Solicitud 263378

Datos generales

Multi-disciplinary research (Investigación multidisciplinaria)

Si

Key word (Palabra clave)

triborheology, coefficient of friction, materials, lubrication,prosthesis

Título de la propuesta en español

Estudio Triboreológico de Sistemas Sólido/Líquido con Aplicaciones Médicas

Title of the proposal (Título de la propuesta en inglés)

Triborheological Study of Solid/Liquid Systems with Medical Applications

Resumen ejecutivo en español

La interacción entre fluidos complejos y superficies sólidas es importante en muchos proce sos fisiológicos, como el flujo de líquido sinovial entre las superficies de la articulación de la rodilla que experimentan flexión o la lubricidad del ojo. Las propiedades de tales fluidos vis coelásticos y cómo interactúan con las superficies circundantes son clave para sus funcion es fisiológicas. En este proyecto, combinamos triboreología y reología para obtener informa ción esencial para comprender y abordar los problemas de fricción, desgaste y lubricación relevantes para la osteoartritis.

Executive summary (Resumen ejecutivo en inglés)

The interaction between complex fluids and solid surfaces is important in many physiologi cal processes, such the flow of synovial fluid between knee joint surfaces undergoing flexio n or the lubricity of the eye. The properties of such viscoelastic fluids and how they interact with surrounding surfaces are key for their physiological functions. In this project, we comb ine triborheology and 'bulk' rheology to obtain essential information for understanding an d addressing issues of friction, wear and lubrication relevant for osteoarthritis.

Overall objective (Objetivo general)

To investigate the frictional dynamics of several solid-liquid systems, mainly biomaterials fo r prosthesis and tissue engineering. Therefore, to improve the worldwide population health through research. In particular, osteoarthritis, which has become a serious health and econ omic issue in my Mexico.

Specific Objectives (Objetivos específicos)

- Characterize the rheology of different HA samples under shear. Define, prepare and c haracterize other lubricant fluids.
- Search for/Fabrication of - substitute materials of cartilage Characterize different prop erties of the surfaces i.e. mechanical properties, roughness, etc
- Perform the experiments with the triborheometer

Background (Antecedentes)

The interaction between complex fluids and solid surfaces are important in many physiolo gical processes, such the flow of synovial fluid between knee joint surfaces undergoing flexi on or the lubricity of the eye. The properties of such viscoelastic fluids and how they interac t with surrounding surfaces are key for their physiological functions. In this project, we com bine triborheology and 'bulk' rheology to obtain essential information for understanding a nd addressing issues of friction, wear and lubrication relevant for osteoarthritis. - Why the f ocus on systems relevant to Osteoarthritis (OA)? Osteoarthritis is the most common rheum atic disease in the general population [1] and can significantly impair the quality of life of in dividuals. This disease affects millions of people in Mexico and the world. According to Arth ritis Research, millions of people in the Mexico alone seek treatment for osteoarthritis each year and this number is expected to double by 2030. The prevalence of OA in Mexico is only partially known, but a recent study indicates a prevalence of 10.5% [2]. Furthermore, societal and economic costs can be enormous, with up to 1/3 of OA sufferers retiring early or reduci ng the hours they work because of their condition – it is estimated that million working day s are lost in the Mexico because of osteoarthritis. This is therefore a very timely project that addresses an important subject. - This project combines the complementary techniques of rheology (looking at the fluids response to imposed stress) and triborheology (dealing with friction and lubrication in the presence of a fluid) to understand the behaviour of complex fluids and their interaction with solid surfaces for the improvement of human health. This r esearch is important as many physiological processes involve fluids that exhibit a complex r heology (e.g. saliva in the oral cavity and the squeezing flow of synovial fluid between joints under compressive loads) in which their response to applied stress (or strain) involves a co mbination of solid-like elasticity and liquid-like ability to flow. These viscoelastic properties are key for their physiological functions and their effective interaction with surrounding sur faces. In this project, we focus on biofluid analogues and prosthetic fluid/materials relevant for osteoarthritis. Osteoarthritis is a degenerative joint disease that can hinder the quality o f life of individuals and cause large societal and economic burden. It affects millions of peo ple in Mexico (disability-adjusted life year, DALY-193). The human skeletal system is made u p of just over 200 bones, which meet at junction points. The knee joint is a type of hinge joi nt that is able to handle large loads. Articular cartilage and synovial fluid in the joint enable movements at certain coefficient of friction. It is known that if a knee has low coefficient of friction, it can keep healthy without wearing. Diseases and traumas can unbalance the biol ogical equilibrium healthy knee function. Even with the aid of pharmaceuticals and physic al treatment the relatively low regenerative nature of articular cartilage may eventually lea d to artificial replacement of the joint. Hyaluronic acid (HA) is the main rheologically functi onal component in the synovial fluid that lubricates and protects the joints. This protection is lost in osteoarthritis. We aim therefore to address questions such as: How does HA degra de under different conditions? How does the molecular architecture of HA affect the rheolo gical properties and lubrication ability of the fluids? How can prosthetic fluids/materials use d in this context be improved? We will use a combination of rheology, together with triborh eology to gather essential information for understanding and addressing issues of friction, wear and lubrication. By studying these fundamental properties, we open the door to the d evelopment of new systems using both natural and synthetic materials, in order to substitu te current systems and/or improve their lifetime and safety.

Description (Descripción)

Many physiological processes, such the squeezing flow of synovial fluid between our knee j oints or the motion saliva while we eat, involve fluids that exhibit a complex rheology in whi ch their response involves a combination of solid-like elasticity and liquid-like ability to flow. These so called viscoelastic properties are key for their physiological functions and their int eraction with the surfaces surrounding them. This project combines rheology and triborhe ology to understand the behaviour of complex fluids and their interaction with solid surfac es for the improvement of human health. Tribology is the study of the friction between two

surfaces rubbed against each other and rheology focuses on the fluids response to impose d stresses. The combination of these two studies results in triborheology, which is essential for understanding and addressing issues of wear. There are many examples where these st udies can be applied, such as the wearing of knee cartilage, the lubricity of the eye, as well as the friction and flow of lubricating greases in the skin. Here, we focus on biofluid analog ues and prosthetic fluids/materials relevant for osteoarthritis. Osteoarthritis is a degenerativ e joint disease that affects millions of people in Mexico and the world. It can be very painful (many people report being in constant osteoarthritis-related pain), resulting in low life quali ty and causing large societal and economic burden. By studying these fundamental prope rties new systems can be developed using both natural and synthetic materials which may substitute or improve current systems and improve their lifetime or safety. The proposal foc uses on building research excellence in Engineering, and is aligned with the Mexico priority themes identified by Conacyt "Manufacturing the Future" and "Healthcare Technologies". T his proposal contributes to addressing an important health problem in the Mexico - osteoa rthritis, which causes significant individual, economic and societal burden. Estimates indic ate that millions of people/year seek treatment for osteoarthritis in the Mexico, high percen tage of whom are in constant pain, with some of them retiring early or reducing their worki ng hours. By advancing our capabilities in fluid/material characterisation, the project contri butes to the Mexico´s formulation capabilities, a priority highlighted in the Report of the H ealth Innovation Strategy Board. The research will be published in journals and internation al conferences, raising the profile of Mexico-funded research. The potential high impact an d interdisciplinary dimension of the planned research outcomes will strongly contribute to Mexico excellence and competitiveness in a global setting. Dr Medina has developed an in novative triborheometry fixture/design in collaboration with Prof. McKinley at MIT. The tran sfer of Medina's skills and capabilities through invited lectures and hands-on laboratory ses sions will be integrated into classes taught at Tecnologico de Monterrey and cinvestav and will be open to the wider community of undergraduate and postgraduate students, enhan cing the training of the Mexico workforce. - Key research questions and aim Hyaluronic aci d (HA) is a very high molecular weight polysaccharide and the main rheologically functiona l component of the synovial fluid (SF) that lubricates and protects the joints [3-4]. HA molec ules stretch at strain rates of biological relevance and works with HA solutions and gels indi cate that its flow characteristics may be vital in joint protection by synovial fluid [3-4]. It is k nown that in osteoarthritis this protection is lost and HA is degraded. In healthy SF, HA has a molecular weight of a few million Daltons [4] and quantitative measurements of HA in se rum may provide important information on disease progression. The role of architecture an d molecular weight, in particular, has been a long standing question for the medical comm unity [5]. We aim therefore to address the following questions: - How does HA degrade und er different conditions? - How does the molecular architecture/ weight of HA affect the rhe ological properties and lubrication ability of the fluids? - How do prosthetic fluids and other lubricants perform relative to healthy SF and HA solutions? - How can prosthetic fluids/mat erials used in this context be improved? The outcomes of this research will lead to enhance d understanding of SF function, the factors leading to development of disease and to furth er improved prosthetic fluids, an alternative to joint replacement.

Hypothesis and / or forecast (Hipótesis y/o pronósticos)

In Mexico, many people suffer from problems related to the wear of cartilage, which is spec ially problematic given our country is composed of a community in constant movement. It is amazing for foreign visitors how physical most of our jobs are. This constant activity, in tu rns, results in even more wear and tear due to high coefficients of friction between the bon es. In Mexico, the annual years of healthy life lost per 100,000 people due osteoarthritis has i ncreased by 54.4% since 1990. Estimates indicate that women are specially affected, with 2 442.1-years of healthy life lost per 100,000 women in Mexico, compared to 1,619.3 per 100,00 0 men. It will strengthen the bonds between Mexico and the world in terms of research, bu

t also in terms of education. The research will be published in collaboration in high-impact j ournals and presented at important international conferences, raising the profile of Mexic o's research. Human resources formation is a key benefit of this fellowship as Mexicans Aca demics, Researchers and Students will undergo a comprehensive mobility and training pro gramme.

Methodology (Metodología)

Methodology and Work Packages We have divided the research in two work packages, whi ch are intimately linked and will run side by side for the duration of the project (project year s 1, 2 and 3). WP1. Evaluating the rheology of the fluids with lubricant properties: A key chall enge for successful lubrication in the proposed systems is understanding the rheological b ehaviour of the fluid. This WP deals with the rheological characterisation of the fluids under shear and flow conditions and will provide rheological parameters that support understan ding of the boundary, mixed and hydrodynamic lubrication. In particular, we will investigat e the behaviour of HA from a wide variety of sources, incorporating linear and branched m olecules of varying molecular weight, with the aim of understanding the role of molecular architecture in the function of synovial fluid in the joints. We will also examine the changes that occur in extensibility and molecular weight as mechanical degradation of HA, which is of direct relevance to synovial fluid functionality. The outcome will lead to the enhanced un derstanding of synovial fluid function, the factors leading to development of disease and to further improved prosthetic fluids, an alternative to joint replacement. Furthermore, this W P will feed directly into WP2 in which these will be used as lubricants. Other lubricant fluids will also be tested following the results of WP2. For fluid characterisation under shear we wi ll use shear rheometers (TA Instruments DHR3 rheometers, which is available in participati ng institution), which will allow us to quantify not only shear viscosity, but also other releva nt material properties, such as storage and loss moduli. Characterisation of rheological pro perties of the fluids is also crucial, since unlike Newtonian fluid flows—in which the extensi onal viscosity is proportional to the shear viscosity—extensional flows of viscoelastic fluid of ten lead to unexpectedly large flow resistances. Rheology will be performed using a rheom eter available in the laboratory, which allows evaluating a characteristic relaxation time of a fluid [6,7]. WP2. Triborheological design of solid/liquid systems: This work package focuses on understanding the triborheological characteristics of the systems. The performance of t he materials at the macro-scale (i.e. the millimetre scale, upwards), micro-scale (i.e. roughn ess) and nano-scale (fluids with nano-particles). The objective of this WP is to understand t he relationship between the material architecture, the roughness, texture, geometry of the surface and the response of the fluid as a lubricant. In this WP, we will also use numerical modelling to develop understanding of the coefficient of friction of the material with the c omplex fluid. A numerical approach will allow a wide range of systems to be investigated, a nd the boundary, mixed and hydrodynamic lubrication mechanisms to be understood. This work package will consider the influence of the complex fluid in the lubrication process (e. g. viscosity, shear stress, normal forces), with a particular focus on the effect on wear out iss ues. The system under consideration will look at simulants of cartilage and at substitutes of synovial fluid and the HA solution. Specimens, for example hydrogels [8] and complex fluid s will be manufactured and/or commercially obtained for each application (the specimens will be tested at the collaborating Universities), to provide material data for the numerical modelling. We will look to develop innovative systems to study the frictional dynamics of se veral solid-liquid systems. The triborheometry fixture/design includes various hardware co mponents including helical springs of different stiffnesses. The fixtures are adapted to a fu nction with a commercially available rheometer and the experimental set-up would be mo dified according to the system undergoing analysis. By altering process conditions, the effe ct of surface roughness and lubricant fluid would enable us to measure the coefficient of fr iction at different angular velocities and normal forces for the different solid-liquid systems [9]. The research supported by the conacyt-ciencias de frontera call would encompass expe

rimental details for novel triborheology tests and materials characterization. It would allow us to further improve the triborheological systems. The triborheometer offers perfect parall elism between the top and bottom clamp which would in turn enable its use on a broader spectrum of samples than is currently possible and analysis could be carried out at any te mperature. The bottom fixture includes a stepped disposable-peltier plate in which a dispo sable plate serving as a sample holder is adapted. The top fixture is formed by 8 mm plate or/and a ring. A disposable plate holding a sample is attached to the beam coupling. The sa mples are secured to the disposable plates using double-sided tape. Once the top and bott om fixtures are set up as described, the top fixture is brought down such that normal force is applied to the bottom sample, inducing full contact of the two samples. The triborheome tric fixture provide the information required for minimum and maximum coefficient of fric tion determination. It is the purpose of this research to reduce the coefficient of friction of many systems where the wear a big issue [10]. It is expected that different lubricants will be evaluated, in order to highlight the useful characteristics of the liquids as a function of their molecular composition. This collaborative research can then be extended to include the m easurement of the coefficient of friction for many systems, i.e. lubricant/hard-hard & hard-s oft surfaces. The results would give valuable insights that can be applied to real health prob lems, decreasing diseases and traumas due to a high coefficient of friction between joints, resulting in healthy joints function [11]. We would be testing new systems in the triborheom eter and will provide more options for improved lubrication.

Results (Resultados)

(3) Co-Applicant's research group: The proposed project will also expand the capabilities of the Co-Applicant (Dr. Luna-Barcenas) laboratory to a new research field in the area of tribor heology. Dr Medina will provide specific training in this area at the cinvestav laboratory, an d this will support the co-applicant future research efforts and applications in this area. (4) Undergraduate (UG) and postgraduate taught (PGT) students: Dr Medina and Dr Luna-Bar cenas will also deliver a series of invited lectures and hands-on laboratory sessions at the co llaborating Universities, some of which will be integrated into UG classes at the Masters/Ph D level. It will therefore be open not only to researchers in the Applicant and Co-Applicants groups, but also to the wider community, including UG and PGT students, and as such con tribute to equipping well the next generation of engineers for the coming decades. (5) Gen eral dissemination in conference and seminars. The PI (Dr. Medina) and Co-Investigator (Dr. Luna-Barcenas) will each deliver research seminars to the collaborating research group dur ing the planned exchange visits. Funding has also been requested for the PI, co-investigato r, graduate students and participants to each attend at least one nacional and/or internatio nal conference per year. In addition, Mexico national conferences will be targeted to publici se the main results in a timely manner and to liaise with industrialists (e.g. scientists from p rivate company meetings). This will allow the PhD student to gain experience in delivering research presentations and networking. The choice of conferences will alternate between t he disciplines of the PI, Co-Investigator and participants. Include also interdisciplinary conf erences, to broaden their experience and the target audience. Candidate conferences inclu de: 1. International Congress on Rheology 2. Meetings of The Society of Rheology. 3. Confere nces of the Polymer Processing Society 4. Annual European Conference in Rheology. 5. Me etings of the Division of Fluid Dynamics of the American Physical Society. 6. Congress of th e International Society of Biomechanics 7. The 25th Congreso Anual de la División de Diná mica de Fluidos de la Sociedad Mexicana de Física 8. Congreso de Investigación y Desarroll o del Tecnológico de Monterrey 9. Meetings of the Bristish Society of Rheology

Mechanisms to integrate the different results generated by the proposed research line s (Mecanismos para integrar los diferentes resultados generados por las líneas de inve stigación propuestas)

This research relies on a close collaboration between the two groups, with frequent web-based discussion (emails and webinars), but in which exchange visits will play a key role in terms of knowledge transfer. It will involve a broad training, development and dissemination programme, which includes a range of different activities: - training through research - training through workshops and courses to develop new scientific skills as well as transferable skills - delivery of tutorials and seminars - exchange visits - participation in conferences and seminars - organisation of two thematic workshops (one at the cinvestav and one at Tecnologico de Monterrey) The programme has been tailored according to each recipient group as follows: (1) Training and development of the PI (Dr. Medina) applicant. The main goal in terms of career advancement of the applicant is to establish a solid academic profile in science and ensure the development of her research group. Dr Medina has identified the following skills requirements that will be addressed by the proposed project, and that will support future research activity. 1.1 Scientific skills that will enhance the PI applicant's (D.I. Medina) set of competences in the broad area of rheology. Experimental: rheometry and microfluidics for rheology purposes, which will include microdevice fabrication as well as charaxterization techniques for flow and material diagnosis. The PI applicant (D. I. Medina) will also have the chance to network and discuss her work with other cinvestav and Tecnologico de Monterrey faculty members, faculty who leads the tribology and material groups and faculty who leads Osteoarthritis Technology NetworkPlus and experts in clinical movement analysis, functional analysis, biomechanics of the human body in motion, rehabilitation engineering, rehabilitation technology, rehabilitation robotics and robotic surgery especially applied in orthopaedics and stroke. The interaction with these professors has great potential to provide valuable biomechanics insight that will enhance the project's impact. 1.2 Leadership-related skills The PI applicant and participants will benefit from programmes offered at the Tecnologico de Monterrey for personal and professional development in Academic practice, Researcher development, Learning and Teaching and Knowledge Exchange, as well as develop and strengthen leadership in Higher Education (e.g. Research Impact – focused on advancing researcher skills in key areas such as funding, publications and impact – and Managing Research – focusing on enhancing engagement and collaboration with business, industry and the public sector). (2) PI applicant's research group: A PhD student/research assistant based at Tecnologico de Monterrey will be engaged on the project. He/She will be jointly supervised by both investigators, and funding is requested for the reseracher to spend part of each year of the project as a research visitor in cinvestav. This collaboration will allow the student to be trained in rheology of complex fluids, including using microfluidics for rheometry purposes, and characterization of materials (at Tecnologico de Monterrey and cinvestav), and in triborheology and mechanical testing (in Tecnologico de Monterrey). During visits to cinvestav and other academic institutions, the PhD student will be able to attend relevant lecture courses and research seminars. Besides technical skills, the researchers (participants) will also benefit from the Tecnologico de Monterrey Researcher Development Programme, to develop generic and transferrable skills that are essential tools for today's Researchers, including: oral presentation techniques, technical writing skills, logical thinking and problem-solving.

Social appropriation actions of the knowledge generated (Acciones de apropiación social del conocimiento generado)

The proposed research will generate data that is of significant value to the research community: The following measures will be taken to share and disseminate this data: 1. Academic publications: The research outcomes will be published in international journals in the areas of Complex Fluids and Rheology, Surface Science, Microsystems, Biophysics and Soft Matter Physics, Tribology and Material sciences. 2. Open data repository: To ensure secure data storage and to facilitate data sharing between collaborating partners and with the wider research community. We aim to have all publications open access. The approved author manuscript and associate data sets will be made available, where possible, and mirrored across t

he institutional repositories. 3. Presentation at international conferences: Funding is reques ted for the investigators to attend relevant conference to present the outcomes of the rese arch, and to expand their current collaborative research network (see justification of resour ces). 4. Workshop: To further disseminate the outcomes of the research, the workshops will be based at Tecnologico de Monterrey and cinvestav, and will specifically target academics and research students in Mexico. 5. Website: To showcase ongoing research to a wide-audie nce, allowing faster dissemination of the core ideas and interim results of the Ciencia de Fr ontera call.

Bibliography (Bibliografía)

[1]Burgos-Vargas et al., Reumatol Clin. 2014,10:152-159 [2]Peláez-Ballestas et al., J Rheumatol Suppl. 2011,86:3-8. [3]Bingöl et al., Biorheology 2010,47:205-224. [4]Haward et al., Biomicroflu idics 2013,7:044108 [5]Osteoarthritis: National Clinical Guideline for Care and Management i n Adults, 2008, Royal College of Physicians (UK). [6]Galindo-Rosales et al., Microfluid. Nanofl uid. 2013,14:1-19 [7]Haward, Biomicrofluidics 2016,10:043401 [8] Bodugoz-Senturk et al. 2008. Biomaterials 2008,29:141-149. [9] Medina et al., The Society of Rheology 2013:SI14. [10] Asik et al., 2008. The Journal of Arthroscopic & Related Surgery 2008,24:1214-1220. [11] Bae et al. 200 6. Arthroscopy Association of North America 2006,22:367-374.

Documento de protocolo

Request (Solicitud)

Concepto	Estado
clave	CF-MG-20191016124318937-263378
Etapa	Solicitud
Estado	En firmas de colaboradores

Modality (Modalidad)

Grupo

Knowledge area (Área de conocimientos)

Concepto	Valor
Area	Ingeniería y tecnología
Campo	Ingeniería
Disciplina	Ingeniería química
Subdisciplina	Ciencia de materiales
Especialidad	Triborheology

Sujeto de Apoyo

Sujeto de Apoyo

Nombre	RENIECYT	Rol	Nivel SNI
DORA ILIANA MEDINA MEDINA	1601410-23	Responsable Técnico	Investigador Nacional Nivel I
ANA LILIA BENAVIDES SALINAS	1601410-23	Responsable Administrativo	
NEIL HERNANDEZ GRESS	1601410-23	Representante Legal	

Corresponsables

Corresponsable 1701645-3

Nombre	RENIECYT	Rol	Nivel SNI
J. GABRIEL LUNA BARCENAS	1701645-3	Corresponsable Técnico	Investigador Nacional Nivel III
PATRICIA ARACELI PACHECO GONZALEZ	1701645-3	Corresponsable Administrativo	
JOSE MAURICIO LOPEZ ROMERO	1701645-3	Representante Legal Corresponsable	

Participantes

Nombre	CVU	Institucion	País de residencia
ELVIA PATRICIA SANCHEZ RODRIGUEZ	100483	Instituto Tecnologico y de Estudios Superiores de Monterrey	México
HERIBERTO CRUZ MARTINEZ	390018	Instituto Tecnologico y de Estudios Superiores de Monterrey	México
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CLAUDIA NOEMI VARGAS HERNANDEZ	335599		
ANTONIO OSAMU KATAGIRI TANAKA	957088		México
GUSTAVO RUIZ PULIDO	830780		México
LAURA CATALINA DUQUE OSSA	893364		México

Nombre	CVU	Institucion	País de residencia
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JESUS ALBERTO MARTINEZ ESPINOSA	960251		México
JOSE IVAN AVILES CASTRILLO	965073		México

Plan de trabajo

Los registros capturados se mostrarán hasta que se agreguen productos.

Año	Objetivo	Meta	Actividad	Producto	Participantes

Desglose Financiero

Monto total solicitado $4,500,000

Institución	Monto
Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional. / Unidad Querétaro	$990,000
INSTITUTO TECNOLOGICO Y DE ESTUDIOS SUPERIORES DE MONTERREY, CAMPUS ESTADO DE MEXICO	$3,510,000

Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional. / Unidad Querétaro

Detalle de gasto de inversión

Gasto de inversión total $0

Detalle de gasto corriente

Gasto corriente total $990,000

Año 1

Investment expenditure (Rubro)	Amount allocated (Monto asignado)	Justification (Justificación)
Gastos de trabajo de campo	$50,000	----------
Honorarios por servicios profesionales	$150,000	----------
Materiales de uso directo	$100,000	----------
Pasajes	$50,000	----------
Total	$350,000	

Año 2

Investment expenditure (Rubro)	Amount allocated (Monto asignado)	Justification (Justificación)
Gastos de trabajo de campo	$50,000	----------
Honorarios por servicios profesionales	$180,500	----------
Total	$230,500	

Año 3

Investment expenditure (Rubro)	Amount allocated (Monto asignado)	Justification (Justificación)
Comisiones bancarias	$1,500	----------
Cuotas de inscripción	$8,000	----------
Estancias técnico-académicas para participantes y visitantes	$60,000	----------
Gastos de trabajo de campo	$50,000	----------
Honorarios por servicios profesionales	$150,000	----------
Pasajes	$50,000	----------
Viáticos	$90,000	----------
Total	$409,500	

INSTITUTO TECNOLOGICO Y DE ESTUDIOS SUPERIORES DE MONTERREY, CAMPUS ESTADO DE MEXICO

Detalle de gasto de inversión

Gasto de inversión total $450,000

Año 1

Investment expenditure (Rubro)	Amount allocated (Monto asignado)	Justification (Justificación)
Equipo de cómputo especializado	$100,000	*To connect with the triborheometer*
Equipo de laboratorio	$50,000	*Fixture of the triborheometer*
Total	$150,000	

Año 2

Investment expenditure (Rubro)	Amount allocated (Monto asignado)	Justification (Justificación)
Equipo de cómputo especializado	$100,000	*Acquire computers necessary for the ...*
Equipo de laboratorio	$50,000	*Purchase of helical springs for the triborheometer*
Total	$150,000	

Año 3

Investment expenditure (Rubro)	Amount allocated (Monto asignado)	Justification (Justificación)
Equipo de cómputo especializado	$100,000	*Purchase of computer to be adapted to the ...*
Equipo de laboratorio	$50,000	*Purchase of a rheometry fixture*
Total	$150,000	

Detalle de gasto corriente

Gasto corriente total $3,060,000

Año 1

Investment expenditure (Rubro)	Amount allocated (Monto asignado)	Justification (Justificación)
Estancias técnico-académicas para participantes y visitantes	$400,000	*Technical and academic stays at universities ...*
Honorarios por servicios profesionales	$200,000	*To hire professional personnel to carry out ...*
Materiales de uso directo	$50,000	*To buy PVA, HA and other chemicals for the ...*
Pasajes	$100,000	*Transportation necessary to continue the project*
Realización de Seminarios y talleres	$100,000	*To disseminate the results in each stage*
Total	$850,000	

Año 2

Investment expenditure (Rubro)	Amount allocated (Monto asignado)	Justification (Justificación)
Estancias técnico-académicas para participantes y visitantes	$400,000	*To carry out a technic-academic stay at a ...*
Honorarios por servicios profesionales	$200,000	*To hire the professional services of ...*

Investment expenditure (Rubro)	Amount allocated (Monto asignado)	Justification (Justificación)
Materiales de uso directo	$50,000	*To buy polymers and fluids necessary to ...*
Pasajes	$100,000	*For mobility to continue the project since it ...*
Realización de Seminarios y talleres	$100,000	*To develop a workshop that includes ...*
Total	$850,000	

Año 3

Investment expenditure (Rubro)	Amount allocated (Monto asignado)	Justification (Justificación)
Auditoría	$45,000	*External audit services will be hired to ...*
Cuotas de inscripción	$50,000	*Payment of conferences' entry fees, such as ...*
Estancias técnico-académicas para participantes y visitantes	$400,000	*To perform experiments in infrastructure that ...*
Honorarios por servicios profesionales	$200,000	----------
Materiales de uso directo	$50,000	----------
Pasajes	$150,000	*The participants will often require mobility ...*
Realización de Seminarios y talleres	$100,000	*A joined workshop of the involved ...*

Investment expenditure (Rubro)	Amount allocated (Monto asignado)	Justification (Justificación)
Viáticos	$365,000	*This will be designated for the assistance to ...*
Total	$1,360,000	

Volver Descargar

"2019, Año del Caudillo del Sur, Emiliano Zapata"

En caso de dudas relacionadas con el sistema de registro de propuestas contactar a:
Centro de Contacto y Soporte Técnico de 08:00 a 20:00 horas, al teléfono: **5553227708**, o por correo electrónico: ***cst@conacyt.mx***
Para dudas relacionadas con la Convocatoria y sus Términos de Referencias, comunicarse al teléfono: **5553227700** ext. 6129, 6123, 6127, 6118

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