Effect of the Electrical Conductivities of Corona Discharge Ground Rolls on Surface Treatment

Presented by:
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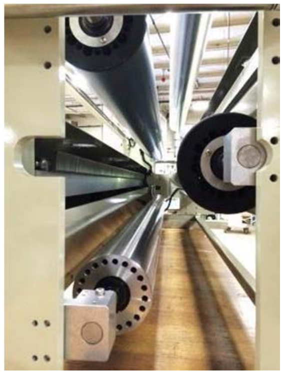
Discussion Agenda

- What Defines a Corona Treatment System
- Review of Physical, Thermal and Electrical Properties of Conductive Ground Roll Coverings of Corona Treatment Systems
- Description and Application of Equipment and Processes for this Study
- Experimental Design
- Results/Conclusions

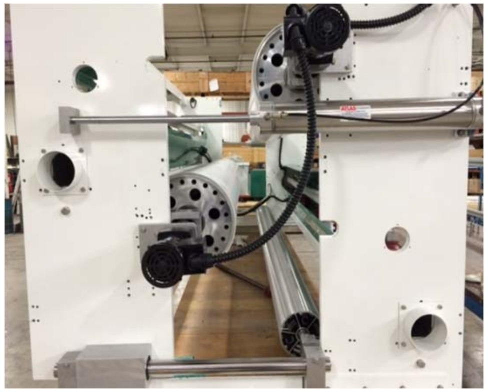
Types of Corona Treatment Systems





Conductive/Bare Roll Systems

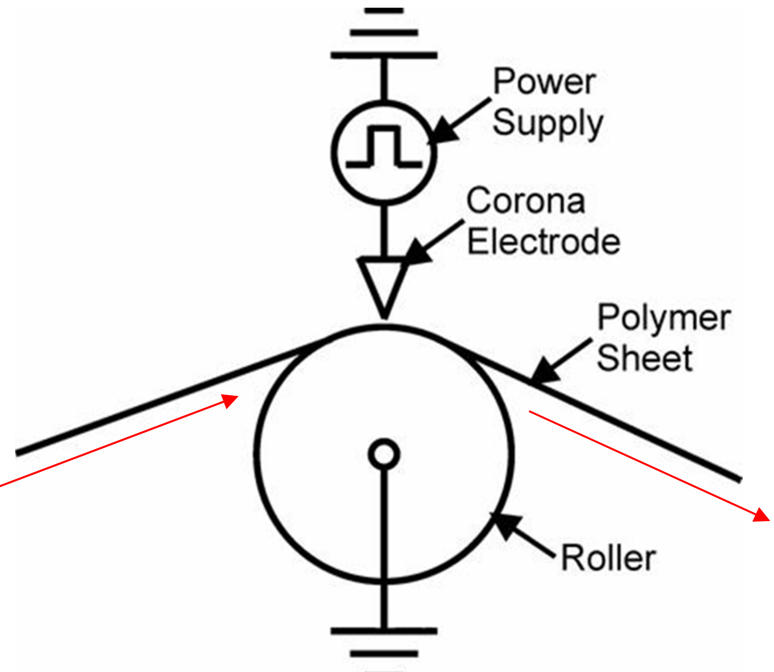
Non-Conductive/Covered Roll Systems

Purge/Pressurized Systems

Split-Box Systems

Principle of Corona Treatment



- Polymer surfaces are continuously treated at a wide range of web speeds

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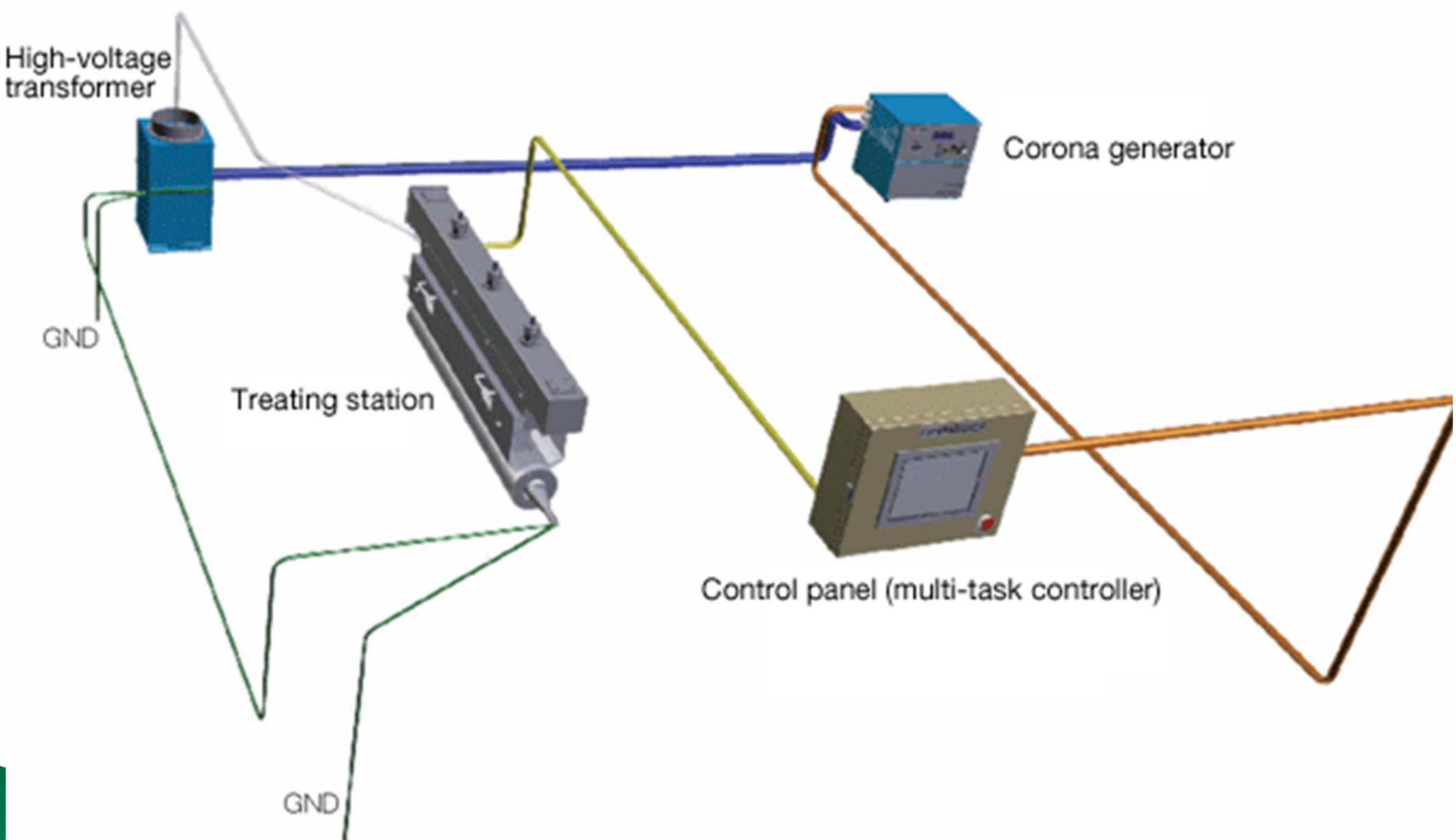
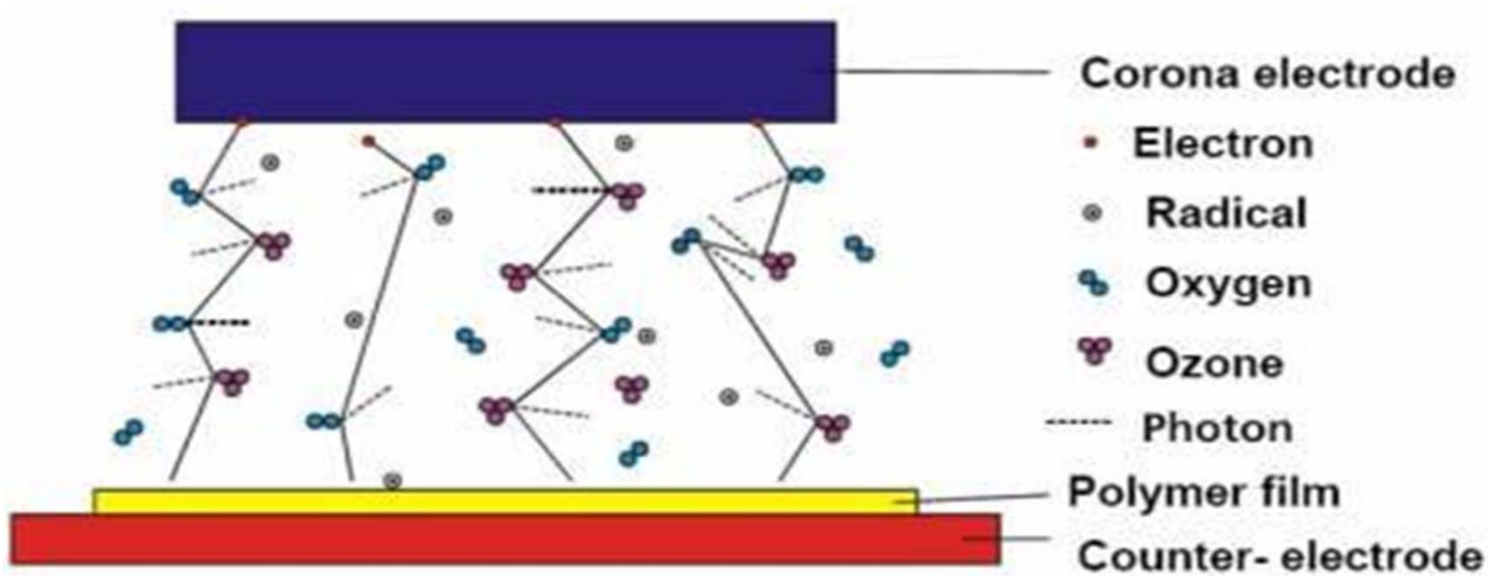
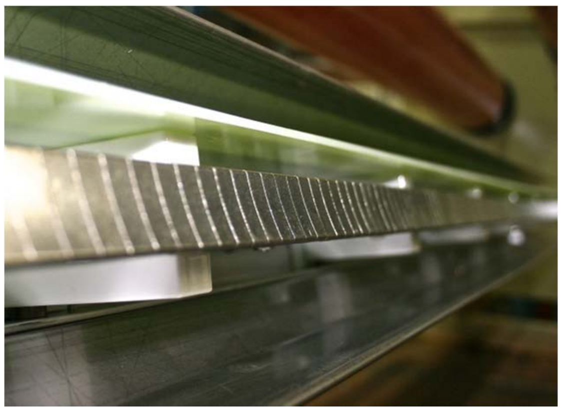


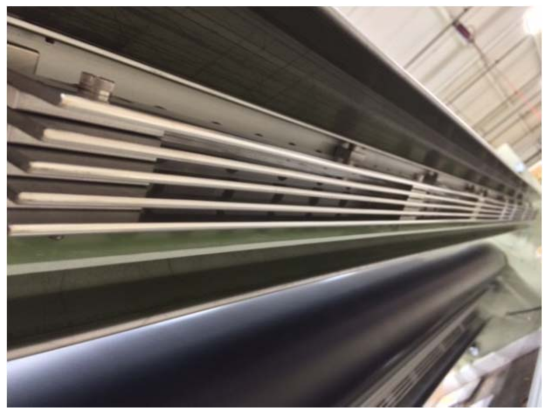
How Corona Treatment Promotes Adhesion



- Corona energy breaks molecular bonds on surface of a substrate
- Open molecular chains bond with free oxygen radicals forming additional polar groups on the substrate surface.
- Polar groups have strong affinity to polar inks, coatings and adhesives; therefore improving wettability and the potential for better adhesion.

Common Types of Corona Discharge Electrodes





Aluminum, Stainless Steel, Titanium

Covered (Insulated) Roll Systems

Ceramic

Covered or Bare Roll Systems

Types of Corona Ground Roll Coverings

Roll Covering Types	Dielectric Strength	Approx. Covering Longevity	Relative Cost
Synthetic Rubber (Hypalon™)	400 v/mil	6-12 months	Low
Epoxy	450 v/mil	6-12 months	Low
Silicone	450 v/mil	6-12 months	Low
Ceramic	500 v/mil	10+ years	Medium
Glassed Steel	900 v/mil	10+ years	High

Definition of Key Terms

- Dielectric Strength - Key property of an insulating polymer film:
    - Dielectric Strength Ratio - Breakdown voltage – to - film's thickness.
- Dielectric Constant - Ability of a material to store electrical energy in an electric field (i.e., corona discharge).
- Breakdown Voltage - Maximum voltage a polymer film can withstand before a conducting path forms through it.
- Resistivity – How strongly a material opposes the flow of electric current (i.e., corona discharge)

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- Advantageous for packaging films to hold energy at their surfaces for the purpose of ink, coating, or lamination adhesive wetting and adhesion.

- Films having a higher dielectric constant is a +

- Dielectric constant relates to the permittivity of the polymer film and its ability to polarize in response to an applied field such as a corona discharge.

- The greater the polarization of a polymer film from a corona discharge at a defined watt density, the greater its dielectric constant.

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Trial - Electrical Properties of ECTFE and LDPE polymers

Properties	ECTFE	LDPE
Volume resistivity (Ω·cm)	$> 10^{15}$	$> 10^{15}$
Surface resistivity (Ω)	$> 10^{14}$	$> 10^{15}$
Dielectric strength at 1mm thickness (kV/mm)	30-35	20-160
Relative dielectric constant at 1kHz	2.5	2.3
Dissipation Factor at 1kHz	0.0016	0.0003

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ECTFE and LDPE chosen for this study:

- Similar resistivity
- Similar dielectric strength
- Similar dielectric constants
- Vastly different dissipation factors

- 'Dissipation Factor': the percent of electrical energy absorbed and lost when electrical current is applied to an insulating material, such as a polymer film.

- ECTFE has a five-fold higher dissipation factor than LDPE.

- One of our Questions…Will this difference influence treatment longevity

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Study Objectives:

Given the electrical properties of these two films...

1) What is effect of the dielectric properties of different conductive ground roll coverings have on the initial surface energy achieved at various watt density corona treatments?

2) What is the relative dissipation (or conversely retention) of surface energy when employing these roll covering types?

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Trial - Corona System Roll Covering Properties

	Plasma-Sprayed Conductive Ceramic	Conductive Sleeve
Shore A Hardness		65
Rockwell C Hardness	70	
Nominal Thickness Range - mils	40-120	.080-.082"

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Films exposed to corona discharges using a roll-to-roll process employing ITW Pillar Technologies' ceramic electrode technology in combination with:

- Plasma-sprayed conductive ceramic (over steel) ground roller manufactured by American Roller.
  ... OR ...
- Conductive sleeve (over steel) manufactured by Jemmco.

- Trial watt densities ranging from 2 to 5 Watts/ft^2/min

- Corona discharge frequency fixed to preclude changes in the dissipation factor (loss factor).

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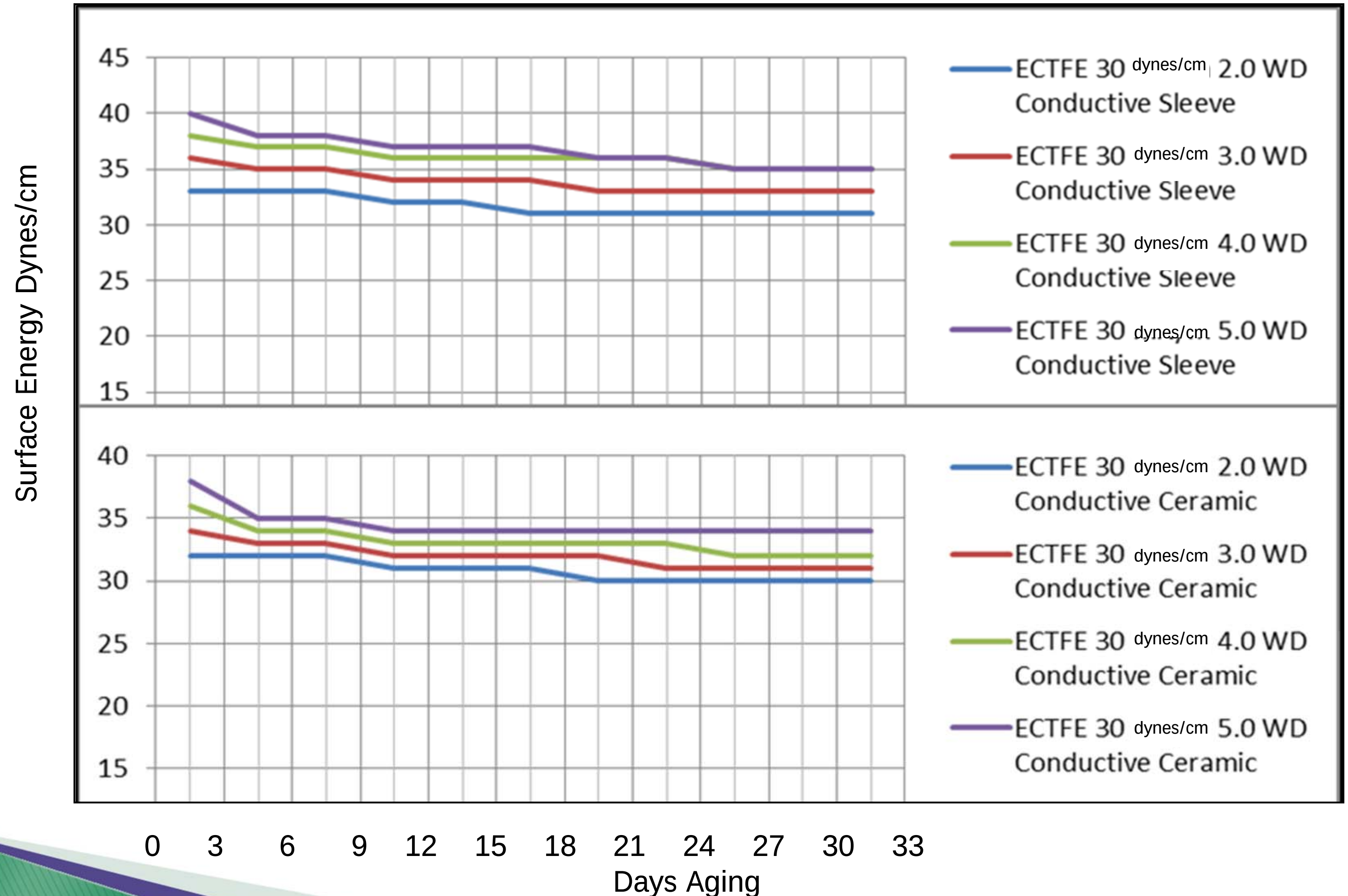
Corona Treatment and Aging Effects of ECTFE Using Conductive Sleeve and Conductive Ceramic Roll Coverings



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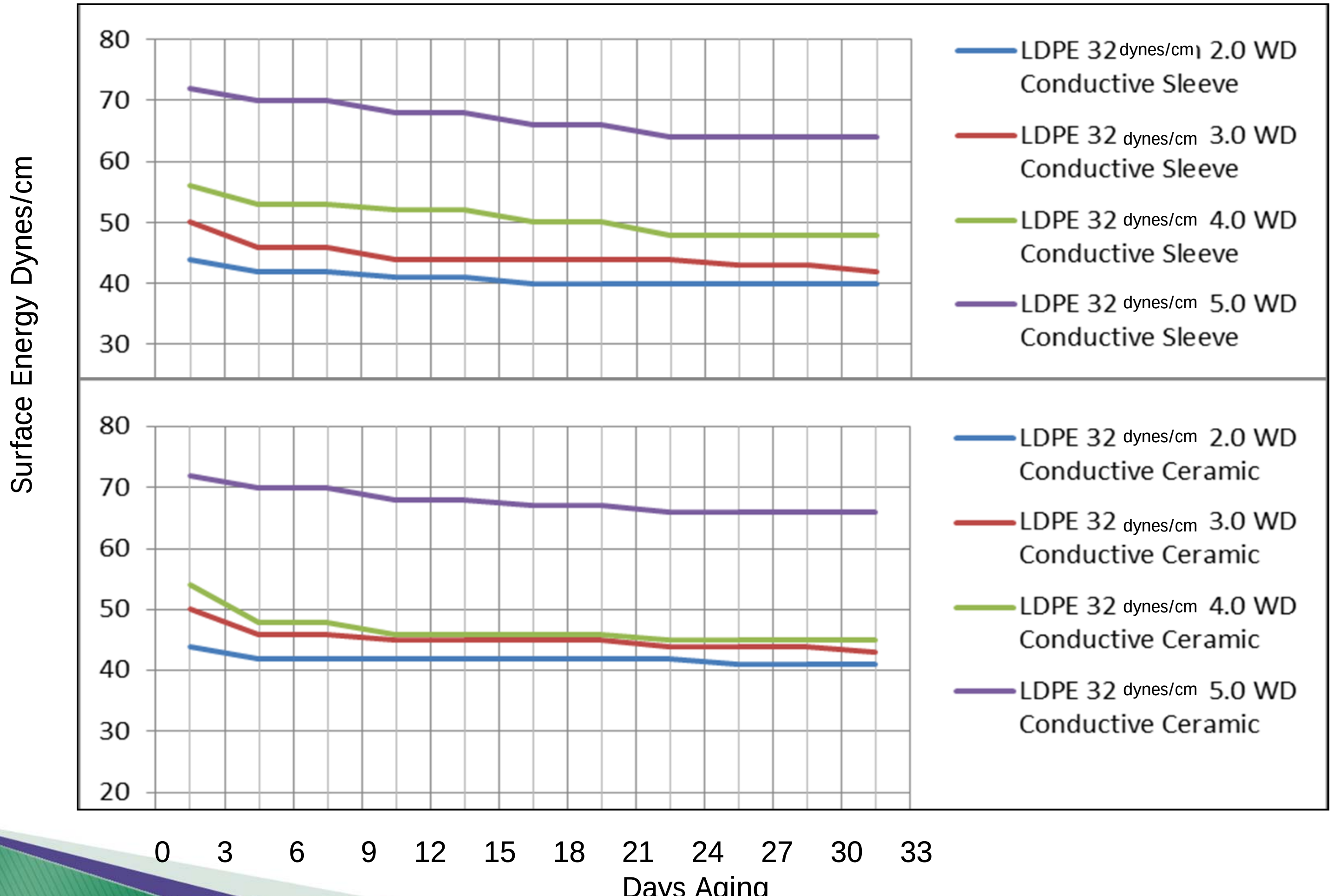
Corona Treatment and Aging Effects of LDPE Using Conductive Sleeve and Conductive Ceramic Roll Coverings



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Key Findings/Confirmations:

- Corona treatment aging effect is prevalent with both films and when using both ground roll covering variants.
- ECTFE is less polar than LDPE
- Conductive sleeve technology provided higher initial surface energies to the ECTFE film within the 2 to 5 $W/ft^2/min$ range, as opposed to the conductive ceramic roll covering.
- This advantage did not present itself within the LDPE trials.
- ECTFE films treated with conductive sleeve technology stabilized at higher surface energy levels after the trial period than the ECTFE films treated with a conductive ceramic roll covering.

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Key Findings/Confirmations:

- LDPE films treated by either conductive roll covering achieved the same initial surface energy level.

- LDPE treated at the highest power density level of 5 $W/ft^2/min$ stabilized within the range of 64 to 66 dynes/cm considering both ground roll coverings, a significant step change from 4 $W/ft^2/min$ which stabilized within the range of 45 to 48 dynes/cm.

- Stabilization surface energy values for both roll covering variants of the LDPE trial materials under 4 $W/ft^2/min$ were similar.

Conclusions:

- Dielectric properties of conductive ground roll coverings can influence the initial surface energy attainable with partially fluorinated, non-polar polymers such as ECTFE.

- Improvement in initial surface-free energy accompanied use of conductive sleeve (over steel) technology when compared to plasma-sprayed conductive ceramic technology.

- Higher level surface energy stabilization of ECTFE can improve with conductive sleeve technology.

Conclusions:

- Dissipation factor was not a definable factor in this study.
- A breakdown voltage "threshold" may be crossed by which polymer surfaces for films such as LDPE can become overpopulated with low molecular weight oxidized materials.
- Further study warranted to examine certain electrical property and current distribution differences between conductive ground roll coverings to discern how surface treatment improvements can be optimized.

Thank you for attending:

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