaldehyde treatment. Isothermal data for adsorption followed the Freundlich model. The percentage of dye removal of the coconut sawdusts can still be improved for it to be used as an alternative adsorbent in wastewater treatment.

Keywords: Adsorption on Surfaces (68.43.-h), Biomaterials (87.85.J), Chemical equilibria and equilibrium constants (82.60.Hc), Environmental safety (89.60.Ec), Infrared spectroscopy in chemical analysis (82.80.Gk), Spectrophotometry in chemical analysis (82.80.Dx).

1. Introduction

Synthetic dyes have been increasingly used in the textile, paper, rubber, cosmetics, and pharmaceutical and food industries. Extensive use of dyes poses pollution problems in the form of colored wastewater which impart toxicity to aquatic life and are damaging the aesthetic nature of the environment [1, 2]. In addition, some dyes and/or their metabolites are either toxic or mutagenic and carcinogenic. Lots of cases throughout the world are reported about the role of dye in connection with variety of skin, lung, and other respiratory disorders [3].

The conventional wastewater treatment is not very effective in treating dyes wastewater because these colored compounds are stable in water and usually resistant to light and many chemicals. It is usually treated with either physical or chemical processes. However these processes are very expensive and cannot effectively be used to treat the wide range of dye waste [2, 4]. It is therefore of high importance to find simple and inexpensive way for their removal.

Adsorption, which is the binding of molecules or particles to a surface, is the procedure of choice among the numerous alternative techniques because of its efficiency in the removal of pollutants from effluents too stable for conventional treatment methods. Apart from the high quality product obtained, the processes have proved feasible especially if the adsorbent is inexpensive and readily available [2, 3]. New adsorbents can be found from forest and agricultural production byproducts, however, without pre-treatment processes, the adsorption capacity of these materials is very low.

The aim of this study was to investigate the possibility of formaldehyde and sulphuric acid treated coconut products sawdust such as coco lumber sawdust, coco bowl sawdust and coco husk sawdust as an alternative adsorbent for the removal of methyl red in wastewater. Formaldehyde and sulphuric acid were used to chemically treat possible adsorbents in other studies [1, 2]. The effects of various parameters such as initial dye concentration, adsorbent dosage, contact time, and pH were monitored and the percentage of dye removal calculated. The effects of formaldehyde and sulphuric acid treatment were consequently also investigated.

2. Methodology

2.1 Preparation of formaldehyde treated coconut sawdust

The coconut products obtained from the market (coco bowl and coco husk) were dried under the sunlight and were sawed to a fine powder along with the coco lumber obtained from a construction site. The coconut sawdusts were then separated by a metal sieve to get a particle size under 20 μm .

The powdered coconut sawdust was treated with 1% formaldehyde in the weight to volume ratio of 1:5 at 26 °C for 5 hours to polymerize and immobilize the color and water soluble substances. Then the sawdusts were filtered out of the mixture and were washed with distilled water to remove the free formaldehyde. It was then dried and was kept in an airtight container.

2.2 Preparation of sulphuric acid treated coconut sawdust

Powdered form coconut sawdusts were mixed with sulphuric acid in a 1:1 ratio. The mixture was exposed to sunlight for 8 hours. The sawdusts were then washed with distilled water and soaked in 1% sodium bicarbonate solution overnight to remove residue acid. The material was dried and was kept in an airtight container.

2.3 Dye solution preparation

Methyl red dye ($C_{15}H_{15}N_3O_2$) was obtained from the Natural Science Research Institute at the University of the Philippines, Diliman Quezon City. Methyl red is a pH indicator that turns red in acidic solution.

The stock solution, 500 mg/L, was prepared by mixing an accurately weighed quantity of the dye with distilled water. The experimental solution of desired concentration was obtained by successive dilutions. Dye concentrations were determined using the absorbance values measured before and after the treatment, at 617 nm with Elmer-Perkins UV-Visible Spectrophotometer. Initial pH values were obtained by addition of HCl or NaOH.

2.4 Adsorption experiment

For each adsorption experiment, 100 mL of dye solution of known concentration and pH was added to 400 mg of each of the sawdusts in a circular flat bottomed plastic container. The mixture was agitated for 5 minutes at 15 minutes interval. Samples were taken from the container at a pre determined time. The adsorbents were separated from the solution by filtration and then centrifuged at 4000 rpm for 5 minutes.

The experiment was done by varying the concentration of dye solution (50 – 250 mg/L), amount of adsorbent (0.2-1.0 g/100mL), pH (3- 7) and time of contact (15, 30, 45, 60, and 120 min).

3. Results and Discussion

3.1 Effect of initial dye concentration

Figure 1.a shows the percentage of dye removal of varying initial dye concentrations. Results show that higher percentage of dye removal occurs using the sulphuric acid treated sawdusts, followed by the formaldehyde treated sawdusts and the least percentage of dye removal is seen in the untreated sawdusts. Among the sulphuric acid treated sawdusts, coco lumber has the highest percentage of dye removal followed by the coco bowl sawdust. In the process of dye adsorption, dye molecules initially have to encounter the boundary layer effect before diffusing from the boundary layer film into the adsorbent surface. This is followed by the diffusion of dye into the porous structure of the adsorbent. At high dye concentrations, diffusion of dye through the boundary layer is harder compared to diffusion at low concentrations. Therefore, the percentage of dye removal decreased as the initial concentration of dye is increased even though the amount of dye being adsorbed is increased. This is because higher dye concentration saturates the initially available sites of the sawdust for adsorption and the interaction between the adsorbed particles is not negligible.

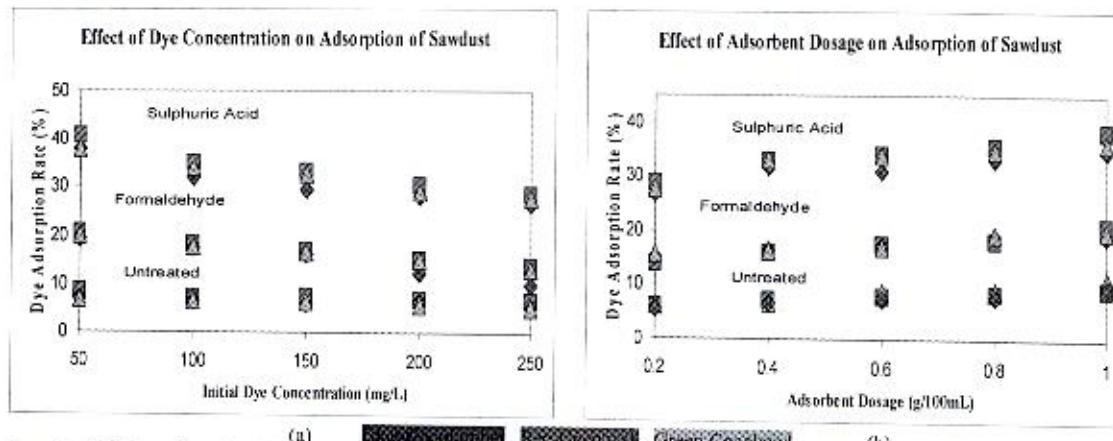


Figure 1. (a) Effect of varying initial dye concentration on adsorption of untreated and treated sawdusts. The experiment was carried out at fixed adsorbents dosage (400mg/100mL), pH (7.0) and time contact (120 mins). (b) Effect of adsorbent dosage on adsorption of untreated and treated coconut sawdusts. The experiment was carried out at fixed initial concentration (150mg/L), contact time (120 mins) and pH (7.0).

3.2 Effect of adsorbent dosage

For the case of varying adsorbent dosage, it was found out that sulphuric acid treated coconut sawdusts have the highest dye removal percentage, as shown in figure 1.b. Increasing the adsorbent dosage increase the dye removal capacity of the coconut sawdusts for each treatment. This increase is due to the increased in surface area and availability of adsorption sites brought about by the addition of adsorbents. Coco lumber and coco bowl sawdust are the ones that performed better for the sulphuric acid treatment. However, the dye removal capacity was almost the same in the formaldehyde treated sawdusts.

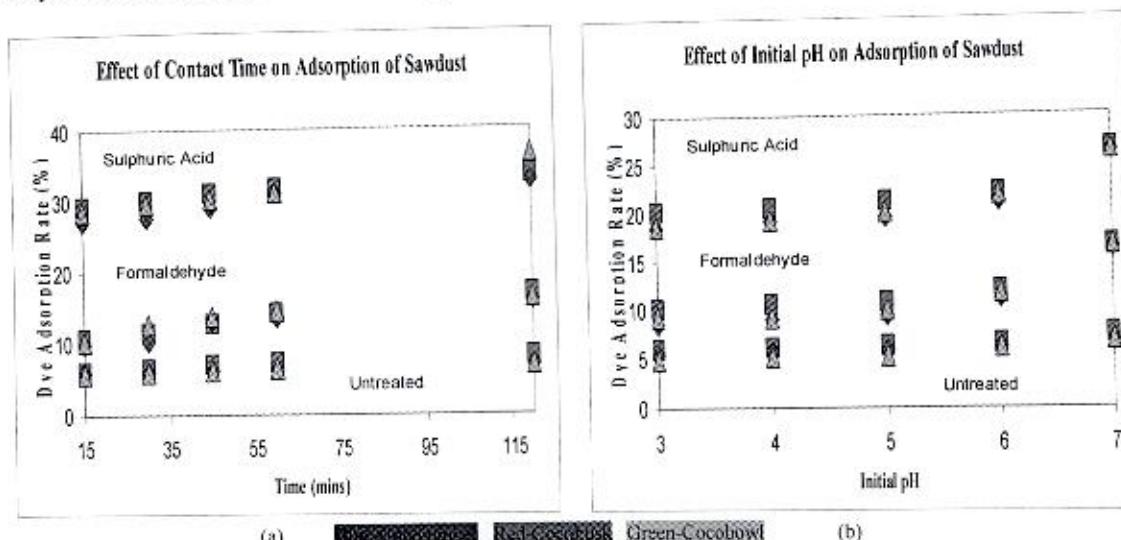


Figure 2. (a) Effect of contact time on adsorption of treated and untreated coconut sawdust. The experiment was carried out at fixed initial dye concentration (150mg/L), adsorbent dosage (400mg/100mL) and pH (7.0). (b) Effect of initial pH on adsorption of treated and untreated coconut sawdust. The experiment was carried out at fixed initial dye concentration (150mg/L), adsorbent dosage (400mg/100mL) and contact time (120 mins).

3.3 Effect of time of contact

Sulphuric treated sawdusts have the highest percentage of dye removal. It was found out in Figure 3 that increasing time of contact increased the percentage of dye removal (Figure 2.a). Although the saturation point was not shown, the number of available site for adsorption decreases as time goes by until saturation. Both treated and untreated coconut sawdusts achieved equilibrium only after 120 minutes. This may be due to the fact that sulphuric and formaldehyde treated coconut sawdusts have macro and micro pores which results in more accessibility large time contact between the dye molecules and the sawdust adsorption sites [2].

3.4 Effect of pH

The results shown in Figure 2.b show that at low pH or acidic solution, the percentage of dye removal is low for all the sawdust treatments. A slight rise is seen as the pH increased from 6 to 7 for both the formaldehyde and sulphuric acid treatment. In the untreated sawdusts, the percentage of dye removal was almost constant for all the sawdusts. As the pH of the solution decreases, the number of negatively charged adsorbents sites increased, but this did not enhance the adsorption of the positively charge dyes cation as in methyl red [5]. Sulphuric acid treated coconut sawdusts has higher percentage of dye removal compared to formaldehyde treated and untreated sawdusts. However this difference is also not significantly affected by pH. This could be due to hydrolysis of the adsorbent in water which created positively charged sites [6].

3.5 Adsorption isotherms

It is possible to express the results of the experimental adsorption measurements using equilibrium adsorption isotherms. These equilibrium models provide insights into the sorption mechanism and into the surface properties and affinity of the adsorbent. With the data from the varying dye concentrations, the Freundlich equation was employed to study the adsorption isotherm of methyl red. The Freundlich equation is an empirical relationship to describe the sorption of solutes in a liquid onto an inhomogeneous adsorption surface [4]. Freundlich equation was linearized as follows:

$$\log \frac{x}{m} = \log k + \frac{1}{n} \log C_e \quad (1)$$

Where x/m is amount of acid dye adsorbed (x) per unit weight (m) of adsorbent, C_e , is the equilibrium concentration, k and n are empirical constants and their values were obtained from the intercept ($\log k$) and slopes ($1/n$) of linear plots of $\log x/m$ versus $\log C_e$.

From Table 1, the correlation coefficients for treated and untreated coconut sawdusts were found in between 0.986-0.999. The maximum adsorption capacity for the sawdusts was 53.74 mg/g (sulphuric acid treated cocolumber), 51.84 mg/g (sulphuric treated cocobowl), and 50.00 mg/g (sulphuric treated cocohusk).

Table 1. n , k and R^2 values for methyl red on treatment with treated and untreated coconut sawdusts.

Adsorbent		n values	k values	R^2 values
Untreated	Cocolumber	1.158	4.263	0.997
	Cocohusk	1.160	3.627	0.986
	Cocobowl	1.170	4.242	0.991
Formaldehyde Treated	Cocolumber	1.385	1.028	0.994
	Cocohusk	1.740	1.186	0.903
	Cocobowl	1.375	1.070	0.992
Sulphuric acid Treated	Cocolumber	1.411	2.347	0.999
	Cocohusk	1.403	2.070	0.995
	Cocobowl	1.348	2.077	0.949

Conclusions and Recommendation

The removal of methyl red from simulated wastewater using treated and untreated coconut sawdusts has been investigated for different conditions. For this study, it was found out that chemically treated (sulphuric acid and formaldehyde) sawdusts showed better performance compared untreated sawdusts. In addition, higher percentage of dye removal was obtained from the sulphuric treated sawdusts. However, this result may be affected by the concentration of the chemicals used. This result suits the findings in other adsorbent experiments. However, the highest percentage of dye removal recorded from this study is only 41% which is very low compared to similar studies [1, 2] which used sugarcane bagasse (96% dye removal). This low percentage could be attributed to the difference in particle size of the adsorbents and the continuous agitation of the sample solution which was utilized in other studies. It is recommended that similar methodology should be used in the coconut sawdusts.

The adsorption of methyl red by coconut sawdusts was dependent on the initial methyl red concentration in the wastewater, the adsorbent dose and on the contact time. The results show that the percentage of dye removal increased as the amount of adsorbent increased. Higher adsorption percentages were observed at lower methyl red concentrations. Dye removal percentages increases with time until saturation of available sites occur. Among the three coconut sawdusts, no significant difference was found in the percentage of removal. Percentage errors are small enough to be not significantly affect the results. This means that any of the sawdusts can be used as adsorbent. Since coconut by-products are considered as waste, the data obtained in this experiment may be useful for designing an economically cheap wastewater treatment for dye removal using coconut products as adsorbents.

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Adsorption of Chromium(VI) for Wastewater Treatment by Native Sawdust

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Abstract

Adsorption of chromium(VI) for wastewater treatment using native sawdust derived from hardwood tanguile, and softwoods palochina and coconut were investigated. Various parameters such as adsorbent surface area, adsorbent dose, adsorbate concentration, contact time and pH were studied. Equilibrium was reached after 2 hours at an optimum pH of 2. Langmuir isotherm model fitted with the adsorption data with $R^2 = 0.978 \pm 0.008$. Softwoods were found to be better adsorbents, with higher maximum adsorption capacities for coconut(0.455mg/g) and palochina(0.444mg/g), than treated hardwood tanguile(0.387mg/g). Results indicate that HCl-treated coconut sawdust is the most efficient adsorbent with the highest chromium removal of 74.53% at equilibrium.

Keywords: Adsorption on Surfaces (68.43.-h), Biomaterials (87.85.J), Chemical equilibria and equilibrium constants (82.60.Hc), Environmental safety (89.60.Ec), Infrared spectroscopy in chemical analysis (82.80.Gk), Spectrophotometry in chemical analysis (82.80.Dx).

1. Introduction

Heavy metal pollution in wastewater has been an increasing problem due to rapid industrialization. One of the major heavy metals in focus due to its hazardous effects is chromium. Its compounds gain access to ground and surface waters through industrial processes such as automobile refinishing, electroplating, leather tanning, paint, photography, and aerospace applications [1,2]. Chromium is one of the sixteen top toxic pollutants because of its carcinogenic effects on human health, especially in its hexavalent form [1]. The maximum limit for chromium(VI) concentration in drinking water is 0.05mg/l. [2].

Previous studies on the removal of hexavalent chromium from wastewater indicate that adsorption using sawdust is one of the most highly efficient and low-cost method [2,3]. Hence, the use of sawdust in wastewater treatment is a practical if not the best way to help reduce water pollution. To enhance the adsorption capacity and efficiency of adsorbents, it can be pretreated chemically or mechanically [3].

There are different types of wood found in the Philippines. They can be classified into hardwood and softwood and combinations of both. Among the hardwood are *tanguile*, *kamagong*, and *narra*. Examples of softwood are *palochina*, coco lumber, and pine. In this study, sawdust from *tanguile*, *palochina* and coco lumber are used. The study aims to establish the adsorption capacity of the sawdust mentioned earlier and to differentiate between the two types of wood--hardwood and softwood. Various parameters such as the adsorbent surface area, adsorbent dose, adsorbate concentration, contact time and pH are investigated.

This paper is composed of five (5) parts. In part 2, the different models used to compute for the adsorption capacity of sawdust are discussed. Sample preparation and characterization as well as the experimental protocols are presented in part 3. Results of the experiment are presented and discussed in part 4 and lastly, the conclusions are expressed in part 5.

2. Theory

In adsorption, pollutants are removed by adherence to the surface of a solid (adsorbent) by physical forces. These adsorbents such as sawdust are porous substances that have high surface area and high affinity for the pollutant. In its aqueous phase, hexavalent chromium can be reduced through direct and indirect reduction mechanisms. In direct reduction mechanism, chromium(VI) is directly reduced to lower oxidation state chromium by direct contact with the electron-donor groups of the adsorbent that have lower reduction potential value than chromium(VI). In indirect mechanism, three steps are involved in the process; (i) binding of anionic chromium(VI) to the positively charged groups present in the adsorbent surface, (ii) reduction of chromium(VI) to lower oxidation state chromium by electron-donor groups, and (iii) release of reduced chromium into the aqueous phase due to electronic repulsion between positively charged groups. Therefore, as the number of

electron-donor groups which mainly affects the reduction of chromium(VI) decreases, more chromium(VI) bound on the adsorbent will remain in its hexavalent form[4].

Concurrently with the reduction of chromium(VI), oxidation of lignin takes place. Lignin and cellulose are the main components of almost all the plants. The main constituent of most of the physical and chemical properties of plants is lignin, and one difference between hardwoods and softwoods is their lignin content. Compared with hardwoods, softwoods contain 25% to 50% more lignin [6]. Oxidation of lignin leads to the formation of carboxyl and hydroxyl groups on the adsorbent surface [8].

The adsorption mechanism is described by the Langmuir isotherm model. It assumes that the uptake of metal ions occurs on a homogeneous surface by monolayer adsorption without any interaction between adsorbed ions [1]. It is also appropriate for adsorption mechanisms wherein the number of adsorption sites is small relative to the number of metal ions. The model is shown below where q_e (mg/g) is the adsorption capacity, θ (mg/g) is the Langmuir constant related to max. adsorption capacity and is equal to 0.942, b (L/mg) is the Langmuir constant related to energy of adsorption and is equal to 0.251, and C_e (mg/L) is the equilibrium concentration.

$$\text{Langmuir} \quad q_e = \frac{\theta \cdot b \cdot C_e}{1 + b \cdot C_e} \quad (1)$$

3. Setup and Methodology

The tanguile, palochina and coconut sawdust are collected from a local sawmill and were sieved at two sizes: 105-145 μm (fine) and 210-420 μm (coarse). Each sample is washed twice with deionized water to remove any soluble materials that may interact with the metal ions. For each sawdust type, half is left untreated, and the other half is treated by reaction with 0.1M Hydrochloric acid (HCl) for 15 minutes. The sawdust are dried and the FTIR spectra are obtained for the treated sawdust, and the sawdust after adsorption on a Shimadzu Prestige 21 FTIR spectrophotometer.

Test solutions are prepared by dissolving exact amount of $\text{K}_2\text{Cr}_2\text{O}_7$ (adsorbate) in deionized water, and addition of exact amount of sawdust (adsorbent) to the solution. Adsorption experiments are conducted by varying the surface area (fine and coarse), adsorbent dose (0.25, 0.50, 0.75, 1.0, 1.25g/25mL), adsorbate concentration (0.25, 0.50, 0.75, 1.0, 1.25mg/100mL), contact time (5, 30, 60, 120, 240mins) and pH (2, 4, 6, 8, 10) at a constant temperature of 300K. The pH of the solution is maintained at a pH of 2 by adding 0.1M HCl or NaOH. The mixture is centrifuged then filtered using Whatman No.42 filter paper. Equilibrium concentration of chromium(VI) for different sawdust are determined by reacting with 1,5-diphenylcarbazide as colorimetric reagent, and the absorption is measured using Perkin Elmer Lambda 1 UV/Visible Spectrophotometer at 540 nm by colorimetric techniques.

4. Results and Discussions

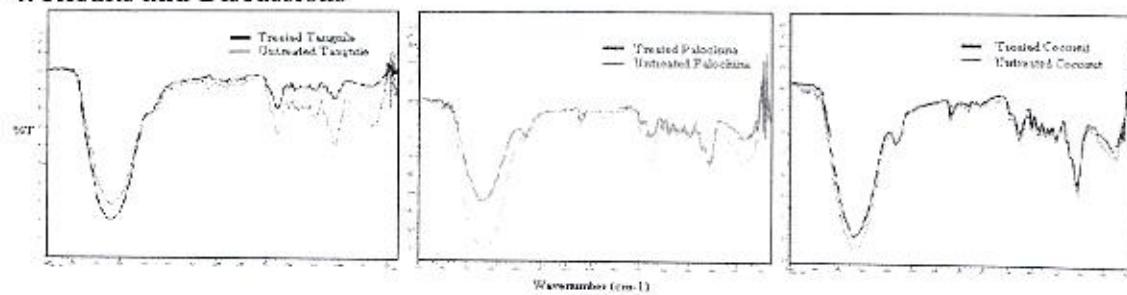


Figure 1. FTIR spectra for untreated and treated sawdust before adsorption

FTIR spectra of untreated and treated sawdust before adsorption of tanguile, palochina and coconut sawdust are shown in Figure 1. For each type of sawdust, the FTIR spectra showed peaks at 3350, 2350, 1650, 1025, and 650 cm^{-1} . Increase in the intensity of some untreated sawdust peaks such as those for 3350, 1650, 1025 and 650 cm^{-1} for palochina and coconut sawdust were observed, indicating an increase in the concentration of their assigned compounds which are hydrogen-bonded compounds, amines, C-O bonded compounds, and alkynes respectively. Otherwise, decrease in peak intensity indicates decrease in the concentration its corresponding compound.

Table 1 displays the percent chromium removal for untreated and treated adsorbents for fine and coarse sizes. Sample conditions of 0.5g/25mL adsorbent dose, 0.5mg/100mL adsorbate concentration, 4 hours contact time, and optimum pH of 2 at a constant temperature of 300K were carried out. It can be observed from Table 1 that adsorption by HCl-treated adsorbents removes chromium(VI) by 41.9% \pm 1.3 higher compared to untreated adsorbents. The HCl treatment increases the %adsorption of sawdust by the removal of soluble wood extracts,

resulting to the increase in surface area and porosity of the sawdust. It is noted that surface area increases the number of possibly available electron-donor groups in the adsorbent for contact with chromium(VI), thus increasing adsorption. For the same adsorbent dose, fine sawdust adsorbs chromium(VI) better than coarse size sawdust by $7.7\% \pm 1.3$.

Table 1. Adsorption of chromium(VI) by untreated and treated adsorbents for two different sizes.
[Conditions: adsorbent 0.5g/25mL, adsorbate conc. 0.5mg/100mL, contact time 4 hours, pH 2, temp. 300K]

Adsorbents	% Chromium Removal	Adsorbents	% Chromium Removal
Treated Tanguile (coarse)	59.56	Untreated Tanguile (coarse)	17.53
Treated Tanguile (fine)	68.64	Untreated Tanguile (fine)	25.85
Treated Palochina (coarse)	70.98	Untreated Palochina (coarse)	26.23
Treated Palochina (fine)	77.16	Untreated Palochina (fine)	36.07
Treated Coconut (coarse)	74.89	Untreated Coconut (coarse)	33.92
Treated Coconut (fine)	80.88	Untreated Coconut (fine)	40.86

For the following adsorption experiments, treated coarse-size sawdust were used as adsorbent.

The effect of adsorbent dose on the adsorption of chromium(VI) for tanguile, palochina and coconut sawdust are presented in Figure 2a. As shown in the figure, %Chromium removal for all sawdust types increases with the adsorbent dose due to the increase in contact surface area as adsorption sites. Thus, probability of chromium(VI) adsorption increases as well as adsorption efficiency.

In Figure 2b, the effect of adsorbate concentration on adsorption is presented. It can be observed that percentage of chromium removal for all sawdust types decreases with an increase in adsorbate concentration. At higher concentrations, the available electron-donor groups in the adsorbent surface decreases due to the increasing initial number of chromium(VI) ions, resulting to lower %Chromium (VI) adsorbed.

For Figure 2c, it can be observed that adsorption of chromium(VI) increases with longer contact time between sawdust and chromium(VI) ions. After 120 minutes, no significant change in the %Chromium removal was observed for tanguile, palochina and coconut sawdust, indicating that equilibrium phase has already been reached through adsorption. Since 100% chromium removal was never reached at equilibrium, it indicates that the number of adsorption sites is not enough to reduce all the chromium(VI) ions in the solution, as assumed by the Langmuir model. Further increase in the adsorbent dose for the same experimental conditions could lead to 100% chromium removal.

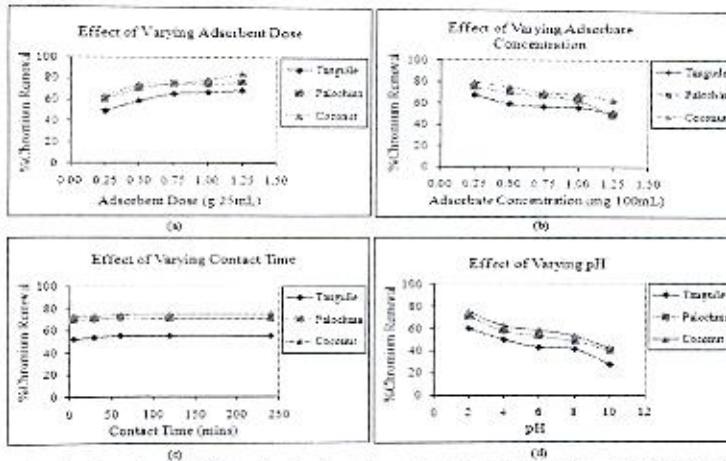


Figure 2. Graphs showing the effects of adsorbent dose, adsorbate concentration, contact time, and pH to adsorption of Chromium(VI) at a constant temperature of 300K.

The effect of pH on chromium(VI) adsorption is shown in Figure 2d. As can be observed, optimum pH is 2, and increasing the pH decreases the %Chromium removal, and thus adsorption efficiency. As the pH of the aqueous solution decreases, more hydrogen ions from HCl coordinate with the carboxyl and hydroxyl groups in the adsorbent surface making it more positive. Thus, the more positive the surface of the adsorbent, the faster the rate of chromium(VI) reduction from aqueous phase, due to enhanced binding of anionic chromium(VI) species with the positively-charged groups.

As can be observed from the experimental data, for all varying parameters, coconut sawdust exhibits the greatest %Chromium removal followed by palochina and then by tanguile. This agrees with the expected result wherein softwoods adsorb chromium(VI) better than hardwoods due to their higher lignin content, which creates

more positive adsorbent surface concurrently with chromium(VI) reduction. Thus, softwood sawdust like coconut and palochina adsorbs better than hardwood sawdust like tanguile.

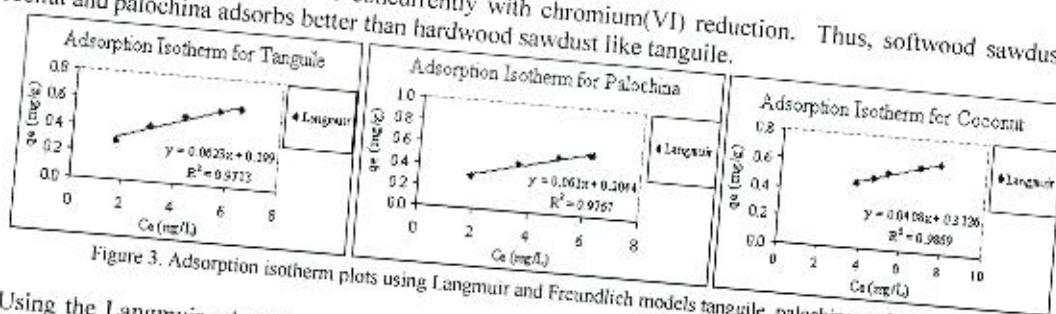


Figure 3. Adsorption isotherm plots using Langmuir and Freundlich models tanguile, palochina, and coconut.

Using the Langmuir adsorption model, the adsorption mechanism of the system was analyzed. From the slopes of the plots in Figure 3, a decrease in the amount of adsorbed chromium(VI) per gram of the adsorbent is observed for increasing equilibrium concentrations. This indicates that the plot slowly approaches saturation point wherein no significant concentration of chromium(VI) can be further adsorbed even for a longer contact time, as was shown in Figure 2c. These isotherm plots successfully described the adsorption mechanism for the three sawdust wherein, the number of adsorption sites is not enough to reduce all the chromium(VI) ions in the chromium-sawdust mixture due to insufficient adsorbent dose. Using the Langmuir model, the calculated adsorption capacities for treated tanguile, palochina, and coconut sawdust were determined to have values of 0.387, 0.444, and 0.455mg/g respectively.

5. Conclusions

Studies show that fine-size sawdust removes chromium(VI) in wastewater by 7.7%±1.3 higher than coarse-size sawdust. HCl-treated coconut sawdust was found to be the best adsorbent for chromium(VI), with a percentage chromium removal of 74.53% at equilibrium conditions of 120 minutes contact time and optimum pH of 2. Percentage Chromium removal increases with increasing adsorbent dose or contact time, and decreases with increasing adsorbate concentration or pH. Langmuir isotherm model fitted with the adsorption data with $R^2 = 0.978 \pm 0.008$, indicating smaller number of adsorption sites relative to the number of chromium(VI) ions in the mixture. Softwood sawdust was found to be better adsorbents, with higher maximum adsorption capacities for coconut(0.455mg/g) and palochina(0.444mg/g), than treated sawdust derived from the hardwood tanguile(0.387mg/g). Results indicate that HCl-treated coconut sawdust is the most efficient adsorbent with the highest %chromium removal of 74.53% at equilibrium.

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CERTIFICATION OF EMPLOYMENT AND COMPENSATION

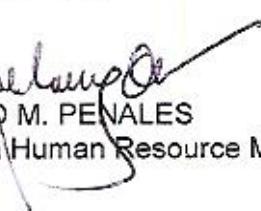
TO WHOM THIS MAY CONCERN:

This is to certify that Ms. MA. AMELIA S. MINOZA is employed by The Church of Jesus Christ of Latter-day Saints since August 01, 1997 up to the present. She has a full-time appointment as ACCOUNTING CLERK in the Financial Reporting & Controls Department. She receives an equivalent annual compensation of P460,616.00 inclusive of holidays and 13th month pay.

This certification is being issued upon the request of Ms. MINOZA for whatever legal purposes this may serve.

Issued this 27th day of June, 2008 at Quezon City, Metro Manila.

Certified by:


NILO M. PEÑALES
Area Human Resource Manager