BCR

X Brazilian Conference on Rheology

Rio de Janeiro • 2024

July 31st - August 2nd

Book of Abstracts

Presentation

Welcome to the X Brazilian Conference on Rheology (BCR 2024)! The Conference will run from July 31st to August 2nd at Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio), Rio de Janeiro, Brazil.

The conference is endorsed by the Brazilian Society of Rheology, a member of the International Committee of Rheology, and is organized by PUC-Rio with financial support from CNPq and CAPES.

The event aims to bring together professionals, academics, and students, fostering a multidisciplinary environ ment conducive to the dissemination of knowledge, exchange of ideas, and establishment of partnerships and collaborations.

The X BCR will feature lectures by invited professionals and professors, technical sessions, and a poster session. English will be the official language of the conference.

Areas of Interest

- Advances in constitutive equations
- Advances in rheometric techniques and experimental methods
- Biomaterials and biological fluids
- Blends and composites
- Colloids and glasses
- Emulsions, foams and interfacial rheology
- Food rheology
- Industrial rheology
- Microrheology and microfluidics
- Non-Newtonian fluid mechanics
- Polymeric fluids
- Suspensions and granular materials
- Viscoplasticity and thixotropy

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Conference Venue

Rio Datacentro Building
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July
31
Wednesday

Program

BCR
X Brazilian Conference on Rheology
Rio de Janeiro • 2024

08:30/ 08:50	Conference Opening
	Session Chair: Nezia de Rosso
08:50/ 09:10	**Rheological analysis of combined flow assurance issues** (Eliana P. M. Castaño, Priscilla R. Varges, J. E. Leiva-Mateus, Tiphane Figueira, Andrea Mora, Ludmila N. Costa, Pedro Sampaio, Cynthia Barreto, Osvaldo J. Karnitz, Marcia C. Khalil de Oliveira, Mônica F. Naccache, Paulo R. de Souza Mendes)
09:10/ 09:30	**Rheology applied to the study of petroleum industry processes assisted by nanotechnology** (Esteban Taborda, Yurany Villada, Lady Giraldo, Camilo A. Franco, Farid Cortés)
09:30/ 09:50	**Methodology proposal for reducing the flow start-up pressure of gelled waxy oils** (Nezia de Rosso, Diogo E. V. Andrade, Cezar O. Ribeiro Negrão)
09:50/ 10:10	**Evaluating gelation temperature for waxy oils from unidirectional, oscillatory, and axial force tests** (André da Silva Guimarães, Thiago O. Marinho, Príamo Albuquerque Melo, Roney L. Thompson, Marcio Nele)
10:10/ 10:40	Coffee-Break
	Session Chair: Diogo Andrade
10:40/ 11:00	**Rheological characterization of the non-Newtonian fluid used as a barrier element for temporary well abandonment** (Guilherme Mühlstedt, Alberto U. Costa Neto, Roque M. Duarte Junior, Cezar O. Ribeiro Negrão)
11:00/ 11:20	**Enhancing hydration and dispersion of biopolymers in water-based drilling fluids using ethanol as a dispersant agent** (Julio Jorge de Almeida Abdala, Patrícia V. de Oliveira, Nezia de Rosso, Cezar O. Ribeiro Negrão)
11:20/ 11:40	**Pore stability during rheological tests of alkali-activated composites for CO_2 capture** (Madeleing Taborda-Barraza, Alexander Belga, Luís U. Durlo Tambara Junior, Philippe Jean P. Gleize, Afonso R. Garcez de Azevedo)
11:40/ 12:00	**Food tribological model system testing with cocoa mass samples with different rheological properties** (João Mesquita, Florian Rummel, Martina T. Shona Marsh - Netzsch)
12:00/ 13:30	Lunch
	Session Chair: Mônica F. Naccache
13:30/ 14:20	**Plenary Lecture - Flow classification** (Roney L. Thompson - Universidade Federal do Rio de Janeiro)
14:20/ 14:40	**The evolution of cement rheological behavior and 3D concrete printing** (Flávio H. Marchesini)
14:40/ 15:00	**On rheological neural differential constitutive equation** (Elias C. Rodrigues, Roney L. Thompson, Dário A.B. Oliveira, Roberto F. Ausas)
15:00/ 15:30	Coffee-Break
	Session Chair: Paulo R. de Souza Mendes
15:30/ 16:20	**Plenary Lecture - Engineering interfacial rheology for the stabilization of soft multiphase materials** (Alexandra Alicke - Eindhoven University of Technology)
16:20/ 16:40	**Emulsions of polymer solutions as drag reducers** (Guilherme Rainho Melhorim, Edson José Soares, Cleocir J. Dalmaschio, Marcia C. Khalil de Oliveira, Osvaldo Karnitz Junior, Plínio M. Dias da Silva)
16:40/ 17:00	**Tuning the rheology of ferrofluid emulsions using magnetic fields** (Taygoara Oliveira, Lucas H. Pires da Cunha, Arthur Leite Guilherme, Rayssa Gomes dos Santos)
17:00/ 17:20	**Using microscopy to help understanding rheology** (Eliana P. M. Castaño, Lorena R. da C. Moraes, Priscilla R. Varges, Paulo R. de Souza Mendes, Mônica F. Naccache)

Notes:

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Program

	August 01 Thursday	Friday August 02
	Session Chair: Sergio S. Ribeiro	**Session Chair: Priscilla Varges**
08:40/09:30	**Plenary Lecture - Computational rheology of structured materials** (J. Esteban López-Aguilar - Universidad Nacional Autónoma de México)	**Plenary Lecture - Use of tribo-rheological techniques to improve technological properties of dairy products** (María Laura Olivares - Universidad Nacional del Litoral)
09:30/09:50	**Mathematical model of waxy oil gelation to assess material shrinkage** (Nezia de Rosso, Denis B. Barbara, Júlio J. A. Abdala, Silvio L. M. Junqueira, Cezar O. Ribeiro Negrão)	**W/O emulsions stabilized solely by cocoa butter-based oleogels: effect of crystal-crystal interactions on rheological performance** (Elizabeth Tenorio-Garcia, Andrea Araiza-Calahorra , Michael Rappolt, Elena Simone and Anwesha Sarkar)
09:50/10:10	**Annular displacement flows in oil well cementing operations** (Frederico de Carvalho Gomes , Sergio S. Ribeiro , Priscilla R. Varges, Rodrigo L. Fernandez, Lucas C. Mendonça, Matheus A. Mendes Freitas, Mônica F. Naccache, Paulo R. de Souza Mendes, Marcio da Silveira Carvalho, Carlos P. C. Carvalho, Umberto Sansoni Júnior, André L. Mardins, José Marcelo S. Rocha, Ingrid E. da Silva)	**Analysis of wall shear stress for hematocrit dependent blood model in hemodialysis fistulae** (Janaína A. Silva, José Karam-Filho)
10:10/10:40	**Coffee-Break**	**Coffee-Break**
	Session Chair: Ivan Rosa de Siqueira	**Session Chair: Elias Rodrigues**
10:40/11:00	**Thixotropic dynamics of three-dimensional flow in coating dies** (Stélio Henrique Lopes, Sergio S. Ribeiro, Marcio da Silveira Carvalho)	**Power law fluid flow in partially porous and fractures channel: numerical model and validation** (Sergio Yoshio Ogata Junior, Vinicius Gustavo Poletto, Ayrton Cavalini Zotelle, Fernando Cesar De Lai, Silvio Luiz de Mello Junqueira)
11:00/11:20	**Modeling the inline mixing of non-Newtonian and Newtonian fluids** (Ricardo Knesebeck, Cezar O. Ribeiro Negrão)	**Reformulation of constitutive equations based on the generalized Lie derivative** (Débora de Oliveira Medeiros)
11:20/11:40	**Numerical study of free surface flows with a generalized Newtonian interface** (Filipe Oliveira da Silva, Ivan Rosa de Siqueira, Roney L. Thompson)	**Direct numerical simulations of power-law fluids in smooth and rough channels** (Hamidreza R. Anbarlooei, Daniel Onofre de Almeida Cruz, Gustavo Eduardo Oviedo Celis, Matheus de Souza S. Macedo, Roney L. Thompson)
11:40/12:00	**Improvement capabilities of MCR series: capillary extensional and automation rheological measurements** (Jorge Maia - Anton Paar)	**A short introduction to tribo-rheometry** (Hans Michael Petri - Reoterm)
12:00/13:00	**Lunch**	**Lunch**
13:00/14:00	**SBR Meeting (Optional)**	**Visit to the GReo Laboratory (Optional)**
	Session Chair: Bruna Costa Leopércio	**Session Chair: Flávio H. Marchesini**
14:00/14:50	**Plenary Lecture - Yielding and plasticity in disordered materials: microstructure, memory, and flow** (Paulo E. Arratia - University of Pennsylvania)	**Plenary Lecture - Porous particle suspensions: the reduction of lubrication forces is at the origin of their behavior** (Mario Minale, Johanna Vargas Clavijo, Hajar Nassiri, Claudia Carotenuto - University of Campania)
14:50/15:10	**Rheological behaviour of nanostructured complex fluids with two-dimensional (2D) materials** (Ricardo J. E. Andrade, Josué Cremonezzi, Ely Cargnin, Nathália M. Moraes Fernandes, Hélio Ribeiro, Lorena R. da C. Moraes, Yago Soares, Monica Naccache)	**Squeeze flow of suspensions supported by pressure mapping and interparticle distances with microstructural representation** (Franco Ancona Grandes, Victor K. Sakano, Andressa C.A. Rego, Markus S. Rebmann, Fábio Alonso Cardoso, Rafael Giuliano Pileggi)
15:10/15:30	**Rheology of graphene oxide nanosheets in xanthan gum** (José Canazas R., Nathalia M. Moraes Fernandes, Lorena R. da C. Moraes, Hélio Ribeiro, Ricardo J. E. Andrade, Monica F. Naccache)	**Impact of particle motion on viscosity measurement in non-colloidal suspension flows: a numerical study** (Nezia de Rosso, Cezar O. R. Negrão)
15:30/15:50	**Coffee-Break**	**Continuum modeling of non-Newtonian flow in porous media** (Allan B. G. Motta, Roney L. Thompson)
		Session Chairs: Eliana P. M. Castaño and Lorena R. da C. Moraes
15:50/16:00		**Poster Session**
	Session Chair: Ricardo J. E. Andrade	
16:00/16:20	**Improving efficiency of polymer injection in enhanced oil recovery processes with silica nanoparticles** (Andrea Mora, Anthony Hutin, Jorge Avendano, Marcio S. Carvalho)	
16:20/16:40	**How the morphology and structure of innovative graphene oxide (GO) dispersed in xanthan gum (XG) affects the rheological behavior** (Nathália M. Moraes Fernandes Hélio Ribeiro, Monica F. Naccache, Lorena R. da C. Moraes, Matheus S. Dias, Camila M. Maronezze, Ricardo J. E. Andrade)	
16:40/17:00	**Exploring the role of rheology in enhancing performance of lithium-ion battery manufacturing** (Danmer Maza Quinones, Marcio da Silveira Carvalho)	
17:00/17:20		
17:20/17:30		**Conference Closing**
19:00/23:00	**BCR 2024 Cocktail at Maguje Restaurant,** Jardim Botânico Street 1003, Jardim Botânico, Rio de Janeiro.	

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Plenary Speakers

Paulo Arratia

University of Pennsylvania, EUA

Distinguished faculty member in Mechanical Engineering and Applied Mechanics, as well as Chemical and Biomedical Engineering at the School of Engineering and Applied Sciences. His research primarily explores the behavior of complex fluids, including polymeric solutions, colloidal suspensions, and human blood. A central goal of his work is to unravel the physical and chemical forces that dictate the structural properties of these fluids, with the aim of designing materials with exceptional characteristics. Paulo's research spans a wide range of interdisciplinary topics within soft-condensed matter and fluid dynamics. His interests include the swimming mechanisms of microorganisms, flow instability, and rheology. By providing novel insights into these areas, his work seeks to advance engineering practices, enhance energy efficiency, minimize waste, and improve diagnostic technologies.

Mario Minale

University of Campania Luigi Vanvitelli, Italy

Mario Minale is a Full Professor of Chemical Engineering, specializing in the Principles of Chemical Engineering. He earned his degrees from the University of Naples Federico II and has received several awards, including undergraduate and dissertation prizes. Minale has held prominent roles in rheological societies, including Past President of the European Society of Rheology and President of the Italian Society of Rheology. He has delivered keynote and plenary lectures at international conferences and chaired sessions, notably the 12th Annual European Rheology Conference in 2018. His editorial roles include Associate Editor of "Frontiers in Soft Matter" and Member of the Editorial Board of "Processes". Minale has over 160 publications, focusing on the rheology of heterogeneous systems, non-Brownian suspensions, polymer blends, and flow through porous media. His recent research explores innovative applications like tire powder recycling, drug release modulation, and anaerobic digestion for enhanced H_2 yield.

Alexandra Alicke

Eindhoven University of Technology, Netherlands

Earned her Bachelor's degree in Petroleum Engineering from Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio) in Brazil in 2011. She continued at PUC-Rio, completing her M.Sc. in Mechanical Engineering in 2013 under the supervision of Professor Paulo R. de Souza Mendes with a thesis titled "LAOS Rheological Characterization of an Elastoviscoplastic Material." Concurrently, she worked as a research engineer in PUC-Rio's Rheology Group, engaging in both fundamental research and industry collaborations. In 2016, she began her doctoral studies at ETH Zürich in the Department of Materials under the guidance of Professor Jan Vermant. She completed her D.Sc. in 2021 with a thesis titled "Elastoviscoplastic Interfaces and Their Role in the Stability of Multiphase Materials." Since September 2022, she has been an Assistant Professor in the Department of Mechanical Engineering at Eindhoven University of Technology in the Netherlands. Her current research focuses on the experimental processing of complex materials and the design and characterization of complex fluid-fluid interfaces.

José Esteban López Aguilar

Universidad Nacional Autónoma de México (UNAM), Mexico

Professor in the Chemical Engineering Department at the Faculty of Chemistry, Universidad Nacional Autónoma de México (UNAM), where he has been a faculty member since 2017. He completed his Bachelor's and Master's degrees in Chemical Engineering at UNAM and later earned his PhD in Chemical Engineering from Swansea University, Wales, UK. At Swansea University, he also undertook postdoctoral research at the Zienkiewicz Centre for Computational Engineering and held an academic position at the College of Engineering. He has been a visiting fellow at the Basque Centre for Applied Mathematics in Bilbao, Spain, and is an Associate Member of the Institute of non-Newtonian fluid mechanics in the UK. His research focuses on non-Newtonian Fluid Mechanics, with particular emphasis on computational rheology and the constitutive modeling of complex fluids and soft matter, including viscoelastic surfactant solutions, polymer melts and solutions, suspensions, and biofluids.

María Laura Olivares

Universidad Nacional del Litoral, INTEC (CONICET-UNL), Argentina

Professor at Universidad Nacional del Litoral (UNL) and a Researcher at CONICET, affiliated with the Instituto de Desarrollo Tecnológico para la Industria Química (INTEC) in Argentina. She earned her B.Sc. in Biochemistry from UNL in 2000 and her Ph.D. in Chemical Technology from UNL in 2007. She has been a visiting scholar at the Universidad de Granada in Spain, hosted by Professor Juan de Vicente, in 2016 and 2020. Her primary research interests include the rheology and rheometry of food materials, as well as the physical chemistry of colloidal systems. These areas are closely linked to Argentina's food industry, particularly its renowned dairy sector. Her current research focuses on developing new and healthier food products, aiming to advance both the science and application of food technology.

Roney Leon Thompson

Universidade Federal do Rio de Janeiro, Brazil

Professor in the Department of Mechanical Engineering at UFRJ and COPPE-UFRJ. He earned his Ph.D. in Mechanical Engineering from Pontifícia Universidade Católica do Rio de Janeiro in 2001. In addition to his doctoral degree, he holds master's degrees in Economics from IBMEC and Mechanical Engineering from PUC-Rio. He serves on the Editorial Boards of several prestigious journals, including the *Journal of Non-Newtonian Fluid Mechanics*, *Rheologica Acta*, and *Applications in Engineering Science*. He is also an Associate Editor for the *Journal of Brazilian Mechanical Science and Engineering*. He is a founding member, past president, and former vice president of the Brazilian Society of Rheology. Additionally, he served as Secretary of the Committee on Rheology and Non-Newtonian Fluids (2009-2018) and the Fluid Mechanics Committee (2018-2021) within the Brazilian Association of Mechanical Sciences (ABCM). Currently, he is the Coordinator of the Graduate Program in Mechanical Engineering at COPPE-UFRJ. His research contributions span a broad range of areas, including elasto-viscoplastic materials with time dependence; the behavior of complex materials with free surfaces; modeling of Newtonian and viscoelastic turbulence; machine learning applications; flow classification; dimensionless numbers in non-Newtonian fluid flows; acidification processes in reservoirs; cold starts of gelled paraffinic oil; hydrate rheology; non-Newtonian flow in porous media; ferrofluid emulsion rheology; and interfacial rheology, among others.

Oral abstracts

OR-01

Rheological analysis of combined flow assurance issues

Eliana Paola Marín Castaño[1], Priscilla Ribeiro Varges[1*], J. E. Leiva-Mateus[1], Tiphane Figueira[1], Andrea Mora[1], Ludmila O. N. Costa[1], Pedro Sampaio[1], Cynthia Barreto[1], Osvaldo Karnitz Junior[2], Marcia Cristina Khalil de Oliveira[2], Monica Naccache[1], Paulo R. de Souza Mendes[1]

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Flow assurance issues pose significant financial and safety challenges in the oil industry. Given that hydrates, paraffins, and asphaltenes in water-in-oil emulsions can occur concurrently, it is crucial to assess their combined effects. However, studies often focus on these factors separately. Quantifying the risk of pipeline blockage involves determining the rheological properties of the resultant fluids. Understanding interfacial rheology is equally important, providing insights into system behavior. This work aims to develop a rheological methodology to analyze these simultaneous occurrences using various techniques, including bulk and interfacial rheometry. Bulk rheometry reveals viscosity and yield stress, crucial for assessing a fluid's ability to initiate and maintain flow under different pressure and temperatures. Meanwhile, interfacial rheometry tests elucidate the underlying causes observed in bulk rheometry. Tests are performed with a Langmuir trough, a drop tensiometer, and the Double Wall Ring geometry in a rotational rheometer to provide insights into the phenomena involved in agglomeration, gelling, and hydrate formation processes. Complementary Cryo-SEM and optical microscopy analysis enable the investigation of fluid microstructures. Ultimately, these methods aim to identify critical combinations of occurrences and determine the necessary tests to identify parameter combinations that lead to conditions posing potential risks to flow assurance.

OR-02

Rheology applied to the study of petroleum industry processes assisted by nanotechnology

Esteban Taborda[1]*, Yurany Villada[1], Lady Giraldo[1], Camilo A. Franco[1], Farid Cortés[1]

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Knowing the behavior of the fluids present in the oil and gas industry is of vital importance for the control and optimization of production processes. In this sense, understanding the rheological behavior of fluids subjected to different chemical and thermodynamic situations is a technical challenge. constant. Recently, nanotechnology has demonstrated high impact as a tool to enhance multiple processes in the oil and gas industry [1-6], and many of these applications alter the rheological behavior of many fluids directly related to the processes in question. In this sense, the objective of this work is to demonstrate the use of rheology as a fundamental tool for fluid characterization in processes of the oil industry assisted by nanotechnology. In more detail, the work will present three important processes in the oil and gas industry: i) increase the mobility and transport conditions of heavy and extra-heavy crude oil [7, 8], ii) improve the performance of drilling fluids [9, 10], ii), and iii) improve polymer injection technology in enhanced recovery (EOR) processes [11, 12], through the use of nanomaterials. To this end, steady-state rheometry and dynamic rheology are incorporated to understand the phenomena and relate the performance and microstructure of the fluids used. The results of these investigations consolidate rheology as a fundamental science in the understanding of fluids, from their formulation, structural understanding and performance in the oil industry. The findings of this research show interesting results of a disruptive technology of great importance to the energy industry in general.

References

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OR-03

Methodology proposal for reducing the flow start-up pressure of gelled waxy oils

Nezia de Rosso[1], Diogo E. V. Andrade[2*], Cezar O. R. Negrão[1]

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In the offshore scenario, during the production and transportation of waxy crude oils by pipelines the material can reach temperatures as low as 4 °C. The wax crystallizes in the bulk at low temperatures, entrapping the oil, and the material gets a solid-like structure when the flow is interrupted. The gel break-up, and consequently the flow start-up, demand pressures much higher than the usual steady-state operational pressure. This work discusses a methodology proposal for reducing the flow start-up pressure employing rheometrical and experimental tests. The experimental set-up is a homemade experimental rig, consisting of two syringe pumps connected to a 56.6 m long pipeline (10.3 mm I.D.). The whole experimental loop was placed within a thermal chamber to control the system temperature. The experiments were conducted using a Brazilian crude oil provided by Petrobras and a model wax oil. The sample was heated to an initial cooling temperature and then cooled quiescently until the final temperature. During the start-up, we can measure the flow rate and the pressure along the pipeline where three high-frequency pressure transducers were installed. We show that through the oscillation of the pipeline inlet pressure, it is possible to reduce the maximum pressure required to start up the flow. Some analyses were also performed in the rheometer to deepen the analysis.

OR-04

Evaluating gelation temperature for waxy oils from unidirectional, oscillatory, and axial force testes

André da Silva Guimarães[1], Thiago Oliveira Marinho[2], Príamo Albuquerque Melo[1], Roney Leon Thompson[3], Marcio Nele[1*]

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The measurement of the gelation temperature for waxy oils is an important step in the field of flow assurance. This is because it delimits the situation in which the material achieves the solid-like state that may cause pipeline blockage. In this context, the literature presents methods based on rheology tests to determine this limit, which can be based on unidirectional, oscillatory, and axial force measurement tests. However, each method can generate different results and interpretations for the gelling point. In view of this, this work aims to evaluate the gelation temperature together with the wax crystal appearance temperature (WAT) of model oils, by means of an experimental plan with paraffin concentrations ranging from 2.5 to 7.5 wt% and cooling rates from 0.4 to 0.8 °C/min, using the three types of methods mentioned above. Firstly, the WATs were determined via differential scanning calorimetry tests. Concerning the rheology tests, in the unidirectional method, the onset of viscosity during cooling was evaluated under the imposition of a constant stress of 0.1 Pa. The oscillatory method evaluated the crossing temperature of the storage and loss modulus for the gelation temperature at a frequency of 0.2 Hz and a deformation amplitude of 0.01 %. Finally, the axial force method evaluated the onset of the normal force during oil cooling in a quiescent situation. The unidirectional and oscillatory tests were carried out using a geometry of grooved concentric cylinders to prevent wall slippage and the axial force test using a 60 mm flat plate geometry on a TA Instruments DHR-3 rheometer. As a result, it was observed that the limit temperatures determined by each method do not coincide and show a tendency to occur in sequence. As an example, a WAT at 28.0°C, a viscosity onset temperature at 26.0°C, an axial force onset temperature at 21.0°C and a modulus crossing temperature at 20.4°C were determined for oil containing 5.0 %wt wax and cooled at 0.6 °C/min. The sequence of events was repeated for most of the situations proposed in the experimental plan. It can be concluded that with the appearance of particles, the first effect observed in the oil is an increase in viscosity due to the formation of a suspension. However, the normal force manifestation due to the oil's contraction and the predominance of elastic over viscous behavior only occurs from a more advanced stage of crystallization and gelation. Therefore, the WAT can be understood as an indication of the changes in rheological behavior that will follow during cooling, and the measure of the crossing of the modules as the most critical situation, in which the solid behavior of the material becomes predominant.

OR-05

Rheological characterization of the non-Newtonian fluid used as a barrier element for temporary well abandonment

Guilherme Mühlstedt[1*], Alberto Ulson Costa Neto[1], Roque Martins Duarte Junior[1], Cezar Otaviano Ribeiro Negrão[1]

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The oil industry is actively engaged in research to enhance extraction techniques and mitigate environmental impacts. Detailed preliminary analyses are essential to ensure environmental safety from well exploration through to decommissioning. The well abandonment phase presents significant challenges in properly isolating rock formations and preventing fluid leaks. According to the Brazilian National Petroleum Agency (ANP), decommissioning expenses in Brazil are estimated to reach approximately R$ 57 billion from 2023 to 2027. This estimation includes both onshore and offshore installations, with around 7,000 wells expected to undergo decommissioning within this period. The rising demand for decommissioning has prompted increased investment in the exploration of novel methodologies applied to the barrier envelope system, aiming to develop more economically viable solutions with minimized environmental impact. The proposed approach involves the utilization of a complex, non-Newtonian water-based fluid, resembling to a drilling fluid, serving as a barrier element within the wellbore system. Understanding the rheological behavior of this fluid is crucial for preventing formation leaks during decommissioning. The aim of this study is to provide the rheological data necessary to ensure the safe temporary abandonment of oil wells. The fluid formulation includes barite, limestone 2-44, polyanionic cellulose, and brine. Our testing methodology encompasses sample characterization to determine the appropriate analysis geometry and includes protocols to reduce water evaporation during the sample analysis. Each step of the flow curves employs freshly homogenized samples to avoid fluid misrepresentation. Oscillatory tests were performed to understanding the material's viscoelastic behavior and stability.

OR-06

Enhancing hydration and dispersion of biopolymers in water-based drilling fluids using ethanol as a dispersant agent

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The incorporation of ethanol as a dispersant agent in base water drilling fluids presents significant advancements in the hydration and performance of biopolymers such as xanthan gum, hydroxypropyl methylcellulose (HPMC), and starch. This study explores the effects of ethanol on the rheological properties of drilling fluids, emphasizing its role in enhancing the hydration of these biopolymers. A series of laboratory experiments were conducted to evaluate the impact of varying ethanol concentrations on the dispersion, hydration, and interaction of xanthan gum, HPMC, and starch within water-based drilling fluids. The results demonstrate that ethanol substantially improves the hydration of these biopolymers, resulting in viscosity and yield stress similar to those used in the current formulation. Enhanced hydration facilitated by ethanol leads to a more uniform and efficient dispersion of the polymers, contributing to better fluid flow characteristics.

OR-07

Pore stability during rheological tests of alkali-activated composites for CO_2 capture

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Development of porous parts capable of sequestering carbon dioxide (CO2) requires ensuring that the porous agents can remain active during the processing piece, i.e., its mixing, molding, densification, and hardening. However, it is known that part of its effect is lost during these stages due to the energetic instability represented by internal air balls [1]. Likewise, it is expected that the additives will be able to produce well-distributed pores, with a reasonable size (mesopores) [2] and that they will be stable during the hardening of the material. Thus, this study intends to evaluate the rheological changes of an alkaline activation with CO2 capture application purposes. Unitary and hybrid systems consisting of metakaolin, slag, and fly ash in different proportions, were evaluated via rotational rheology and mini-slump, and subsequently checking the permanence of the pores via compression resistance after 14 days, microscopy and porosimetry by mercury intrusion. The main variables of the system were various agents such as mineral oil, surfactant, aerosig and hydrogen peroxide, with different percentages of addition, characterized in a rotation sweep and by their temporal superposition. This evaluation would make it possible to indicate which combinations of precursors and additives can favor pore stability, as well as, comparatively, which processing conditions may favor or harm pore stability.

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OR-08 Sponsor

Food tribological model system testing with cocoa mass samples with different rheological properties

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Understanding mouthfeel is essential for the design of food. The perceived mouthfeel depends on several factors such as saliva and food structure is one of the key parameters. Tribology is one of the relevant methods for understanding mouthfeel during food oral processing [1,2]. Model system testing is a promising approach to understand the fundamentals of food tribology. In this study, the authors present an approach as how to characterize the influence of particle size distribution on the tribological behavior of a model tribosystem. The tribological model system comprises of a glass ball and three elastomeric counter bodies which are held in a tribology cell on a rotational rheometer. Finely ground cocoa mass samples with different particle size distribution are used as samples. Results are shown in the form of Stribeck curves and extended Stribeck curves [3]. The results are discussed using complementary rheological measurement results as well as particle size distributions of the samples.

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OR-09 Plenary Lecture

Flow classification

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Flow classification is an open problem. Classical flow classifications examine aspects like laminar × turbulent, steady-state × transient, incompressible × compressible. Here, we discuss flow type. A motivation for this study is the observation that most non-Newtonian fluids behave differently when subjected to a viscometric flow or an extension flow. Although these classical motions are well-defined, it is hard to determine the flow type when it is neither viscometric nor extensional. In addition, extensional flows are a broader class than viscometric flows since the latter has a single set of material functions, while the former exhibits an infinite number of sets of material functions. We discuss the challenges for comparisons between viscometric and extensional material functions. Even in the Newtonian context, flow classification is fundamental due to its connections with other physical phenomena like heat transfer, flow mixing, chemical reactions, etc. Some studies associated with the vortex concept can also bring insights into the current subject of analysis. In this regard, a key concept is the persistence of straining. We also explore dynamic flow classifications by considering the persistence of quantities like the conformation tensor or the stress tensor. From the perspective of yield stress materials, we notice that load type needs to replace flow type in order to address pre-yielding conditions. Emphasis is given to the decomposition of a symmetric tensor with respect to a second where one part of the first is coaxial while the other part is orthogonal to this second tensor. With this tool, we can show insights with respect to tensor representation and the construction of a Deborah number

OR-10

The evolution of cement rheological behavior and 3D concrete printing

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The construction industry has witnessed a significant evolution with the emergence of 3D printing technologies for concrete [1, 2]. These innovative construction methods involve the precise deposition of fresh concrete layers through nozzles, enabling the additive fabrication of intricate large-scale structures without the need of traditional formworks. This aditive construction approach offers notable advantages over conventional methods in terms of Sustainability and design flexibility. However, progress in this field has been hindered by the trial-and-error approach widely employed. There is a pressing need for a deeper understanding of the critical rheological properties for the successful implementation of 3D concrete printing. In this presentation, the evolution of the rheological behavior of hydrating cement systems is examined from a comprehensive model perspective as recently described in the literature [2, 3]. The working principles of the model are discussed as well as model validation against experimental data obtained for cement pastes with delayed and accelerated hydration. It is shown how the model can employ data from rheometry, calorimetry and mechanical analysis to capture the evolution of the rheological behavior of cement systems from the initial fresh state up to the final solid state. Besides that, a simple method to experimentally estimate relevant parameters of the model is highlighted in view of recent developments [4]. Moreover, the diferente stages of 3D concrete printing as well as key rheological properties for layer deposition and long-term structural stability are emphasized. This endeavor represents a concerted effort towards transitioning from a trial-and-error to a model-based design strategy in the field of 3D concrete printing.

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OR-11

On rheological neural differential constitutive equation

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Formulating a rheological constitutive equation requires a deep understanding of how fluids respond to various stress conditions. The complex nature of certain fluids, including their multiple scales, time dependence, viscoelasticity, viscoplasticity, and distinct flow behaviors, pose challenges in accurately developing a rheological equation to describe their behavior. In some situations, rheological constitutive equations may have only restricted terms because of factors like simplification or limited information. This lead to inaccurate predictions and limited model development. Therefore, it is essential to identify and include any missing terms in the formulations to improve the accuracy and reliability of the model predictions. This will ultimately lead to a better understanding and control of the modeled fluid. Scientific machine learning [1-3] tools can aid in ameliorating the limitations imposed during the development of constitutive equations from first principles only. The Universal Differential Equation (UDE) methodology, introduced by Rackauckas and co-workers [4], involves incorporating a universal approximator, such as a neural network, into a differential equation. The differential equation will be adjusted as the network learns from available data, thus recovering missing terms. The methodology described is hybrid since it uses prior physical knowledge as a differential equation and a machine learning algorithm (data-driven methodology). This work will address a tensor basis neural network (TBNN) [5, 6], which preserves frame indifference, and its integration with some constitutive viscoelastic equations used as prior knowledge. Hence, a neural differential formulation will be detailed and applied to predict different numerical rheological experiments. In a different application, we examined how the method could assist a simple model in learning from the data of a more complex model. This technique enables a fair assessment of different viscoelastic models.

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OR-12 Plenary Lecture

Engineering interfacial rheology for the stabilization of soft multiphase materials

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Soft multiphase materials such as emulsions and foams are relevant to a diversity of applications, ranging from food and pharmaceutical sciences to oil and mining industry. Due to the large interfacial area present in these materials, control over the interfacial properties is of utmost importance in determining their stability. Different routes to impart stabilization can be explored, with a prominent one being the use of particles to achieve the so-called Pickering stabilization. Colloidal particles are widely employed to provide Pickering stability to these large interfacial area systems. Their colloidal nature makes them prone to irreversibly adsorb at interfaces, and the flexibility to tune interactions makes them ideal candidates as model systems to understand the behavior of more complex interfaces. Typically, these are used to fully cover the surface of bubbles and droplets. Yet, analogously to bulk materials, the elastoviscoplastic nature can be achieved by different material design routes. In my talk, I will discuss different handles that are available to tune these interactions, and consequently the microstructure and rheological behavior of complex fluid-fluid interfaces. By using custom-built interfacial rheology set ups that enable clean kinematic conditions and combining them with in-situ microscopic observations of the 2D suspension microstructure, it is possible to relate the rheological properties to underlying changes in microstructure, not only in shear but also in compression [1]. Finally, I will discuss how the measured interfacial rheological properties relate to microscale stability in microfluidic experiments that mimic the main driving forces for coarsening mechanisms [2].

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OR-13

Emulsions of polymer solutions as drag reducers

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Drag reduction by polymers is a critical issue, with several applications first reported more than 70 years ago. Drag-reducing flows usually contain a small amount of polymers in the order of ppm (part per million). The most important application is the transport of liquids in pipelines. The operation of long pipeline systems contains polymer injection points where a concentrated polymer solution is injected into the pipeline with a controlled flow rate to reach a desired polymer concentration. For specific applications, such as oil production in deep water, a viscous concentrated polymer solution can be a massive problem for the operating system. Commonly, the injection system in the platform, which is more than 4,000 m away from the production pipeline in the deep water, has a limited flow rate capacity. We show that emulsions of polymer solutions can overcome such a limitation. We produced emulsions that were less viscous than a reference polymer solution. For practical applications, at least three requirements must be fulfilled: 1) the emulsion must be stable before its injection; 2) the mixing process used to obtain the emulsion must minimize the mechanical polymer degradation, which reduces the drag reduction efficiency; 3) once injected into the pipe system, the water drops must easily disrupt to free the polymer into the solvent, the oil.

OR-14

Tuning the rheology of ferrofluid emulsions using magnetic fields

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Ferrofluid droplets and emulsions are tunable soft materials poised to revolutionize numerous technological applications, including microfluidic devices, drug delivery systems, lab-on-achip technologies, and advanced smart materials. Viewed as homogeneous materials, ferrofluid emulsions exhibit remarkably complex behavior owing to the intricate interplay of magnetic forces, surface tension and hydrodynamic forces at the microscale. Through our numerical study on the rheology of magnetic emulsions, we have unveiled several intriguing characteristics and demonstrated how external magnetic fields can be harnessed to finely tune the material properties of the emulsion at a bulk level. In this presentation, we highlight key findings concerning the rheology of ferrofluid emulsions. For the dilute regime in simple shear flows [1], we have observed that the typical shear thinning behavior of emulsions can be suppressed when a magnetic field is applied parallel to the flow direction. Conversely, when the field is orthogonal to the flow, the emulsion exhibits shear thickening under certain high magnetic field intensities. Additionally, the action of magnetic forces at the droplet scale induces internal torques, resulting in an asymmetric stress tensor. In this situation, the rotational viscosity, associated to the antisymmetric part of the stress tensor (couplet), alongside shear viscosity and normal stresses differences, is necessary to fully describe the material's rheology under simple shear. This behavior arises from anisotropic microscopic states, which, as mentioned, generate complex asymmetric stresses. The same mechanism induces shear stresses in magnetic emulsions subjected to pure planar extensional flow [2]. In fact, it is conceivable that, for a general situation where the magnetic field direction relative to the flow is arbitrary, a complete description of the stress state of the emulsion should require a total of eight material functions. In the concentrated regime, the interplay between hydrodynamic and magnetic interactions among droplets leads to even more intricate dynamics at the inner scale, characterized by phenomena such as droplet migration and droplets chain formation and desegregation. We also present preliminary results on the behavior of moderately concentrated magnetic emulsions under simple shear, serving as an illustration of future work in this direction.

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OR-15

Using microscopy to help understanding rheology

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Non-Newtonian fluids are extensively employed in many industrial applications, such as food, pharmaceutical, and petroleum industries. The internal structures of these complex fluids hold significant interest for rheologists, as they provide crucial insights that enhance the analysis and comprehension of the outcomes of rheological experiments [1]. One method for learning more about the microstructure of fluids is cryo-Scanning Electron Microscopy (cryo-SEM). Several studies in the literature question whether this technique can adequately reveal the native networks of fluid [2]. There are several issues that should be considered when employing cryo-SEM to analyze fluids microstructure. Here, we present some promising implementation cases of this cryo-SEM approach for various non-Newtonian fluids, comparing the microstructure visualization with the rheological results. Some examples show the microstructure and rheology through the evolution of Laponite suspension as it ages, of Carbopol and Xanthan Gum suspensions with the addition of nanoparticles, and of a cement slurry during hydration.

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OR-16 Plenary Lecture

Computational rheology of structured materials

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In this talk, an overview is presented of our recent work on the rheology of structured materials from a theoretical and computational perspectives. Here, the rheological characterization of a diversity of tixo-viscoelastoplastic materials is interwoven with the predictive capabilities of our hybrid finite-element/finite-volume numerical algorithm, in a strategy to advance in the prediction and explanation of benchmark experimental results. Our focus here is on typical model-flows, such as contraction-expansion and flow past sphere, for which pressure drop and drag measurements provide information on their dynamics in terms of the energy required to sustain a given flow rate, and its kinematic reflection in flow-structure evolution. Early developments are discussed on the treatment of the well-known High Weissenberg Number Problem, which is the ceiling posed by the degree of non-linearity a numerical scheme can resolve in the solution approximation to a complex flow, being this one of the main challenges to the Computational Rheology community. With this purpose, a variety of constitutive models is studied, ranging from those under the Bautista-Manero family of fluids, originally devised to capture the thixo-viscoelastoplastic rheological features of wormlike micellar solutions, to the classical Phan-Thien-Tanner models. Here, in the benchmark rounded-cornered contraction-expansion geometry, we attained an increase of several orders-of-magnitude in the critical Weissenberg number level for solution divergence, practically facing no limitation on the target degree of non-linearity. This is achieved via the generally applicable ABS-f and the VGR corrections. The ABS-f correction acts upon the stress-invariants used to promote non-linear features in conventional differential-type constitutive equations for viscoelastic fluids, helping in problem-regularization and physically-consistent material-property calculation in complex deformations. The VGR correction deals with proper velocity-gradient estimation, used to consistently specify velocity-gradient components at boundary symmetry lines and to impose conservation-of-mass discretely over the flow-domain. With such computing power, several research avenues are explored with the objective to mimic, capture, and explain the key phenomenology of experimental flow-regimes for several materials, including polymer solutions, wormlike micellar solutions, and biofluids. For polymers, we proposed the novel swan INNFM constitutive models, engineered to describe the extremely-active extensional viscosity response of these materials, and with which we have been able to quantitatively capture and explain the extreme-high enhanced pressure-drops measures and the evolution of vortices reported experimentally. For biofluids, specifically for human sputum, we performed simulations of extensional deformation under FiSER and CaBER modes to study systematically the extensional viscosity of human sputum in different degrees of development of illnesses in the respiratory systems, such as COPD. For wormlike micellar solutions, with further development of rheological equations-of-state in the Bautista-Manero framework, we captured extremely non-linear phenomena related to negative wakes and oscillations in the descent of spheres in these materials, and the simulation of shear banding in complex contraction-expansion flows.

OR-17

Mathematical model of waxy oil gelation to assess material shrinkage

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Production of waxy oil in deep and ultra-deep waters is challenging, mostly due to low temperatures at the subsea bed. During the oil uplift from the reservoir to the subsea wellheads, the oils are subjected to temperatures as low as 4°C at the seafloor. Heat transfer from the oil to the marine environment occurs during transportation. As it cools down, the oil gelifies and reduces its volume. It is well known that oil gelation increases the oil viscosity and provides a yield stress to the material, reducing its flowability. Minimum start-up pressure is expected to be proportional to the material yield stress. On the other hand, volume reduction due to thermal contraction may cause the appearance of voids inside the material that can also affect the minimum required start-up pressure. Despite the significant number of works evaluating the effect of oil gelation in the flow start-up of gelled oil, not many have given attention to the impact of voids inside the material caused by shrinkage. The current work proposes a mathematical model of the phase change process (gelation) during cooling to assess the volume shrinkage. The model is based on the mass, momentum, and energy conservation equations. The Enthalpy-Porosity model is used to simulate the solidification process, and the mushy zone is treated as a pseudo-porous medium with the porosity varying from 1 to 0 as the material solidifies. An experimental setup was built to compare the measurements with the simulation results with qualitatively good agreement. The simulation results also show that the sample's final shape depends on the process cooling rate.

OR-18

Annular displacement flows in oil well cementing operations

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For a successful oil well cementing operation, it is necessary to accurately predict the flow of drilling fluids, spacers, and cement slurries along the well to obtain pressure distribution, pressure drop, and fluid displacement efficiency. Failure to predict displacement accurately can compromise the safety and integrity of the well through unwanted influx, collapse of well walls, inefficient transport of cuttings, failure to isolate zones, among other issues. Viscosity and density ratios, along with inertia and geometric irregularities, can induce hydrodynamic instabilities, leading to ineffective displacement. This process is very complex due to the non-Newtonian behavior, transient flow dynamics, and complex geometry associated with eroded zones. In this work we present the development of a high-performance simulator for annular well fluid displacement dynamics, aimed at providing a deeper understanding of the physical phenomena observed during oil well cementing and plugging processes [1, 2]. The main goal is to develop a 3D simulator to describe the transient displacement of a sequence of complex fluids within various well annular geometries, considering different rheological properties and flow regimes. The governing equations for mass and momentum conservation consider a Generalized Newtonian Fluid model [3] dependent on pressure and temperature, aiming to mimic the viscoplastic behavior exhibited by these fluids. This system of equations is numerically discretized using the Finite Difference Method and solved using Intel's MKL PARDISO library. The simulator is designed to describe fluid flow within the annulus space, considering changes in inclination, direction, eccentricity, and diameter. The displacement of a sequence of several non-Newtonian fluids under laminar or turbulent flow regime is considered. The solver, implemented in C++, enhances computational efficiency through process parallelization and high-performance computing (HPC). Preliminary results show good agreement with commercial software and experimental setups in several annular displacement scenarios.

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OR-19

Thixotropic dynamics of three-dimensional flow in coating dies

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Various industrial and natural applications involve flow of thixotropic liquids [1]. Understanding and predicting the flow behavior of such liquids is essential for process improvement in different sectors, including the production of precision coated thin films. In all premetered precision coating, the liquid is delivered through a coating die. The geometry of the internal cavities of the die needs to be properly designed to obtain a uniform flow rate along the die slot, which leads to a uniform film thickness in the cross-web direction. The design of the geometry of coating dies is usually done by numerical solutions of the three-dimensional flow of the liquid and searching for a geometry that leads to a uniform flow rate through the slot. Most of these models describe the non-Newtonian characteristics of the liquid using a Generalized Newtonian Model, with the local viscosity being a function of the local deformation rate and neglect time-dependent behavior, which can be relevant in coating of particle suspensions. This can lead to very inaccurate description of the flow and therefore, internal cavity geometry of coating dies that fail to deliver uniform flow rate through the feed slot. This study addresses the three-dimensional flow of thixotropic liquids inside the cavities of coating dies. Time-dependent behavior is modeled using a kinetic equation for the material fluidity, which is defined as the reciprocal of viscosity, and specifies uniquely the material microscopic state. The model accounts for the mechanisms of buildup and breakdown of the microstructure with no postulated functions nor additional auxiliary parameters [2]. The 3D finite element numerical model, proposed and implemented in Python based on the precompiled library named Dolfin, is developed within the open-source project FeniCs [3] and allows for a realistic representation of thixotropic fluid flow in complex geometries. The results show that thixotropic behavior has a strong effect on the performance of the coating die if the characteristic times of the liquid is in the same order of the residence time and should be considered in the design of coating dies for particle suspensions applications.

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OR-20

Modeling the inline mixing of non-Newtonian and Newtonian fluids

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Inline mixing is a process in which two or more phases are blended continuously as the different flows converge within the same line. This approach offers the advantage of eliminating the requirement for traditional mixing tanks, which can reduce equipment costs and streamline operations. However, it can be challenging to ensure the homogeneity of the resulting mixture and prevent uneven distribution of phases. Extensive research has been done to optimize this type of process for Newtonian fluids, but few studies have considered non-Newtonian ones. Nonetheless, there are several industrial applications for mixing non-Newtonian fluids, such as in the food industry, oil and gas exploration, and sewage systems. This study aims to model the mixing of a non-Newtonian and Newtonian fluid at the junction of two lines, by using Computational Fluid Dynamics. The simulation consists of injecting a high-viscosity nonNewtonian fluid into a pipe with flowing water. The fluids are assumed to be incompressible and fully miscible by employing the Eulerian multiphase model. The simulations explore several parameters, such as Reynolds numbers, Newtonian-to-non-Newtonian fluid ratio, and geometric configurations of the junction. Results highlight the impact of flow characteristics and design parameters on the mixing effectiveness, measured as homogeneity of the resulting mixture and pressure drop on the intersection. In conclusion, the study provides insights into the dynamics of phase interaction under varying conditions and optimizing inline mixing processes involving non-Newtonian fluids.

OR-21

Numerical study of free surface flows with a generalized Newtonian interface

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Complex multiphase fluid-fluid interfaces appear in several kinds of processes, from natural and biological ones, commonly observed in food, environment, and living systems, to those used in industry, such as enhanced oil recovery and manufacturing processes. In practice, however, the liquids used in these applications are often doped with surfactant molecules, polymer chains, and solid or deformable particles. These species are known to have an impact on the bulk liquid material's rheology. Nevertheless, if they migrate to the interface between the phases, they may also result in a complex interfacial rheological behavior, as it is supported by recent studies [1, 2]. We present a computational study of free surface flows with rheologically complex interfaces, with shear-thinning and shear-thickening effects, in a planar extrudate swell flow and also in the film formation region of a slot coater. The equations of motion for incompressible Newtonian liquids in the bulk flow are coupled with a Generalized Newtonian constitutive equation, extending the Boussinesq-Scriven model, in the dynamic boundary condition at the liquid-air free surface and solved with a mixed finite element method. We introduce appropriate dimensionless parameters to explain a full set of results that reveals a significant effect on the interface and therefore the flow dynamics. The results show that for slot coating flows, interfacial effects have a significant influence on development length and film thickness, the velocity field, and the recirculation pattern in the coating bead. In planar extrudate swell flows, these interfacial effects influence the size of the extrudate, its velocity profile, and its development length as well.

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OR-22 Sponsor

Improvement capabilities of MCR series: capillary extensional and automation rheological measurements

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MCR 702e is a modular platform where its structure allows, in addition to conventional rheological studies of materials, it also allows the coupling of a second motor that allows a multitude of applications and tests to be carried out. The objective of the presentation aims to show that the MCR 702e goes beyond the limits of conventional applications, making it possible to use it as a capillary extensional rheometer and can also increase the number of data generated by the laboratory with automation. These unique features not only break the barrier of equipment development but also help research groups and researchers to elevate their research into rheology.

OR-23 Plenary Lecture

Yielding and plasticity in disordered materials: microstructure, memory, and flow

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When stressed sufficiently, amorphous materials yield and deform plastically via reorganization of microscopic constituents. Despite much effort, understanding the interdependence of yielding, plasticity, and microscopic structure in non-equilibrium states (i.e. under stress) remains a major challenge. In this talk, I explore this interdependence by cyclic shearing a dense colloidal suspension using a custom-built interfacial stress rheometer. This setup allows for simultaneous measurement of the bulk rheology (G', G'') and characterization of the suspension microstructure, and particle trajectories. We find that even when the deformation is globally reversible, local rearrangements are plastic, displaying hysteresis and altering rheology [1]. The former is a sign that the self-organized steady state is in fact a limit cycle. This reversible plasticity vanishes at small strain amplitude and is gradually overwhelmed by irreversibility as the yielding transition is surpassed. Next, we use the concept of (structural) excess entropy to investigate the relationship between relaxation dynamics and microscopic structure. Results show that structural relaxation induced by plastic flow depends on and scale with the strain-rate and microscopic order measured at earlier and later times, respectively. Thus, measurement of sample *static* structure (via excess entropy) provides insight about both strain-rate and constituent rearrangement *dynamics* in the sample at earlier times [2]. A relationship between structure and rheology can be obtained by examining how sample memory is stored in the elastic regime and lost as plasticity increases [3].

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OR-24

Rheological behaviour of nanostructured complex fluids with two-dimensional (2D) materials

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The synthesis, characterization, modification, and application of two-dimensional (2D) materials, including graphene and its derivatives (such as graphene oxide - GO), and hexagonal boron nitride (h-BN), are currently receiving much attention due to their unique properties derived from its nanostructure. These special characteristics lead to innovative and disruptive applications, such as 3D printing of electrodes for energy storage, multifunctional nanocomposites, smart materials through 3D/4D printing, conductive inks, among others. However, for these materials to be produced on a large scale, several challenges still exist, namely the fundamental understanding of the rheological behavior of these materials dispersed in different dispersant matrices. Fluids composed of 2D materials and dispersing matrices tend to form complex systems due to their unique morphological and structural properties, which will govern the macroscopic rheological properties. In this sense, we have been working on the functionalization of graphene and h-BN, dispersed on different model fluids (Polyethylene glycol – PEG, Carbopol and xanthan gum) with the main objective to study the rheological properties during shear flow. It was shown that higher oxidation times increase the functional groups, which leads to a higher dispersion and exfoliation of GO sheets in the PEG. Moreover, the addition of GO in a PEG solution results in significant growth of the suspension viscosity, and a change of the fluid behavior from Newtonian to pseudoplastic. This effect is related to the concentration and oxidation level of the obtained GO particles. However, when the GO was dispersed in Carbopol, promoted a decrease in viscosity, yield stress and elasticity, mostly due to chemical interactions between the 2D material and the model fluid. More recently, the rheological properties of oxidized hexagonal boron nitride (h-BN-Oxi) were investigated, and the results revealed that the increase of h-BN-Oxi concentration led to the increase of viscosity with the concentration of h-BN-Oxi nanomaterials. Also, it was observed a transition from pseudoplastic behavior for concentration up to 15 mg mL-1, to a yield stress above, well described by the Herschel-Bulkley model. This behavior was ascribed to the complex network obtained by the h-BN-Oxi nanostructures with the xanthan gum. These results provide fundamental insights into rheological response of this 2D materials in complex fluids which is critical for the development of various solution processing and manufacturing techniques.

OR-25

Rheology of graphene oxide nanosheets in xanthan gum

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Xanthan gum (XG) is a biopolymer used as a viscosifier in many industries, from food to cosmetics and oil & gas. Moreover, functionalized graphene, such as graphene oxide (GO) may have a great potential when suspended in complex fluids, improving mechanical, thermal and electrical properties. The introduction of GO nanosheets into non-Newtonian fluids can significantly improve many important properties, but attention must be paid to the effects of GO addition on the rheology of the base fluid, which plays a key role in many industrial processes. The present work aims to study the effects of the addition of GO nanosheets on the rheology of aqueous dispersions of xanthan gum. The application is focused on the use of XG as a viscosifier in drilling fluids. Drilling operations are extremely important in the oil & gas industry, and as the demand for high-quality oil & gas resources increases, the need for improved drilling fluids is even more necessary. Graphite oxide was obtained from graphite using the modified Hummer's method. The solutions of GO in XG are obtained by ultrasonic exfoliation and mechanical stirring techniques. The influence of concentrations of GO (with constant concentration of XG) is investigated through the analysis of rheological tests performed in steady and oscillatory flows. The flow curves and the storage and loss moduli are obtained using the rotational rheometer ARES-G2 (TA Instruments) with smooth concentric cylinders geometry. Tests are performed at different temperatures to evaluate rheological stability. The results indicate that interaction between GO nanosheets and XG polymer chains has a notable influence on the rheology of the solution. Furthermore, it is shown that the dispersions maintain the viscoelastic and shear thinning behavior of the pure XG, while the viscosity function increases with GO concentration.

OR-26

Improving efficiency of polymer injection in enhanced oil recovery processes with silica nanoparticles

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Partially hydrolyzed polyacrylamide (HPAM) is widely employed in enhanced oil recovery (EOR) process. However, its effectiveness is hindered by degradation of polymer molecules during flow through injection lines, valves and reservoirs. This degradation leads to a decrease in average molecular weight and subsequently reduces the solution's viscosity and viscoelastic properties, impacting its effectiveness on displacing oil. Our research characterized the degree of mechanical degradation of HPAM solutions using shear and extensional rheology. We induced degradation by flowing the solutions through a valve with varying constriction and flow rates and through a microfluidic porous medium model. Our findings reveal that the addition of silica (SiO2) nanoparticles has a negligible effect on the shear and extensional viscosities of fresh solutions and minimizes the mechanical degradation of HPAM solutions. The rheological properties of HPAM solutions with SiO_2 nanoparticles are not significantly affected by mechanical degradation, suggesting that incorporating nanoparticles could enhance the efficiency of polymer injection in EOR processes by stabilizing HPAM solutions. Our research delved into the topic of oil displacement flow, utilizing microfluidic devices as models of porous media. In this study, we explored the efficiency of both fresh and degraded HPAM polymer solutions in the displacement of oil, and our findings suggest that fresh HPAM is more effective than degraded HPAM in this regard. Additionally, we also investigated the potential of silica nanoparticles in improving EOR processes. The results showed that the addition of silica nanoparticles into degraded NPs-HPAM solutions could boost oil recovery by 9-13%, which is a significant increase. This finding highlights the enormous potential of nanoparticles in the field of EOR and suggests that they could be a promising avenue for further research and development.

OR-27

How the morphology and structure of innovative graphene oxide (GO) dispersed in xanthan gum (XG) affects the rheological behavior

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The surging demand for oil in recent decades has propelled the exploration of ultra-deepwater (offshore), underscoring the pivotal significance of this sector. However, this practice comes with limitations such as potential environmental issues and challenges in penetrating salt layers. Drilling fluid plays a crucial role in the well drilling process, encompassing functions such as cooling the drill bit and transporting cuttings to the surface. Water-based fluids or water-based muds (WBM) are environmentally friendly, but they are susceptible to degradation under high pressure and temperature conditions and have lower efficiency compared to oil-based fluids or oil-based muds (OBM). To address these challenges, companies are turning to nanotechnology-based solutions to develop fluids capable of operating effectively under extreme conditions. Among the nanomaterials utilized for this purpose, graphene oxide (GO) stands out for its exceptional mechanical strength, lubricating properties, and compatibility with water-based fluids. GO, being chemically stable, also enhances the rheological properties of the fluid. Considering this, the aim of this work is to develop a water-based fluid with enhanced properties for oil extraction. This endeavor aims to develop and characterize nanostructured WBM containing GO and xanthan gum (XG), a prevalent biopolymer in the oil industry. To achieve this, a streamlined production method has been devised, utilizing GO as a filler and xanthan gum as the matrix. Initial rheological tests were conducted to analyze the fluid behavior, providing valuable insights into its performance under different conditions. GO is synthesized and exfoliated in water, following which xanthan gum is incorporated, eliminating intricate industrial procedures. This method yields a concentrated dispersion or masterbatch, subsequently diluted in the matrix itself at varying concentrations, thus fostering a more efficient and scalable manufacturing process for the industry. One of the highlights of this study is the correlation between the morphology and structure of the nanomaterial with the rheological properties analyzed, noting an alteration in rheological behavior compared to initial tests with different dispersion methods. The project innovates by using water-based fluids, creating a direct link between nanomaterial interaction with xanthan gum and its effect on fluid properties. Utilizing these fluids not only reduces environmental impact but also minimizes related operational risks. By incorporating GO and XG, not only delivers superior performance in extreme conditions but also meets industry demands for environmentally friendly solutions.

OR-28

Exploring the role of rheology in enhancing performance of lithium-ion battery manufacturing

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Lithium-ion batteries (LiBs) are manufactured by coating process of electrode slurries containing several types of particles and polymers onto a metallic current collector. Rheological properties are normally used to manage and control the manufacturing process: lower viscosity is beneficial for coating process and higher viscosity is suitable for the storage stability against particle sedimentation of the slurries. Rheological properties are strongly related to the microstructure of the slurries, and it can be changed depending on their preparation method related to mixing sequence ([1],[2],[3],[4], [5]). However, because the slurries undergo through different level of stress (shear) during the coating process, it is crucial to take into account the effects of not only the mixing sequence but also the mixing strength or mixing time on the rheological properties when battery electrodes are produced. Therefore, fundamental understanding of electrode slurries rheology is imperative both for improving manufacturing efficiency of LiBs and for achieving the desired LiB performance and durability. This work explores the significance of comprehending Libs rheology in enhancing battery manufacturing process.

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OR-29 Plenary Lecture

Use of tribo-rheological techniques to improve technological properties of dairy products

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One of the most important attributes of foods is texture in the case of solid and semi-solid products and flow behavior in the case of liquid products. At this point, rheology plays an essential role in the development of fundamental techniques to replace the empirical and imitative tests currently used as routine methods in the industry, which are inaccurate, arbitrary and difficult to correlate with the microstructure of the food matrix. Indeed, one of the important roles of rheology in food science and technology is to improve the understanding of what happens to foods at microstructural level by measuring macroscopic parameters (e.g., rheometric functions) when physical or chemical changes are considered. In this presentation, examples of how rheometric techniques and rheological interpretations have been applied to analyze and improve some technological properties of dairy products will be shown. The topics will be related to: (i) Melting properties of Mozzarella cheese during its ripening, (ii) Colloidal and thermal stability of milks affected by the addition of calcium salts, (iii) New formulations of semi-solid gels obtained by combining milk concentrates fortified with calcium and heat treatment. Likewise, understanding the oral processing of foods has also gained research attention. Regardless of the initial state of food, it undergoes a conversion to a form that is rheologically suitable for swallowing in a highly sophisticated dynamic process. Tribology is emerging as a contributing discipline that helps provide insights into the oral processing of foods, as well as their texture and mouthfeel. In this opportunity, the application of tribological techniques to study the lubrication characteristics of microparticulated whey proteins used as fat replacers in dairy systems will be shown.

OR-30

W/O emulsions stabilized solely by cocoa butter-based oleogels: effect of crystal-crystal interactions on rheological performance

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Water-in-oil (W/O) emulsions have attracted heightened attention because of the ever-increasing interest in using non-calorific water to replace calorie-dense fat in food. However, finding food-grade particles to replace the classic surfactant i.e. polyglycerol polyricinoleate (PGPR), E476, commonly used in fat continuous emulsions, whilst providing good stability has been challenging. The Fat crystals can be a promising alternative, as they are hypothesized to stabilize water-in-oil emulsions (W/O) emulsions by a combination of Pickering particles and network stabilization [1]. The network stabilization might contribute significantly to the W/O final properties. Thus, the aim of the project was to study the effect of water content and crystal-crystals interactions in the rheological properties of W/O emulsions. Water-in-oil (W/O) emulsions were stabilized by using oleogels formed with cocoa butter crystals (CB) dispersed in high oleic sunflower oil (HOSFO). The capability of the CB crystals (10-20 wt% CB) to form W/O emulsions (30-60 vol% water) was characterized using cross-polarized light microscopy, cryogenic scanning electron microscopy, and confocal light microscopy. The crystallization process and fat crystal polymorphism in cocoa butter were characterized by small angle (SAXS) and wide-angle X-ray scattering (WAXS) and differential scanning calorimetry. Meanwhile, the rheological properties of the emulsions were examined by viscosity test and frequency sweep tests. Microstructural analyses of W/O emulsions at multiple length scales revealed that platelet-like CB crystals not only surrounded the droplet surface but also the CB fat crystals formed a network in the bulk phase further contributing to stabilization. The increment in the water content increased the emulsion viscosity of 40, 50 and 60% of water (%v/v) and all the emulsions show shear-thinning behavior which further demonstrated droplet aggregation. However, after one month all the emulsions behave similarly, with no change in viscosity, which might be associated with the Ostwald ripening growth of crystals and crystal-crystal aggregation in the bulk phase contributing to locking the water droplets during storage, with rheological properties being largely governed by the CB crystals rather that the water droplet content. New findings from this study demonstrate that CB crystals in the form of oleogels can be used solely to stabilize the water-oil interface with an increased volume fraction of water in a W/O emulsion without any added surfactant. Such stable clean-label Pickering systems offer promise for designing healthy low-fat confectionery products where biocompatibility is a key necessity without compromising on rheological performance, a key parameter for processing and eating textural quality.

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OR-31

Analysis of wall shear stress for hematocrit dependent blood model in hemodialysis fistulae

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Chronic kidney failure is a metabolic syndrome characterized by a total or partial loss of the kidney's filtration capacity. Typically, this condition arises due to the influence of other diseases such as diabetes, severe arterial hypertension, kidney infection, autoimmune diseases, among others. Hemodialysis is as the primary alternative treatment for individuals who have not undergone a kidney transplant or are ineligible for one. Patients undergoing hemodialysis may encounter various complications, including hypotension, vomiting, dizziness, headache, hypertension, hypoglycemia, and fainting. One notable complication related with hemodialysis is the loss of venous access, associated with shear on the vessel walls and the flow patterns generated by the angles of anastomosis. While some studies focus on the functioning of arteriovenous fistulas during the maturation period, this paper addresses matured fistulas. Preliminary research has explored the relationship between shear stress and anastomotic angulation in immature fistulas. Here, the focus shifts to investigating whether this relationship holds true for already matured fistulas. Blood flow is modelled in this work within the generalized Newtonian framework. To capture high and small shear rates and the sites of stagnation flow that could be formed, here we adopt a Sisko-like constitutive relation [1], with hematocrit dependence parameters proposed by Karam and Bortoloti [2], referred here as WS/KB, suitable to capture Newtonian and non-Newtonian behaviors, depending on the shear rate. After obtaining velocity and pressures, shear stresses along the wall are calculated and to analyze the concept of shear stress oscillations over time, the oscillatory shear index (OSI) is determined at each point along the vessel walls. Simulations are conducted with hematocrit levels of 30% and 40%, with anastomosis angles of 20°, 25°, 30°, 35°, 40° and 45°. From the results, a narrow range around 25o is suggested as the most suitable choice for clinical applications, minimizing possibilities of diseases.

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OR-32

Power law fluid flow in partially porous and fractures channel: numerical model and validation

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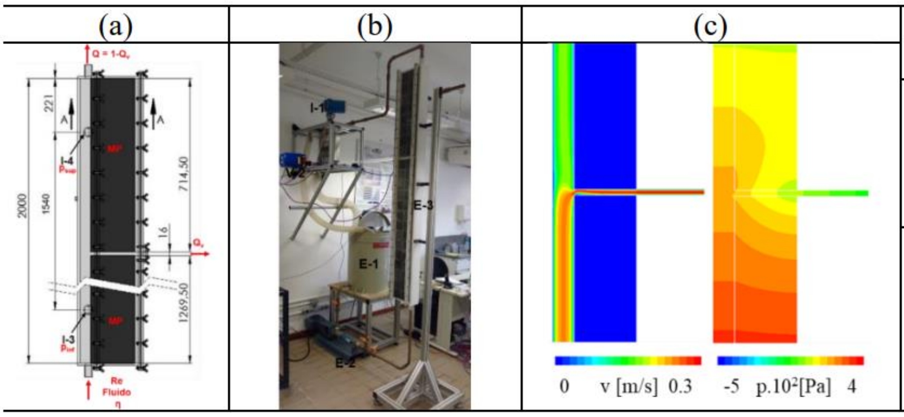
This work presents validation results for a power law fluid flow in a vertical channel bounded by a porous medium with a discrete transverse fracture, as shown in Figure 1 (a). The experimental circuit design, commission, instrumentation, and operation [1], is presented in Figure 1 (b). The fluid rheology characterization employed a FANN35A viscosimeter, curve fitting the shear rate and viscosity according to a power law fluid. Numerical results, displayed in Figure 1 (c) employed the Finite Volume Method [2] with power law viscosity model and porous-continuous model for the porous region. The velocity magnitude field shows the fracture drains a meaningful amount of fluid, leaving the porous region nearly quiescent, while the pressure field elucidates the effects of the fracture. Results validation, shown in Figure 1 (d), represents the pressure difference measured in the vertical channel, between the inlet and outlet, and the pressure difference measured between the fracture outlet and the channel. Good agreement between numerical and experimental results is achieved, thus validating the numerical approach.



(d)	Exp.	Num.
ΔP vertical channel [Pa]	15300.18	15271.20
	0.189%	
ΔP fracture [Pa]	653.10	704.49
	-7.409%	

Figure 1 – Validation results for a power law fluid flow in a partially-porous fractured vertical channel: (a) geometry domain with a 30% flow rate through the fracture and Re=250 at inlet.; (b) experiment overview comprising mixing tank (E-1), pump (E-2), test section (E-3), flow metering valve (V2), and pressure transducer (I-1); (c) CFD results for velocity and pressure field of k=0.186 Pa.sn and n=0.582 fluid; (d) Comparison of numerical and experimental results for the pressure difference along the vertical channel and fracture.

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OR-33

Reformulation of constitutive equations based on the generalized Lie derivative

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Considering the applications of viscoelastic fluids and the complexity of obtaining an accurate mathematical model to describe them [2], this work proposes a new numerical scheme to reformulate the constitutive equations. The proposal is to use the generalized Lie derivative, as proposed by [3], rewriting the constitutive equations that present the upper convected time derivative term, suggesting a new numerical scheme according to a Lagrangian formulation and the finite difference method. Given the different models of constitutive equations that describe viscoelastic flows, many equations have the upper convected time derivative term in their formulations [1], we focus on solving only problems described by the Oldroyd-B model, highlighting the importance of correctly treating the term in question. Knowing that numerical approximations can also generate numerical instabilities during the simulations, the new proposed formulation allows us to investigate the causes of these instabilities that plague, mainly, simulations involving high Weissenberg numbers, as seen in manufactured problems [4, 5]. To reformulate the constitutive equation, theoretical foundations, definitions, hypotheses, and properties that support the mathematical construction of the proposed numerical scheme was presented [4]. The preliminary results made it possible to evaluate the effectiveness of the proposed mathematical model and verify that the order of convergence of the numerical scheme is in line with theoretical results in manufactured problems. The numerical scheme can also be extended to more complex problems, which allows a greater time step compared to other methods in the literature, with accuracy of results and shows efficiency in solving numerical tests with high Weissenberg numbers when combined with stabilizing methods [5].

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OR-34

Direct numerical simulations of power-law fluids in smooth and rough channels

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The effect of roughness on the turbulent flow of generalized Newtonian fluids, to the best of our knowledge, has not been addressed before in the literature. For this reason, we have conducted several direct numerical simulations (DNS) of power-law fluids on pressure-driven rough and smooth channels. The rod-roughened channel was employed, with square rods placed along both walls of the channel. The rods heights were of 1.7% of the channel's half height h, with a pitch-to-height ratio of 8. To comprehensively study the influence of rheology on these flows, a total of five simulations in the range $0.5 \leq n \leq 2.0$ were carried on the smooth case, with two values of Re_τ. On the rough case, three simulations with n = 0.5, 0.75 and 1.0 were conducted. The finite volume open-source software OpenFOAM was used. Reference DNS simulations of [1, 2] were used to validate the rough and smooth Newtonian simulations, respectively, with our simulations closely matching the references. Results demonstrated that the turbulent structures on the smooth channel are strongly affected by rheology. As the flow becomes more shear-thinning, the near-wall structures become longer, suggesting the requirement for larger computational domains. For shear-thickening cases, the structures are smaller, and the velocity fluctuations were more pronounced. A connection between changing the power-law index and varying the Reynolds number in Newtonian flows was observed. On the rough simulations, it was observed that two vortices were enclosed by consecutive rough elements. Our results demonstrated that the shapes of these vortices are weakly rheology dependent. The shifts in the mean streamwise velocity profiles, in comparison to the smooth channel, were also weakly dependent on rheology. When decreasing n, considerably small changes to the value of the roughness function were observed.

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OR-35 Sponsor

A short introduction to tribo-rheometry

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Originally, tribology was used to characterize the lubrication behavior of oils and greases for example for gears and engines. But lubrication is not only important for automotive industry. Nowadays, a lot of research is going on to study the frictional properties of foods and beverages. One reason for this is to quantify the so-called mouthfeel to improve the customer acceptance towards for example plant-based food alternatives. But also, when it comes to analyzing sensory properties of cosmetics or pharmaceutical creams and ointments, or in other areas like coatings, tribology can be useful. The presentation gives a short introduction into the basics of tribo-rheometry and shows some application examples we can develop with universal rheometers.

OR-36 Plenary Lecture

Porous particle suspensions: the reduction of lubrication forces is at the origin of their behavior

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Porous particles are widely used in the field of drug delivery, adsorption process, and energy storage. The present work focuses on the rheology of non-Brownian suspensions of porous silica particles immersed in a Newtonian Polyisobutene (PIB). Three different porous particles, with different porosity and similar size, are used, and the results are compared with those obtained on suspensions of irregular silica particles and of hollow glass spheres. The rheological response of the porous particle suspensions is unique if the particle volume fraction is corrected to account for the polymer adsorbed into the particles. Hollow glass sphere suspensions show a Newtonian behavior for particle volume fractions up to 40%, thus indicating a nice dispersion of the silica spheres in the PIB, thanks to a nice solvent particle interaction that guarantees a good particle solvation. Conversely, above a critical volume fraction, the porous particles and irregular silica suspensions show a shear thinning behavior and the presence of a yield stress. This suggests that the shear thinning is due to adhesion forces between the particles that promote the microstructure rearrangement with the shear rate. The adhesion forces between irregular particles or porous particles are of the same order of magnitude, as estimated according to Gillissen et al. [1]. The critical volume fraction of the porous particle suspensions is much smaller than that of the irregular silica particles ones, 0.02 vs. 02. The viscoelastic spectra indicate that the percolated microstructure of the porous particle suspensions is denser and stronger than that of the irregular particle ones. The different behavior of the porous particle suspensions with respect to the irregular ones is proposed to be due to a reduction of the lubrication forces occurring when two porous particles approach each other because of additional interparticle fluid drainage mechanisms: 1) fluid flux through the porous particles; 2) propagation of the interparticle shear flow within the porous particles. The lubrication force is estimated when two porous disks approach each other and it is shown that the first mechanism dominates at low shear rates, when the percolated microstructure is generated, while the second prevails at high shear rates, where the particle clusters are disaggregated. The same particles are immersed in a different Newtonian solvent, PEG, that thanks to its polarity and the OH groups may solvate silica particles much better than PIB. The interparticle forces will accordingly change and indeed the suspensions made with the hollow glass spheres or with the irregular silica particles show a predominantly Newtonian behavior also at high volume fractions. Porous particle suspensions behave differently, confirming that the reduction of lubrication forces is the key factor at the origin of their peculiarities.

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OR-37

Squeeze flow of suspensions supported by pressure mapping and interparticle distances with microstructural representation

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The squeeze flow test has been employed for the rheological analysis of a wide range of materials, presenting relevant similarities with the flow conditions of many processing techniques [1]. Despite the relatively simple execution, the results of the test involve many variables and factors, and the analysis can become complex, especially for suspensions. A recent development was the incorporation of a pressure mapping device to the experimental setup, in a method called Pressure Mapped Squeeze Flow (PMSF) [1-3]. Combined with a thorough physical characterization and concepts of interparticle separation distances (IPS), the additional information greatly enhances the comprehension of the flow behavior [2].

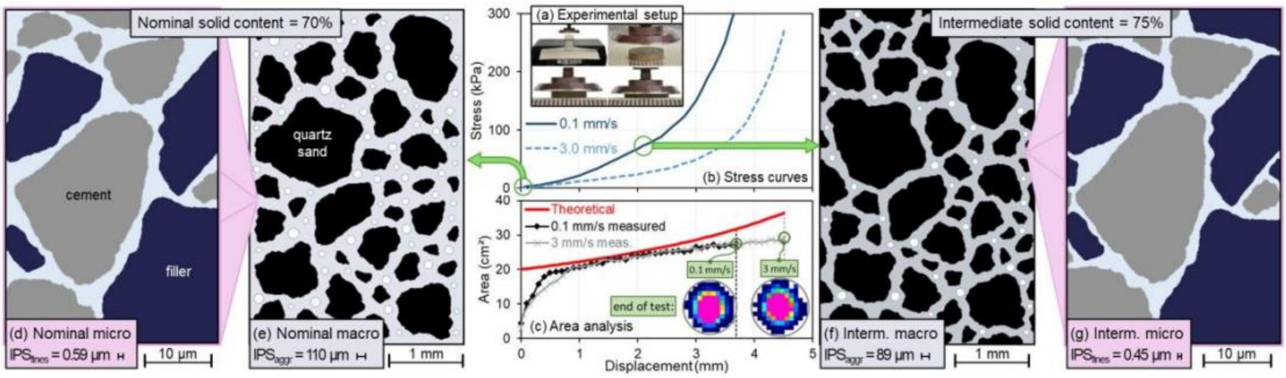

Fig. 1 - (a) PMSF setup; (b) squeeze flow stress curves; (c) analysis of the area measured by the sensor; and representation of the mortar's microstructure in two levels under (d,e) nominal condition and (f,g) intermediate condition of phase separation.

Fig. 1 shows results for a cement-based mortar that undergoes significant phase separation. The microstructure of the sample is represented in two levels (macro with aggregates on paste, and micro with fines on water within the paste), supported by calculations of IPS and images from SEM and DIA [2]. The intermediate step, after liquid phase migration starts taking place, shows the aggregates closer together and a more concentrated paste, which hinders the flow and increases the chances of contact between particles, leading to jamming. This same set of techniques can be applied to a variety of materials and behaviors, with valuable information being provided by PMSF, including the measurement of the contact area displayed in Fig. 1, but also additional pressure distribution data that can be dissected to reveal details and causes for the macroscopic behavior observed [2,3], and lead to directed adjustments in the mix design.

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OR-38

Impact of particle motion on viscosity measurement in non-colloidal suspension flows: a numerical study

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This work investigates transient non-colloidal suspension flows in various geometries, including cone-and-plate, plate-plate, and cylindrical configurations, to understand the impact of particle motion on viscosity measurement. The study uses mass and momentum conservation equations to model the two-phase liquid-solid flow, applying an inhomogeneous Euler-Euler approach where both phases are treated as continuous. The primary aim is to assess how particle motion influences suspension homogeneity and the measured apparent viscosity over time. Findings indicate that rheometric flow induces particle motion, significantly affecting viscosity measurements, with buoyancy effects dominating at low shear rates and inertia effects at high shear rates. Numerical experiments varying Reynolds number, particle volume fraction, density ratio, and particle size reveal that particle motion and apparent viscosity are influenced by the rotation of either the lower or upper plates, with particle motion driven by gravity and secondary flows perpendicular to the main circumferential flow. Concentric cylinder measurements are the least impacted by particle motion. The study proposes a time limit and a critical Reynolds number beyond which particle motion does not affect the measurement of suspension viscosity. Good agreement was observed between measured and computed particle distributions, enhancing understanding of the interplay between buoyant and non-buoyant flows in these systems.

OR-39

Continuum modeling of non-Newtonian flow in porous media

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Numerous industrial applications motivate the study of the flow of non-Newtonian fluids through porous materials. A significant example is the matrix acidizing process to improve permeability. Ideally, this process creates channels, known as wormholes, traversing the entire domain while minimizing acid consumption [3]. Another common oil industry application involves removing residues from porous media via fluid injection. Many injected fluids exhibit complex rheological behavior, such as shear rate dependence, pH dependence and even viscoelasticity that emerges when employing polymer solutions [2]. In certain scenarios, the complex nature of the fluid is of interest. For instance, self-diverting fluids, like non-Newtonian acids, treat non-preferential regions of porous media by locally adjusting viscosity based on acid concentration, leading to temporary mobility reduction. These challenges have prompted the development of various models, addressing acidification scenarios and considering the non-Newtonian nature of fluids. Numerous approaches exist to model flow in porous media. High-resolution methods, representing porous media as interconnected tube networks, accurately capture key physics but require higher computational costs [1]. Alternatively, the two-scale continuum approach balances accuracy and computational efficiency, modeling the pore scale while solving equations on a higher scale, known as the Darcy scale. The effectiveness of this approach heavily relies on pore-scale assumptions. Typically, a homogeneous representation of the representative elementary volume (REV) is used, treating porous media heterogeneity as a porosity function of position [4]. In our study, we proposed a methodology to introduce porous heterogeneity within the REV of a two-scale model for generalized Newtonian fluids by incorporating a probability distribution of idealized pores with varying pore radii.

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Poster abstracts

PS-40

Influence of PVA fibers on the rheological properties of Class G cement pastes for abandoned oil well plugging

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Cementing is undoubtedly the most crucial operation performed on a crude oil well, occurring immediately after the drilling process. The purpose of the cement paste is to anchor and support the casing column, preventing the migration of fluids between the various permeable zones found in the well [1-2]. Consequently, the primary goal of the barrier material is to withstand in-situ stresses, temperature gradients, and exposure to various chemical agents, while maintaining its structural integrity and long-term durability to seal potential escape routes effectively [2]. To improve the mechanical and durability characteristics that cement sheaths must possess, numerous studies have been conducted involving incorporating various types of fibers. Cementitious materials typically exhibit brittle behavior with low tensile strength and limited deformation capacity [3-6]. Polyvinyl alcohol (PVA) fiber was chosen for this study due to its high aspect ratio geometry, which allows it to behave as a flexible fiber, thereby reducing rheological impact compared to more rigid fibers [7]. This flexibility facilitates the mixing and pumping processes when fibers are dispersed in the cement paste. The present research aims to characterize the cement paste rheology in order to understand how this material behaves when subjected to increasing and decreasing shear rates. The corresponding shear stress and viscosity are calculated from parameters measured by a rotational rheometer with recessed concentric cylinder geometry (Peltier crosshatched). This data will be used to determine which Carbopol is compatible with the paste, allowing us to conduct long-term tests (creep tests) that would be unfeasible with cement paste that undergoes hydration over time. Tests with Carbopol in the rotational rheometer with parallel plate geometry will complement the tests in a vertical pipeline with a circular section, which is a scale model for the intended application of the paste: well abandonment. The vertical duct will measure the immiscibility between the abandonment fluid and the oil below it, where sealing is intended. Additionally, a Couette geometry rheometer with a gap capable of including PVA fibers will be used to evaluate the potential of fibers to delay the miscibility time between fluids in the well. Delaying this time will allow the cement paste to harden and fulfill its sealing function. Therefore, we propose to evaluate the effect of fibers on the rheological properties and determine whether their interactions with the cement paste are beneficial, ensuring that they do not negatively impact the ability to place the cement inside the well.

PS-41

Displacement flow through enlarged regions in annular ducts

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The success of cementing operations in oil wells depends on the effectiveness of the cement slurry in displacing the drilling fluid from the annular space between the formation and the casing. This process is extremely complex due to the non-Newtonian behavior of the fluids, especially in eroded regions. The displacement efficiency depends on various parameters, including the rheological properties of the fluid, densities, flow rates, and geometric factors. This study presents a thorough experimental investigation into the displacement process in oil wells with eroded zones, along with an analysis of its efficiency. The study examines three fluids, Newtonian or non-Newtonian, representative of those found in actual cementing operations. Various combinations of fluids, flow rates, and eccentricities were evaluated. The rheological properties of the fluids were characterized using a rotational rheometer, while densities were measured using a digital densimeter. The acrylic test section features an annular geometry with variable eccentricities ranging from 0% to 100%. A single screw pump was used to maintain a constant flow rate through transfer bottles. A Coriolis flow and density meter installed at the test section's outlet measured the flow rate, pumped volume, and density of the fluids exiting the test section. Initial results indicate that the explored range of flow rates and eccentricities has a minimal impact on displacement efficiency. However, it is evident that the relationship between viscosity and density significantly influences displacement. Further investigations are necessary to fully understand the interactions among the evaluated parameters.

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PS-42

Rheological comparison between hydroxyethylcellulose hydrogel and dental pulp aiming future odontological treatment

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Hydroxyethylcellulose (HEC) is a cellulose derived material manufactured by the etherification of cellulose with ethylene oxide. It is widely used at cosmetic, food and material industry, to name a few, due to it's potential to regulate viscosity of solid, liquid and semi-solid formulations. The aim of this study is to obtain hydrogels of HEC with controllable rheology properties that can emulate dental pulp ones for endodontic regenerative procedure. In the preparation of the hydrogel, ultra-purified water was used in order to dissolve HEC under constant overnight magnetic stirring to obtain homogeneous gels at 1; 2; 3, and 5% (m/v). Then, all the solutions were equally kept for 24 hours in a refrigerator at 4–8°C in a 50mL Falcon® tube. HEC hydrogels rheological measurements were carried out on rheometer (TA Instruments, AR-2000) with a cone (angle of 1°) and plate geometry of 60mm diameter and gap of 23μm. Initially, oscillatory measurements were conducted to determine linear viscoelastic region. Storage modulus (G′) and the loss modulus (G″) of HEC were measured over the strain magnitude range of 0.01–1000 % at 1Hz and 25°C. It was observed that the storage and loss moduli values remained independent of the strain amplitude over the range from 0.01 to 100 %, and, thus, in this strain amplitude range the hydrogels exhibited linear viscoelastic behavior. Constant shear stress of 1 % was then selected on the linear viscoelastic region and the frequency sweep analysis was performed to determine the storage modulus (G′) and the loss modulus (G″). For this assay, the frequency range of 0.01 to 97Hz at 25°C was used. Although the moduli reached by most of the hydrogels are far below from mammals such as pig and the proper human dental pulp rheology found on literature, it was observed that G′ and G″ is quite matched at a frequency range between the analyzed interval for the 5 % (m/v) hydrogel and the human dental pulp, indicating a direct relationship between the addition of HEC in a solution as a simple approach to achieve specific rheology values at the range of concentrations analyzed. In conclusion, the study presents a possibility to emulate rheological properties of natural tissues by modulating the concentration of HEC, leading to applications in a near future.

PS-43

Rheological and mechanical viability of alkali-activated pastes for oil well application

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The introduction of alkali-activated materials for oil wells cementation has been a challenge for two main reasons: the first is about reactions nature under immersion conditions, as these materials are not hydraulic binders so the alkaline ions have to interact rapidly with the precursors, and the second reason is, the rheological and mechanics properties that must be achieved by standard [1] must be very similar to those used to evaluate the special Portland cement for Wells (CPP), due to there are no unified standards for alkaline activations. However, the alkaline solution could be viscose enough to overcome the criteria. In this study, a methodology was implemented to enable binary mixtures consisting of metakaolin (MK), blast furnace slag (BFS) and/or fly ash (FA), with certain additives, so that said rheological properties were achieved by taking rheological readings in rotational and oscillatory mode. Complementing its hardening time with the help of the mini-slump test during the first 6 hours. Additionally, evaluating its compressive strength after 24 hours. As a beginning point, the plastic viscosity limit for the mixtures was defined, as the limit of their pumpability, at 0.45 Pa.s [2] previously defining an activating solution that adjusted to half of this value so that after dry material addition the limit was reached. Subsequently, different proportions were made between MK, BFS and FA and placed in the rheometer, performing a rotation scan, and determining the viscosities of the systems. Finally, the samples were molded into cylinders and cured at 27°C and 52°C and ruptured after 24 hours. The results were compared with the standard criteria and indicated which mixtures are convenient for a given application.

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PS-44

Study of graphene dispersions in mineral oil using different surfactants

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Graphene, as well as its derivatives, are promising nanomaterials for the production of nanofluids due to their excellent intrinsic characteristics. Among the thermophysical profiles and their thermal properties, a relevant property for assessing the potential of graphene-based nanofluids as efficient and reliable heat transfer fluids is viscosity and rheological behavior in a broader sense. In this regard, the aim of this work is to propose a methodology for formulating a graphene nanofluid based on mineral oil. To achieve this, the capacity of the surfactants Sodium Dodecyl Sulfate (SDS) and Cetyltrimethyl Ammonium Bromide (CTAB) to disperse graphene in mineral oil was investigated. Furthermore, the rheological properties of the formulated graphene-based nanofluids were evaluated through rheometric tests. Additionally, the impact of concentration and surfactant on the viscosity of graphene-based nanofluids was analyzed. The results showed that the shear stability of the nanofluids depends on the shear condition, duration of shearing, as well as the type and concentration of the surfactant used. The utilization or absence of surfactant also has significant effects on dynamic viscosity.

PS-45

Analysis of one-dimensional compression interfacial rheology for flow assurance in crude oil samples

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Flow assurance (GARESC) is the term used to designate a set of techniques with the objective of ensuring that the oil flows from the initial point of the reservoir to the point of separation of its components. Under environmental conditions of low temperatures and high pressures, oil can present depositions of paraffins and asphaltenes, as well as formations of hydrates, which influence its behavior and cause risks to flow. Interfacial rheology studies the behavior and interactions of molecules at liquid-gas and liquid-liquid interfaces, crucial in the petroleum industry for processes such as efficient transportation, drilling, hydraulic fracturing and enhanced oil recovery. It evaluates properties such as interfacial tension, which is essential to guarantee flow. The Langmuir trough is an apparatus that unidimensionally compresses the interface, allowing measurement of the interaction, adsorption, desorption, and interfacial stability of amphiphilic molecules, aiming to understand the structural changes that are of paramount importance in industrial petroleum processes. Therefore, the main objective of this work was to analyze the behavior of oil samples (P1467 and P1279) with different characteristics. Targeting flow assurance, unidimensional compression interfacial rheology was used to determine values such as surface pressure and compression modulus of the oil surface formed along the Langmuir trough. Furthermore, the experiment aimed to examine the effect of decreasing temperature and varying the compression rate on the acquired values of surface pressure. A rectangular Langmuir Trough (KSV NIMA 1004) was used. Solutions of 1 mg/mL of petroleum in toluene were prepared, which acted as a surfactant in the experiment. Different compression rates (5, 10 and 20 mm/min) were tested, as well as different volumes of solution (25, 50 and 100 μL). After determination of optimum parameters of compression rate and volume three temperature were tested (4, 10 and 25°C). Before each test, the surface of the subphase (deionized water) was cleaned using a vacuum pump until approximately 0.30 mN/m surface pressure was reached. Then the solution was spread across the surface with a Hamilton syringe. It was observed that P1467 oil presents a compression curve that shifts to a smaller area in the trough, for interfacial pressures lower than 5 mN/m, suggesting a rearrangement of the oil molecules at the interface. Comparatively, the P1279 petroleum monolayer exhibits a more expanded compression-mean molecular area (MMA) isotherm and a higher collapse pressure (πc, P1279 = 20 mN/m) relative to 1467 petroleum (πc, P1467 = 13 mN/m m), indicating greater stability under compression due to stronger interactions, possibly due to van der Waals forces or specific interactions between molecules. This is attributed to the greater presence of asphaltenes molecules in P1279 oil. These compounds are known for their high activity at the interface, whereas the lower collapse pressure in P1467 can be attributed to weaker intermolecular interactions and lower affinity for the interface.

PS-46

Experimental methodology to find the static yield stress in flow assurance occurrences

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The low temperatures and high pressures on offshore oil rigs can lead to the formation of hydrates, emulsions, asphaltenes, and paraffin deposits. These occurrences can negatively impact flow assurance, resulting in reduced flow rates and even blockage of the pipes. Understanding the rheological behavior of crude oil is necessary to propose solutions to these problems. Measuring the yield stress of crude oils is essential to determine an effective value that will be used to start or restart the flow. This work aims to apply an experimental methodology using rotational rheometry to determine the static yield stress (TLE_E) of different types of crude oil. The rheological analysis is correlated with the chemical and physical characteristics of each crude oil sample. Additionally, we studied the effect of different cooling rates (0.8°C/min and 0.08°C/min) on TLEE values. Within the proposed experimental methodology, a stress ramp was applied as an approximate value of TLE_E, which we will use as a starting point to create a Creep curve, a more accurate method. We applied this same experimental methodology to the respective emulsions (50% v/v) from the analyzed crude oils. Preliminary results indicate higher TLEE values for the emulsions compared to the crude oils themselves. Different values were observed depending on the cooling rate, with a larger deviation for the more rapid rate of 0.8°C/min, probably due to non homogeneities caused by a limited heat transfer between the rheometer and the sample at this higher rate.

PS-47

Extensional rheology of dilute ferrofluid emulsions

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In this work, we present how externally applied uniform magnetic fields can alter the planar extensional rheology of dilute ferrofluid emulsions, depending on their direction and intensity. The possibility of actively tuning material properties makes ferrofluid emulsions promising materials for smart fluid applications. Furthermore, as we will see, these materials exhibit intriguing behaviors from the mechanics perspective. The results presented here comprise part of what was recently published [1], but from a new perspective and with the addition of new analyses. Unit microstructural cells with a single suspended ferrofluid droplet subjected to planar extensional flow were simulated to measure the bulk properties. The microstructure is completely linked to the mechanical response exhibited by the bulk fluid due to the imposed motion. The action of the external field, which magnetizes the droplet, competes with viscous forces imposed by the extensional flow and restorative capillary forces. Macroscopically, the anisotropy of the stress tensor can be modified in such a way that it can either suppress or strengthen the usual planar extensional-thickening behavior, or even induce a planar extensional-thinning behavior. For a given extension rate, the contribution of the droplets to the second extensional viscosity can become negative when the field is applied in the neutral direction. When the field is applied in a direction different from the principal directions of the extensional motion, the stress tensor exhibits non-symmetric shear components. This fact suggests the inclusion of new material functions to fully describe the planar extensional rheology of this type of emulsion, such as shear and rotational viscosity coefficients. Similar behavior would be expected in ferrofluid emulsions under uniaxial extensional flows. The effects of the field on the resistance to extension and the resistance to flow, obtained in simple shear tests, vary differently for equivalent fields, resulting in Trouton ratios that generally decrease as the flow intensity grows. These findings, including the presence of shear stresses in extensional motion, lead us to propose future discussions on the connection between both flows linking with linear flows of intermediate intensities.

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PS-48

Impact of kerosene aromaticity on interfacial properties of high-asphaltene Brazilian heavy crude oil

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This research explores the influence of solvent aromaticity on asphaltene stability and interfacial behavior using diluted heavy oils, which better represent the chemical of indigenous oil components compared to prior research employing simple solvent blends with low asphaltene concentrations. A high-viscosity Brazilian crude oil (HO), characterized by elevated asphaltene content, was diluted with two kerosene types: one saturated (Ke_S) and the other saturates/aromatics blends (Ke_{SA}). This dilution strategy aimed to ensure total aromaticity in the oil mixture post-dilution. Subsequently, measurements of viscosity, asphaltene stability, interfacial tension, and elasticity of the oil mixtures were correlated with emulsion stability, considering variations in solvent aromaticity and the ratio of aromatics to saturates. Results indicate that varying kerosene compositions influenced bulk viscosity and asphaltene flocculation, while exhibiting a lesser impact on oil/brine interfacial tension, attributed to the high asphaltene content in the diluted oil (HO:Ke). The elastic modulus decreased with increasing dilutions of Ke_S, while it exhibited relatively consistent behavior for Ke_{SA} blends. This trend correlated with observed discrepancies in emulsion stability, especially at solvent concentrations within the previously reported optimal aromaticity ratio for simple solvent mixtures. Additionally, interfacial segregation of aromatics in Ke_{SA} was observed, which has not been reported in previous studies using complex solvents. These findings imply that patterns observed with model oils, such as heptol with supplemented asphaltenes, may apply to more complex and realistic oil mixtures with higher concentrations of asphaltenes. However, was proposed that maintaining aromatic content may not be able to prevent asphaltene flocculation upon dilution, due to the simultaneous increase in saturates.

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Influence of maltodextrin and cyclodextrin on emulsification dynamics, dispersion characteristics, and dilatational rheological properties of oil-in-water pickering emulsions

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Research was conducted on maltodextrin and cyclodextrin to investigate their ability to improve droplet dispersion and modify interfacial characteristics due to their emulsifying and stabilizing properties. This research explores how maltodextrin (MD) and cyclodextrin (CD) impact the emulsification features (e.g. droplet size distribution, creaming index, and apparent viscosity) and dilatational rheological properties (including surface/interfacial tension and adsorption kinetics) of oil-in-water (O/W) Pickering emulsions with varying levels of vegetable oil concentration. Millipore MilliQ water and soybean oil were employed to produce the oil-inwater emulsions. A 200 mL aqueous phase containing 10% and 20% (w/w water) MD was aerated and hydrated by magnetic stirring for 30 min to form a clear solution. The Pickering emulsions were then prepared by slowly adding the oil phase to the water phase for 5 min in a two-step process: 4 min homogenisation at 13,500 rpm and 1 min rapid homogenisation at 21,500 rpm, both using UltraTurrax (IKA, Germany). When preparing emulsions, the full amount of oil was added beforehand and the remainder in the first minute of homogenisation. Oil and emulsifier (MD and CD) concentrations were investigated at levels of 5%, 20%, 40% oil (w/w) and 1% and 2% (w/w water) CD emulsifier and 10% and 20% (w/w water) MD emulsifier. The stability of Pickering emulsions stabilized by maltodextrin (MD) was assessed using the creaming index (CI). Freshly prepared emulsions were dispensed into 100 ml glass tubes at 25°C, and the rate of subnatant serum layer appearance was observed. Droplet size was measured with a Mastersizer 3000™ and reported as volume (D[43]) and surface diameter (D[32]). Viscosity was measured immediately after preparation at 25°C using a controlled tension rheometer with a CC50 parallel plate system, covering an angular frequency of 1-10 rad/s and a shear rate of 0.1 to 100 s^{-1}. Absolute densities of the phases were measured using a densitometer at 25°C. Surface and interface tensions were measured using a tensiometer with the pendant drop method. The addition of CD significantly increased the stability of the emulsions over time by reducing CI and droplet size values compared to the results of emulsions without CD. The surface and interfacial tensions of MD and CD in aqueous solutions notably decreased compared to pure water, indicating a higher affinity of MDs and CDs for the oilwater interface and their role in forming Pickering emulsions. The results indicate that the type and concentration of dextrin significantly affect the emulsification efficiency, droplet size distribution, and dilatational rheological properties of the emulsions. These findings provide insights into optimizing the formulation of O/W emulsions for various applications in food, pharmaceuticals, and cosmetics by tailoring the use of maltodextrin and cyclodextrin to specific oil concentrations.

PS-50

Interfacial rheology of neuronal cell membrane in Alzheimer's disease

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In Alzheimer's disease (AD), both amyloid plaques and, more prominently, extracellular Aβ oligomers are established biomarkers of neuronal dysfunction and cell loss. Experimental evidence suggests that Aβ peptides significantly alter the organization of neuronal cell membranes, reflected by a decrease in membrane stiffness and pore formation, ultimately contributing to neuronal damage and death. A quantitative understanding of the interactions between Aβ and neuronal lipid membranes is crucial for elucidating the pathogenesis of AD and developing novel therapeutic strategies. This study utilizes interfacial rheology and microscopy techniques to characterize the binding mechanisms and membrane insertion of Aβ peptides. 1,2-dipalmitoyl-sn-glycero-3-phosphatidylcholine (DPPC) was employed as a model for the neuronal lipid membrane. The DPPC was first dissolved in chloroform and deposited dropwise onto a deionized water subphase within a Langmuir trough. To ensure chloroform evaporation and rapid adsorption of DPPC molecules with subsequent homogeneous spreading, the temperature was initially raised above the monolayer melting point, inducing a liquid-expanded (LE) state. Subsequently, the system was cooled to 20°C to promote the formation of a thermally-structured monolayer, enhancing reproducibility. Finally, the temperature was adjusted to the desired measurement conditions of 20°C, 30°C, and 37°C (physiological body temperature). The DPPC monolayer microstructure exhibits a liquid-expanded (LE) phase and a liquid-condensed (LC) phase, separated by a LE-LC transition plateau that occupies a broader range of mean molecular area values at higher temperatures. To investigate peptide interaction, an Aβ (1-40) solution in chloroform was introduced to the subphase surface immediately following DPPC deposition. The quantity of Aβ molecules on the monolayer was weighted based on their mass ratio relative to DPPC to determine the mean molecular area of the resulting Langmuir isotherm. This addition resulted in a shorter LC-LE transition plateau and a decrease in surface pressure along the isotherm. These findings demonstrate that Aβ interaction with DPPC influences the monolayer's extensional rheology. However, to fully elucidate the underlying mechanisms in AD pathogenesis, further studies are warranted. These explorations could include utilizing different Aβ peptide segments, varying Aβ concentration in the monolayer, and investigating the effects at relevant temperatures. Additionally, ongoing research is focused on developing novel N-acylhydrazone compounds that could potentially neutralize Aβ's rheological effects on the model lipid monolayer, paving the way for future pharmacological interventions in AD treatment.

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Lissajous Lights the Way: Decoding Non-linearity in Interfacial Dynamics

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The current literature on interfacial rheology for complex interfaces primarily concentrates on the linear response regime. However, since multiphase systems like emulsions and foams frequently encounter significant and rapid deformations, a crucial area of investigation is characterizing these complex interfaces' nonlinear responses [1]. Dilatational rheology is a field of rheology that studies the elastic and viscous behavior of surfaces in response to changes in area. In other words, it analyzes how surfaces resist and deform when stretched or compressed, i.e., sinusoidally. Initially, we measure the amplitude of the interfacial tension ($\Delta\gamma$) and the phase displacement (φ), which allows us to determine the real, E' and imaginary E'' parts of the compression modulus [2,3]. Subsequently, instead of the interfacial tension (γ), the interfacial pressure ($\Pi = \gamma 0 - \gamma(t)$) is used and plotted as a function of relative deformation ($(A(t) - A0)/A0$) Lissajous diagrams are used to infer non-linearities and deduce the behavior of the interface structure and stability. These curves are a popular method for analyzing cyclical signals. They are also a valuable tool for uncovering non-linearities in experiments that involve oscillating surfaces, whether under shear (sliding) or compression/expansion (dilatational) forces. In this work, we attempted to explain the related physical phenomena in E' and E" moduli measurements with the support of Lissajous figures. Three interfaces with different behaviors were characterized by the same frequency of 0.05 Hz and a deformation sweep of 1- 15 %. Particular emphasis is given to the time-dependence feature of the interface, where adsorption-desorption kinetic processes interfere with the rheological response. Understanding and explaining dilatational rheology with the pendant drop technique is not easy [4].

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PS-52

Influence of shear mixing parameters on the rheology for cosmetic oil in water emulsions stabilized by cationic surfactants

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Emulsions are an important category of cosmetic products. These are dispersed, thermodynamically unstable systems, defined as the mixture of two immiscible or partially miscible liquids, one of which is dispersed in the other, in the form of very small globules or droplets, and stabilized by emulsifying agents [1]. As a result, emulsions consist of two phases: vehicle or surrounding phase, i.e. external and continuous while the other is internal or dispersed [2]. The effect of the long stability period on the properties of an oil-in-water emulsion stabilized by a cationic surfactant at different shear mixing parameters during the manufacturing process was the objective of this study. After one month of stability at 45ºC, the rheological behavior of the samples showed a great difference for samples manufactured with a higher shear mixing parameters. Dependencies of the characteristic rheological parameters on aging were investigated by using different analytical methods such as optical microscope studies, differential scanning calorimetry and laser diffraction to measure particle size. All these methods showed that during the shear flow analysis there is an increase in viscosity due to the restructuring of the emulsion, when carrying out a new test with this same sample, the viscosity of the sample is very close to the sample manufactured with a low shear rate. The relationship between shear mixing parameters and long-term emulsion stability for cosmetic O/W emulsions was demonstrated experimentally and analytically. High shear mixing rate in emulsification accelerated the coalescence of tiny droplets through a Brownian flocculation, resulting in the reduction of long-term stability of the emulsion.

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PS-53

Study of the stability of water-in-oil emulsions stabilized by dispersing agents used for oil spill remediation

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The production of oil is surrounded by risks. One of the most common occurrences is crude oil spills. As soon as the spill occurs, the oil suffers the effects of weathering, one of the main ones is the oil emulsification, especially water-in-oil emulsion, formed due to the natural agitation of seawater. This makes oil dispersion very difficult [1]. When the volume of spilled oil is considerable, chemical dispersion is employed [2]. The objective of this word is to evaluate the rheology of this water-in-oil emulsions formed. The rheological evaluation of these systems is essential to quantify the difficulty of dispersing the oil in each case, and also to understand the role of interfacial interactions in emulsions, especially their stability. The experimental methodology of this research involved simulating a weathering process following a method developed by MACKAY et al. (1984), using three fractions of the same crude oil through simple distillation, producing three distillation residues at 150°C, 200°C, and 250°C [3]. Subsequently, these fractions were subjected to emulsification using the rotating cylinder method developed by MACKAY and HOSSAIN (1982) [4]. The emulsification occurred with a saline solution of sodium chloride (NaCl) at a concentration of 35g/L in pure type 2 water to simulate the marine environment, at oil/water volumetric ratios of 1/10, 1/2, and 3/4, totalizing a 300 ml emulsion in each assay. An Anton Paar MCR-302 Rheometer was used, and the analyses were performed in duplicate. In the more viscous emulsions, flat geometry was used, while in the more fluid emulsions and crude oil, Couette geometry was used. The influence of water content on the shear stress versus shear rate curve and, consequently, on the viscosity of the emulsions was observed, showing that an increase in water concentration increased the dynamic viscosity of the emulsions. The influence of oil weathering on these same properties was also observed, as oils weathered at higher temperatures produced more viscous emulsions. Finally, oscillatory tests were conducted to evaluate the viscoelastic modulus, as well as the interfacial rheology of the emulsions to investigate more deeply the properties and stability of these emulsions formed during oil spill.

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PS-54

Flow of brewery malt waste suspensions - friction losses in fittings in the laminar regime

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Brewers' spent grain (BSG) is the main solid waste, representing 85% of the total by-products generated in the brewing industry. Utilizing agro-industrial by-products is a promising approach to enhance global sustainability and reduce waste. However, a significant gap in the literature pertains to the rheological properties and process engineering of these by-products, which hinders the effective scaling of operations needed to transform them into high-value products. Designing piping and pumping systems for the food industry requires a deep understanding of the pressure drop caused by flow in straight pipe segments, as well as through fittings and valves. The loss coefficient (k) measures the resistance to flow caused by specific components of the piping system, such as valves, elbows, contractions, expansions, and other singularities. It depends on the geometry and specific characteristics of the component (e.g., the angle of an elbow or the opening of a valve). Additionally, the loss coefficient (k) can be correlated with the generalized Reynolds number for Herschel-Bulkley fluids. Therefore, the objective of this work is to relate the loss coefficient (k) with the generalized Reynolds number for Herschel-Bulkley fluids in a butterfly valve opened at angles of 10°, 20°, 40°, and 60°. The rheological behavior of BSG suspensions was studied over a wide range of temperatures (293.15–333.15 K) and BSG concentrations (2, 4, 6, 8 g of BSG per 100 g of suspension) using a rotational rheometer AR-G2 (TA Instruments, New Castle, USA). This rheometer utilized an SPC (Starch Pasting Cell) paddle geometry to prevent particle sedimentation and slippage effects. Regarding rheological properties, the Herschel-Bulkley model accurately fitted the flow curves ($R^2 \geq 0.999$), demonstrating non-Newtonian behavior with yield stress (1.529 Pa $< \tau 0 <$ 4.646 Pa) and pseudoplasticity ($0.830 < n < 0.969$) under all tested conditions. The loss coefficient (k) varied between 14.80 and 1185, while the Reynolds numbers for Herschel-Bulkley fluids ranged from 1.073 to 114.8. Thus, an appropriate relationship between the loss coefficient (k) and the Reynolds number for the three-parameter Herschel-Bulkley model for BSG suspensions can be presented.

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PS-55

Flow of brewery malt waste suspensions: friction factor in the laminar regime

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The utilization of agro-industrial by-products represents a promising approach in the context of global sustainability and waste reduction. However, a notable gap in the literature concerns the rheological and process engineering properties of these by-products, which compromises the effective scaling of operations needed to transform them into value-added products. The design of piping and pumping systems for the food industry requires knowledge of pressure drop due to flow in straight pipe segments and through valves and fittings. The Darcy-Weisbach friction factor (f) is a measure of the resistance to flow due to friction along a pipe. It can be determined as a function of the generalized Reynolds number for Herschel-Bulkley fluids. This Reynolds number is adapted to consider the apparent viscosity and specific parameters of the Herschel-Bulkley model, which is used to describe the behavior of viscoplastic fluids with yield stress [1]. Therefore, the objective of this work was to determine the values of the Darcy-Weisbach friction factor (f) and correlate them with the generalized Reynolds number for Herschel-Bulkley fluids using the two-k method. The rheological behavior of brewers' spent grain (BSG) suspensions was studied over a wide range of temperatures (293.15–333.15 K) and BSG concentrations (2, 4, 6, 8 g of BSG per 100 g of suspension) using a rotational rheometer AR-G2 (TA Instruments, New Castle, USA). This rheometer used an SPC (Starch Pasting Cell) paddle geometry to prevent particle sedimentation and slippage effects. Regarding rheological properties, the Herschel-Bulkley model fitted the flow curves with high accuracy, demonstrating non-Newtonian behavior with yield stress ($1.529 \text{ Pa} < \tau 0 < 4.646 \text{ Pa}$) and pseudoplasticity ($0.830 < n < 0.969$) under all tested conditions. The Darcy-Weisbach friction factor (f) varied between 0.747 and 45.599, while the Reynolds numbers for Herschel-Bulkley fluids ranged from 1.073 to 114.8. Therefore, an appropriate friction factor-Reynolds number relationship for the three parameter Herschel-Bulkley model for brewers' spent grain suspensions can be presented.

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PS-56

Rheological behavior of buffalo milk at different processing temperatures

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Milk is one of the most consumed foods globally and is essential for human nutrition, whether in its pure form or dairy products like fermented milk, cheese, butter, and concentrated milk. Rich in nutrients, milk contains a variety of vitamins and bioactive substances. Its composition includes water, fat, lactose, proteins, enzymes, vitamins, and minerals, with quantities varying by animal species. For example, buffalo milk has up to twice the fat content of cow milk, as well as higher amounts of saturated fatty acids, conjugated linoleic acid, and proteins. These differences influence the rheological behavior of milk from different species. Rheology studies how fluid behaves under shear stress and is essential for food process engineering, particularly in designing and optimizing operations involving fluid flow in pipelines, as well as the sizing of agitators, pumps, heat exchangers, and evaporators. Due to the lack of information in the literature, dairy products from goats, sheep, and buffaloes are often produced based on technological procedures developed for cow milk. This study aimed to evaluate the influence of temperature on the rheological behavior of buffalo milk. The chemical composition of buffalo milk was analyzed for proteins, lipids, ash, carbohydrates, and total solids. Rheological behavior was investigated using a rotational rheometer with concentric cylinder geometry over a wide temperature range (1-90 °C). Commonly reported rheological models such as Newton's Law, Ostwald-de Waele, Bingham, and Herschel-Bulkley were fitted to the experimental data. Regarding the chemical composition, buffalo milk showed significant contents of lipids (6.91%), carbohydrates (4.47%), proteins (3.11%), and ash (0.73%), totaling 15.21% of total solids. In terms of rheological behavior, the shear stress range varied from 0.570 Pa to 3.532 Pa at the lowest shear rate (0.84 s^{-1}) and from 114.278 Pa to 699.529 Pa at the maximum shear rate (168.44 s^{-1}). The shear stress versus shear rate data exhibited a linear behavior, indicating a Newtonian behavior. Among the tested models, the Newton model was the most suitable ($R_{adj}^2 \geq 0.9979$; P (%) $\leq$ 2.2651; RMSE $\leq$ 0.0280) for predicting the rheological behavior of buffalo milk over the wide temperature range studied. The Newtonian viscosity of buffalo milk varied between 4.151 ± 0.017 and 0.679 ± 0.003 (mPa·s) and decreased significantly with increasing temperature. The Arrhenius-type equation successfully described the dependence of buffalo milk viscosity on temperature. Therefore, buffalo milk exhibits Newtonian behavior, its viscosity decreases with increasing temperature, and the Newtonian model is the most suitable for predicting its rheological behavior over the wide temperature range studied.

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Rheological behavior of sheep milk at different processing temperatures

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Sheep milk has a higher nutritional value compared to milk from other species like cows, goats, and buffaloes. Its average composition includes approximately 7% lipids, 5% protein, 19% total solids, 10% non-lipids solids, 5% lactose, and 5% casein. These characteristics make it suitable for producing high-quality dairy products with high yields per liter of milk. The differences in composition, especially compared to cow milk, can impact the rheological behavior of sheep milk. Rheology, the science of how fluids behave under shear stress, is crucial for food process engineering, particularly in designing and optimizing operations involving fluid flow in pipelines, and sizing agitators, pumps, heat exchangers, and evaporators. Due to the lack of information in the literature, dairy products from goats, sheep, and buffaloes are often produced based on technological procedures developed for cow milk. Therefore, this study aimed to evaluate the influence of temperature on the rheological behavior of sheep milk. The chemical composition of sheep milk was analyzed using AOAC (2007) methods, focusing on proteins, lipids, ash, carbohydrates, and total solids. Rheological behavior was investigated using a rotational rheometer with concentric cylinder geometry over a wide temperature range (1-90 °C). Common rheological models such as Newton Law, Ostwald-de Waele, Bingham, and Herschel-Bulkley were fitted to the experimental data. In terms of chemical composition, sheep milk showed significant contents of lipids (7.4%), proteins (5.48%), carbohydrates (4.13%), and ash (0.89%), totaling 17.94% of total solids. At all studied temperatures, a linear relationship between shear stress and shear rate was observed, indicating Newtonian behavior. The shear stress range varied from 0.505 Pa to 3.572 Pa at the lowest shear rate (0.84 s^{-1}) and from 100.293 Pa to 713.633 Pa at the highest shear rate (168.44 s^{-1}). The Newtonian model was the most suitable ($R_{adj}^2 \geq 0.9987$; P (%) $\leq$ 2.1624; RMSE $\leq$ 0.0282) for predicting the rheological behavior of sheep milk over the studied temperature range. The Newtonian viscosity of sheep milk varied between 4.285 ± 0.028 and 0.642 ± 0.002 (mPa·s) and decreased significantly with increasing temperature. The Arrhenius-type equation successfully described the dependence of sheep milk viscosity on temperature. Therefore, sheep milk exhibits Newtonian behavior, its viscosity decreases with increasing temperature, and the Newtonian model is the most suitable for predicting its rheological behavior over the wide temperature range studied.

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Graphene on Waxy oils: a rheological analysis

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Due to high temperatures in the reservoir, the hydrocarbons are dissolved in the liquid phase, therefore the waxy crude oils behave as a Newtonian fluid. As the seafloor temperature is around 4ºC, the oil loses heat to the environment during pipeline transportation. At a certain temperature, the n-paraffins tend to precipitate as crystal structures. The wax crystallization not only considerably increases the oil viscosity but also provides a solid-like structure to the material when the flow is interrupted. In these cases, high pressures are required to break up the gelled structure and restart the flow. Different methods have been proposed in the literature to reduce the oil viscosity and the material's yield stress. In this study, the influence of graphene on the rheological properties of model waxy oils was evaluated. The analysis was performed using a rotational rheometer in which the thermal and shear history of the sample were controlled. In the first part of the work, the effect of the concentration of graphene in the waxy oil was evaluated. Afterward, a specific concentration of graphene was selected to evaluate the flow curve and yield stress during static and dynamic cooling. These results show not only that graphene affects the rheological properties of waxy oil, but also that the sample preparation is an important parameter to be taken into account in this analysis.

PS-59

Influence of thermal history on the rheological characteristics of SiO_2-based nanofluids

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The study of the impact of thermal history on mineral oil-based nanofluids containing silica nanoparticles is essential for understanding the thermophysical properties of these fluids under various temperature and operational conditions. Nanofluids consist of colloidal suspensions of nanoscale particles dispersed in a base fluid, with the addition of nanoparticles capable of enhancing the thermal properties of the fluid. Thermal history refers to the influence of previous thermal conditions on the performance of these nanofluids, representing a crucial aspect for practical applications such as heat transfer in cooling systems, industrial processes, and electronic devices. The presence of silica nanoparticles in mineral oil can modify the characteristics of the nanofluid, impacting not only its thermal conductivity but also rheological properties such as viscosity and critical flow stress. In this context, this work investigates the influence of SiO_2 nanoparticles at different volumetric concentrations (0.5, 1.5, and 2.5%) in mineral oil. The research explores the rheological behavior, obtaining flow curves at various temperatures (4 to 125ºC), as well as evaluates the effect of thermal history on the rheological characteristics, especially viscosity, of SiO_2 nanofluids. The main objective is to understand how the thermal properties of these nanofluids change with temperature variations and how thermal history influences these changes. Experimental results revealed that at low temperatures (4ºC to 15ºC), nucleation of solid SiO_2 particles occurs, leading to the formation of SiO_2 precipitates, resulting in a white, gel-like appearance and affecting the flow point of SiO_2 nanofluids across all analyzed volumetric concentrations. Viscosity increases abruptly at temperatures below 25ºC, whereas it remains nearly constant up to 125ºC. Thus, it is evident that the mechanical behavior of SiO_2 nanofluids at low temperatures is influenced by various parameters, with the main ones being volumetric concentration of SiO_2 and thermal history. Consequently, based on the experimental results, it is concluded that the thermal performance of systems employing this type of nanofluid may be negatively affected by temperature variations below 25ºC, implying the optimization of thermal performance of the systems. This comprehensive research has provided valuable insights into the potential and behavior of SiO_2 nanofluids in mineral oil base, offering useful information for practical engineering applications.

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Investigating the impact of xanthan gum concentration on rheological behavior and yield stress of water-based drilling fluids

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In response to increasingly stringent environmental regulations worldwide, the oil and gas industry is shifting towards more environmentally friendly practices, favoring water-based drilling fluids over oil-based ones. These fluids, often incorporating biopolymers like Xanthan Gum (XG), are chosen for their biodegradability, in line with sustainability standards. However, as drilling ventures explore deeper and more challenging terrains, there is a growing demand for fluids resistant to high pressure and temperature (HPHT) conditions. Therefore, this study aims to unravel the relationship between XG concentration and its susceptibility to temperature variations, impacting the rheological properties of water-based drilling fluids. Utilizing a base mud supplied by Petrobras, XG was added at concentrations of 0.25%, 0.5%, 1%, and 2% by weight, followed by temperature ramp experiments conducted from 25 to 100°C at a constant shear rate of 50 s^{-1}, under 10 bar pressure and 1°C/min increment, employing an Anton Paar MCR 702TD rheometer with a temperature-controlled pressure cell. Subsequently, the data for each concentration was fitted into temperature-dependent viscosity plots, yielding a model delineating viscosity-temperature relations contingent on XG concentration. Findings unveil the thermal impact on the rheological dynamics of XG-infused muds under HT conditions, evidencing viscosity reduction with escalating temperature across all concentrations, corroborating prior research. Nevertheless, higher XG concentrations exhibit attenuated viscosity decline, indicating reduced temperature sensitivity. This comprehension furnishes critical insights for optimizing drilling fluid formulations tailored for HT environments, establishing a nexus among viscosity, temperature, and viscosifier concentration.

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PS-61

Sedimentation of Newtonian and non-Newtonian fluid in directional wells

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Unlike vertical drilling, directional (inclined) drilling of wells enables accessing challenging locations, creating secondary branches, and even multi-drilling from a single platform, thus enhancing well productivity. The understanding of the effects of the wellbore inclination angle in this process remains limited. For any drilling operation, drilling fluids are employed, which are emulsions with multiple functions formulated according to the region's characteristics and the specific conditions under which they will be used. In addition to the cuttings resulting from the process, drilling fluids contain insoluble solids, such as bridging and weighting agents, which can undergo sedimentation when their flow is interrupted. Therefore, particle sedimentation is an undesirable phenomenon for the oil sector since its interest lies in keeping insoluble particles suspended in the fluid to avoid issues in process resumption and equipment operation. In this context, this study aims to enhance our understanding of the influence of wellbore inclination on solid sedimentation in both Newtonian and non-Newtonian fluids. To achieve this, suspensions were prepared, including Newtonian ones (water with CaCO3 and glycerin with glass microspheres) and non-Newtonian ones (xanthan gum with glass microspheres), and a range of tests were conducted from fluid rheological characterization to behavior comparison. Utilizing data from local volumetric solids concentration over time obtained through TARG, at different positions of the test tube and at four different inclinations relative to the vertical axis (0°, 30°, 45°, and 60°), it was observed that the higher the inclination angle, the greater the solids sedimentation velocity, and the Boycott effect becomes evident during suspension separation. Furthermore, there is a change in sedimentation dynamics related to the container inclination and the rheological characteristics of the fluids, associated with the Boycott effect and the gelation of biopolymer structures. Thus, when choosing to use directional wells, one must weigh the benefits that inclined wells offer, such as increased productivity and reduced environmental impact, against the increased solids sedimentation velocity and modification of fluid rheological behavior that may adversely affect the drilling stage.

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Neuroscience in scientific communication

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Scientific journals expect articles that follow academic rules of writing as a way of spreading scientific knowledge. Therefore, the system described earlier makes knowledge accessible mostly to academics. This situation enhances one of the structural problems of many countries, including Brazil, which is the lack of quality education, especially for students with low income, reinforcing the culture of group segregation. As a result, because scientific discoveries are not spread for everyone to understand, there is a miscommunication between academic researchers and common people who may be interested in studying science. The urge to simplify those texts and put them into a format that everyone can understand is what a scientific communicator tries to do. Due to this, we are testing neuroscience perspectives on human interaction to introduce a simplified version of rheology and its applications in our laboratory via social media and to be part of this movement of spreading science. As a result of our work until now, one of the most visualized videos that we have done was for this year's Easter. We made a themed Easter rheology video in which one of GReo´s postdoctoral researcher demonstrates the difference between two types of chocolate. In this video, this fellow made an advance on the impersonal way of scientific traditional communication, discussed earlier, by exposing her image to the public. It resulted in 1606 visualizations, 38 people sent it to others, and we reached 74.5% of non-followers, which are a few ways to analyze Instagram® engagement.

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PS-63

Scanning Electron Microscopy investigations of hydrates and emulsions present in crude oils

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Understanding the rheological behavior and the microstructure of complex fluids is increasingly essential for industries such as crude oil production. These fluids often exhibit varying compositions and contain oil-water emulsions in different proportions. The presence of gases, oil and water with dissolved salts further increases the system's complexity. Therefore, determining the composition, rheological behavior, grain morphology, phase distribution, gas-hydrate stability, and performing precise and reliable microscopy analysis is crucial. Scanning electron microscopy (SEM) has proven to be an effective imaging technique for hydrates. When integrated with cryogenic systems, SEM has provided new insights into emulsions and hydrate growth processes. In this work, cryo-SEM was used to observe the development of grain, surface, and pore structure associated with gas hydrate formation from the reaction of a hydrate forming gas and water droplets dispersed in crude oil. Gas hydrates were synthesized under high-pressure, low-temperature conditions with oil and brine water. The effects of the presence or absence of salt in the water were observed. The size and distribution of droplets were measured, and the distribution of salt crystals within these droplets was examined. Changes in wall thickness and surface roughness of the droplets were noted. Additionally, the geometric disk shapes of the crystals formed at the droplet interface were successfully verified.

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Development of synthetic lightweight drilling fluid

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Drilling in shale formations poses significant challenges in the oil and gas exploration industry due to operational constraints and the complexity of rocks. Developing drilling fluids with low density and specific properties for application in shale formations, especially in narrow operating windows, plays a crucial role. Lightweight drilling fluids are highly desirable due to their ability to mitigate the hydrostatic weight on geological formations, thereby minimizing the risk of damage to subsurface layers and increasing the drill penetration rate [1]. Utilizing Hollow Glass Spheres (HGS) composed of soda-lime borosilicate glass presents a promising solution due to their high strength-to-density ratio and compatibility with oil-based fluids. Incorporating HGS into lightweight can reduce issues associated with compressible fluids, drill string corrosion, cuttings lifting, increased pressure gradients, stuck pipe, and elevated drilling costs [2]. This study aims to develop a 100% synthetic lightweight drilling fluid for operating in shale formations. The fluid was analyzed using a scanning electron microscope (SEM) to verify the morphology of HGS and characterized rheologically before and after the addition of 20% wt of hollow glass microspheres, 3M (S38HS). The final formulation consisted of a composition containing olefin, mineral oil, and lithium stearate, designed to present a rheology similar to 60/40 oil/water drilling fluid, with an initial density of 7.41 ppg. Analysis of the microspheres revealed a morphology of hollow glass spheres, with an average particle size of 8.927 ± 1.66 μm and a thickness of 1.41 ± 1.25 μm. The strategic addition of hollow glass microspheres 3M (S38HS) reduced the fluid density to 6.61 ppg while maintaining its rheological properties. The synthetic fluid's density decrease reached 10.8%, demonstrating the efficacy of the incorporation of hollow glass microspheres in optimizing drilling fluid density without compromising essential rheological characteristics. Therefore, this study aims to significantly contribute to advancing drilling fluid technology by offering a viable and efficient solution to the specific demands of drilling in shale formations.

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Experimental setup for sedimentation of weighting agents with image processing techniques

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The study of sedimentation behavior in a suspension containing dense particles as weighting agents is crucial in various scientific and industrial applications [1, 3]. Understanding the dynamics of particle settling allows for insights into processes such as filtration, sediment transport, and the behavior of suspensions. One effective method for analyzing sedimentation phenomena is through image processing techniques, which enable tracking particle concentration changes in different regions of a test tube over time. The project aims to visualize the sedimentation of barite particles in an aqueous solution using a back-light image processing technique involving LED lumination and high-resolution cameras to capture the process. To develop the methodology for analyzing the captured images, the images are processed in grayscale using code routines for image processing with Matlab™ software. Initially, a reference image of the test tube without particles is obtained to set a background reference. Afterward, the images are extracted, and an alignment process is executed by AI (Artificial intelligence) between the background image and the first frame of the test. The background grayscale is subtracted from each frame, allowing the visualization of light intensity variations caused by particles in the solution. These variations are then analyzed to determine the temporal evolution of concentration at different heights of the test tube, using the average light intensity as a scale parameter. The results are stored and plotted, visually representing the concentration evolution throughout the experiment. Tests have been conducted with different concentrations of dense particles. The initial results showed agreement with previous studies, revealing a gradual decrease in particle concentration over time and a high sedimentation rate after an initial period. Three regions are depicted during the phenomena: clarifying, free settling, and compacting regions [2]. The tests will be performed for forward steps using different fluid matrices encompassing Newtonian and non-Newtonian behaviors. The present experimental study highlighted the effectiveness of the developed methodology for image processing and its relatively low cost and easy execution when compared with other techniques, such as gamma rays.

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PS-66

Nonlinear simulations of magnetorheological fluids subjected to a radial magnetic field

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Magnetorheological fluids (MR) are magnetic materials that have micronized magnetic particles dispersed in a carrier liquid. They find wide-ranging applications in different fields of science and technology, including mechanical prostheses [1] and vehicle suspension [2]. Because of the dispersion of magnetic particles in the microstructure, the viscoelastic properties of an MR fluid change abruptly in response to the application of an external magnetic field. In the absence of an applied magnetic field, the material behaves as a Bingham fluid. Under the influence of a magnetic field, the long particle chains of the microstructure align with the field's direction. This makes its yield stress dependent on the magnitude of the applied magnetic field [3]. The present work employs this rheological model for the behavior of magnetorheological fluids and investigates pattern formation when a droplet of MR fluid is confined in a Hele-Shaw cell and subjected to a radial magnetic field. The magnetic droplet satisfies a modified version of Darcy's law that incorporates the influence of magnetic body forces in addition to a field-dependent yield stress. The Young-Laplace pressure jump boundary condition at the droplet interface is augmented to include the effect of the normal component of the magnetization at the interface. The governing equations are solved by utilizing a vortex sheet formalism and a precise boundary integral method [4], and the numerical simulations examine the distinct patterns that emerge from this MR system. The project intends to explore the impact of the five governing dimensionless parameters on the outcome of droplet deformations. They are the viscosity contrast, the effective surface tension that compares interfacial tension and magnetic influences, the magnetic susceptibility of the material, and two yield stress parameters, one in the absence and another in the presence of the applied magnetic field.

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A rheology-based investigation on the interaction of additives in alginate solutions

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Alginate is a promising polymer in the development of renewable plastic materials. Because of its electrolytic character, it can be solubilized in water – as a salt of, more commonly, sodium – while it can also be rendered insoluble – usually as a salt of calcium or in its acidic form. This versatility allows the formation of films in a three-step process: solubilization of the alginate, evaporation of the solution, and reticulation with a calcium salt. The resulting solution (of the first step) is a viscous dope with a non-Newtonian behavior [1]. In the present study, the solutions were prepared with four additives to provide UV shielding ability and malleability and avoid excessive shrinkage of the films during the evaporation step. To understand how the films' components interacted with each other, a fractional factorial design, varying the proportions of each component, was created. The parameters of the Cross-Williamson model for the viscosity – zero-shear viscosity, consistency, and rate index – were adopted as diagnostic features of the interaction of the components. For making the dopes, lignin was dissolved before the other components were added together for a final solubilization step in a NaOH solution with a concentration elevated enough to ensure a final pH of 10.5. The main component that affected all the parameters evaluated was the alginate concentration in solutions. The lignin content did not significantly impact the zero-shear viscosity or the rate index, although it significantly affected the consistency. This behavior was associated with the need to maintain the pH at 10.5: as the quantity of lignin varied, the concentration of NaOH also needed to vary, canceling the increasing effect of lignin in the solution properties (alginate solutions' viscosity is dependent on sodium ion concentration). The urea acted as a flow enhancer, as previously noted in experiments with cellulose solutions, lowering the zero-shear viscosity and consistency while increasing the rate index [2]. Maltodextrin acted similarly to the alginate, contributing to a general increase in the viscosity profile of the solutions. Its synergistic effect with alginate revealed its plastification character. Borax increased all three parameters, easing the breaking of the gel structure while interacting synergistically with the maltodextrin and the alginate (because of the interaction between the borate ion and sugar hydroxyls) [3].

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Impact of biomass ashes on the rheological properties of drilling fluid

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The search for more sustainable and economically viable alternatives in the well drilling industry has become increasingly urgent [1]. Currently, there is no work in the literature describing the application of biomass ashes as additive in drilling fluids. Thus, the objective of this work was to investigate the applicability of açai ashes as an additive in water-based drilling fluid. For this, a base fluid was prepared, with and without the presence of biomass ashes, with different granulometry (greater and smaller than 300 μm). The rheological properties and filtrate volume were parameters monitored performance. The chemical and morphological characteristics of açai ashes were determined via X-ray fluorescence (XRF), Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and energy dispersive X-ray spectroscopy (EDX). The XRF analysis showed that potassium (K) is the element with the highest concentration in the biomass ashes, followed by phosphorus (P), silicon (Si), and calcium (Ca) [2,3]. The IR-ATR results were complementary to the data obtained via XRF, indicating that, in addition to metals, there is organic matter. The morphological analysis (SEM) showed that biomass ashes have an irregular shape, with high polydispersity. The addition of biomass ashes significantly modified the rheological properties (plastic viscosity and yield strength). In parallel, the use of biomass ashes decreased the filtrate volume from 7.3 mL to 5.2 mL. In addition, the plastic viscosity and yield strength increased by ~30% and ~28%, respectively. In summary, this work showed that the chemical and morphological characteristics of açai ashes are suitable to the preparation eco-friendly drilling fluid with improved properties at low cost.

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PS-69

Influence of AADA100 concentration on the stability of rheological properties of aqueous drilling fluids

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Despite the great advances that have occurred in recent years in oil well drilling processes, there is still a significant demand from the oil industry to develop water-based drilling fluid formulations that can provide greater performance, efficiency and durability. This demand is not only related to environmental or cost issues, but also to the fact that the number of drillings in deep and ultra-deep wells has been increasing. When oil wells are drilled under conditions of high temperature and pressure (HPHT), the use of water-based fluids becomes limited. This limitation is due to the fact that, in aqueous fluids, natural and modified natural polymeric additives are normally used, which efficiently control their properties, but present low thermal resistance, thus causing thermo-oxidative degradation, which leads to loss of efficiency. Therefore, this work aims to obtain a water-based drilling fluid formulation that is capable of circulating in environments with high temperatures, maintaining its properties unchanged or with low changes, through the addition of different concentrations of acrylamide tetrapolymer (AM), 2-acrylamido-2-methylpropane sulfonic acid (AMPS), dimethyldialylammonium chloride (DMDAAC), acrylic acid (AAC) - AADA100, previously synthesized in LMCP. The fluids were formulated in a Hamilton Beach shaker, first solubilizing the AADA100 tetrapolymer at concentrations of 0.5%, 1.0%, 1.5% (m/v) for 20 minutes. Then the other common components of water-based fluid formulation were added, respecting the time of 10 minutes for solid additives and 5 minutes for liquid additives. The tests were carried out for the formulation of unaged and aged fluids in a rotary oven at 70ºC, 80ºC and 90ºC for 16 hours. The rheological parameters, apparent viscosity, plastic viscosity, yield point and gel strength (Gi) and (Gf) were determined in a FANN 35A rotational viscometer. Density was also assessed using a FANN mud balance. The results obtained with the fluids added with AADA100 showed that there was a significant improvement in the values of the rheological parameters of the formulations aged at the three analysis temperatures, in relation to the values found for the standard fluid (without AADA100) under the same conditions. The presence of AADA100 did not interfere with the density values of the formulations, all of which remained within the value specified by the API standard (9.0 and 10lb/gal). These results allow us to conclude that the AADA100 tetrapolymer has significant potential to be used as an additive that increases the thermal resistance of water-based drilling fluids, maintaining the characteristics necessary for the fluid to perform its functions in more critical drilling conditions.

PS-70

Stability of Rheological Properties of Nanofluids Containing AADA/Silica Core-Shell Structures

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Due to increasing environmental pressure, all attention is focused on the use of water-based fluids, as oil-based fluids cause environmental damage. Despite the environmental and economic benefits, there are some challenges that limit their application, especially where temperatures can exceed 200°C. These high temperatures can lead to the degradation of polymeric additives present in the formulation, such as xanthan gum and hydroxypropylamide (HPA), requiring recurrent adjustments to maintain efficiency or complete fluid disposal. Is notable that the number of studies related to the development of new additives that promote high thermal resistance to the fluid are growing. A tetrapolymer based on acrylamide (AM), 2- acrylamido-2-methylpropane sulfonic acid (AMPS), diallyldimethylammonium chloride (DMDAAC), and acrylic acid (AA), called AADA, developed at LMCP, when added in high concentrations into the standard fluid along with other additives, even after aging at temperatures above 100°C, maintained its rheological properties, indicating that its presence generated a positive synergistic effect in this aspect of the fluid. In this sense, the use of nanofluids produced with the insertion of silica nanoparticles associated with AADA, forming a core-shell structure, is being developed and evaluated to improve the efficiency of the waterbased fluid formulation when added in lower concentrations. Thus, this work aims to synthesize and characterize a SiO_2/tetrapolymer AADA core-shell structure, and verify the efficiency of water-based fluid formulations containing this additive at different concentrations to maintain the rheological properties of the fluid unchanged. The synthesis of the hybrid system was carried out by two methods: in situ, where the nanoparticles are previously synthesized, dispersed in alcoholic media, and added during the synthesis of AADA; and in solution, where the tetrapolymer is previously synthesized and dispersed in a media containing distilled water, ethanol, and ammonia hydroxide, and then, tetraethylorthosilicate (TEOS), precursor of silica nanoparticles, is added into the solution drop by drop. After the materials were characterized, the fluids were formulated in a Hamilton Beach shaker, solubilizing first the hybrid system at concentrations of 0.1% and 0.5% w/v for 20 minutes. Then the other common components of the formulation were added. The formulations were aged at 70°C for 16h, in a roller oven, for viscosity tests on the FANN 35A viscometer. The systems at the concentrations studied so far showed the capacity to stabilize the rheological parameters in terms of apparent viscosity, plastic viscosity, gel strength, and yield point, both for unaged fluids and aged fluids, compared to the properties of the standard formulation without and with the presence of the tetrapolymer AADA. Other concentrations and higher aging temperatures will be tested to prove the effective improvement of properties when using the synthesized hybrids.

PS-71

Study of the rheological properties of CMC cross-linked with polycarboxylic acid

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In recent years, hydrogels derived from natural materials have stood out for their low toxicity, biocompatibility, and ability to adapt to a wide range of applications. Among these materials, carboxymethyl cellulose (CMCNa) is a natural polymer derived from agricultural waste that can be used in the development of superabsorbent hydrogels due to its swelling capacity. However, this polymer has poor mechanical properties and one way to improve them is to chemically cross-link it with polycarboxylic acids. In this work, CMCNa was used in combination with starch and hydroxyethylcellulose and subsequently cross-linked with 1,2,3,4- butanetetracarboxylic and itaconic acids, varying the acid concentration (5, 10 and 15%) by solvent evaporation synthesis. The influence of the different acid concentrations on the swelling capacity of the hydrogels was evaluated and subsequently the hydrogels with the highest swelling capacity were subjected to rheological oscillatory tests of strain amplitude sweep and frequency sweep to obtain the viscoelastic properties. The materials with the highest swelling capacity were those with a 5% acid concentration, ranging from 2406 – 4768% swelling. This test also showed the strong influence of increasing the crosslinker concentration on the degree of swelling of the materials. First, it was evaluating the influence of the surface roughness on the measurements using smooth and crosshatched plate-plate geometry (20 mm) and varying the gaps from 0.25 to 0.75 mm. The results show that when using the smooth geometry, the loss and storage moduli vary with the gap, while the gap for grooved plate does not affect the modulus. Therefore, the remaining tests were carried out using the rough plate-plate geometry with a gap of 0.5 mm. The amplitude sweeps tests showed that most of the materials had a greater storage modulus (G'), between 273 and 2560 Pa, than that of pure CMCNa (238 Pa). In addition, the frequency sweep test showed that the modulus does not vary significantly with the frequency and that there is no crossover between the modules. Based on this study, a high degree of swelling was found for the materials composed by 5% of the cross-linking agent and the rheological tests showed the influence of different roughness on the oscillatory measurements and the better stiffness of the produced hydrogels compared to CMC.

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PS-72

Comparative rheological study of the association of biopolymers xanthan gum and guar gum in saline dispersions

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Biopolymers have the ability to form gels and viscous solutions in aqueous media and are an alternative to traditional gums due to their rheological properties and better environmental biodegradability. Among their uses as thickeners, gelling agents, and suspending agents, they are applied in the food, pharmaceutical, chemical, and petrochemical industries. In drilling fluid formulations, polymers are one of the viscosifying additives for water-based drilling fluids. Xanthan gum, a microbial polysaccharide produced by Xanthomonas, exhibits high viscosity at low concentrations, pseudoplastic behavior, and is less sensitive to conditions of high salinity, alkalinity, and temperature, although it has a high production cost. Guar gum, a galactomannan extracted from the seeds of the leguminous Cyamopsis tetragonoloba, is also a viscosifying agent for saline solution-based drilling fluids, providing filtration control by reducing fluid loss from bentonite dispersions and well stabilization characteristics. In this context, this work aims to propose a methodology for formulating an associative system composed of two biopolymers, xanthan gum and guar gum, in saline solution, and also to evaluate the macroscopic properties of the composite fluid and the polymers separately in terms of rheological measurements. The flow curve tests demonstrated that the addition of xanthan gum had a greater effect on viscosity than guar gum. All solutions exhibited markedly non-Newtonian behavior, that is, with very high molecular weight polysaccharides and solid particle charge.

PS-73

Percolation theory and stochastic simulation applied to waxy oil crystallization and gelation

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Due to temperature drops, the crystallization and gelation processes of waxy oil cause severe changes in oil rheology that present a solid-like behavior in the gelled state. These phenomena can cause blockage in field pipelines, particularly during operational shutdowns. This work aims to study the dynamics of waxy oil gel formation using percolation theory and stochastic simulation and its impact on material rheology. The simulation uses an algorithm that generates zero-width lines representing the wax crystals. Python programming language is used to perform the simulations of the gel microstructures, along with fitting probability functions that match the data generated from the simulations. This procedure determines a percolation probability measure for a given stick size and concentration. It was observed in the computational experiment that, for a given stick size, increasing the concentration in a box of a certain size increases the percolation probability, consistent with existing literature that states that the gelation phenomena is favored for larger initial volumes of wax in the oil. Additionally, differential equations governing the physical dynamics of the model, both for the emergence and growth rate of paraffin, were incorporated. Specifically, the Monte Carlo method was used to distribute the crystals in the generated box, while ordinary differential equations and the addition of the nucleation rate added physical dynamics to the model. The fractal dimension of the plots generated by the model was also incorporated into the results. This comprehensive approach helps predict the percolation threshold and understand the intricate patterns formed during the gelation process. Predicting the gelation point represented by the situation in which the network is percolated can be useful when comparing it with rheological measurements. Therefore, by combining stochastic simulation with percolation theory and differential equations, this study provides a framework for analyzing waxy oil crystallization and gelation and its impact on the material's rheological behavior. With this, it is also possible to design better preventive measures and solutions for managing blockages in oil pipelines, ultimately improving operational efficiency and reducing maintenance costs.

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PS-74

Rheological behavior of microparticles in xanthan gum solutions implemented in well drilling

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Drilling fluids are complex soft materials composed of dispersed particles larger than 10 μm in a liquid matrix. The rheological behavior of microparticles in drilling fluids, including yield strength and other properties, has been underexplored. This study aims to analyze the influence of microparticle type and concentration on the static and dynamic yield strength of viscoelastic non-colloidal suspensions similar to drilling fluids. We used two fluids (1% wt Xanthan gum) and particles with diameters of 5, 20, and 50 μm (PSP) and 50 μm (PMMA). Rheological measurements were performed using a rotational rheometer with cross-hatched parallel plate geometry and a 1 mm gap. Steady-state flow curves were used to determine dynamic yield strength, while creep tests were employed to determine static yield strength. Shear stress amplitude sweeps were conducted to analyze the microstructure. The presence of microparticles significantly affects the rheological behavior of the fluid, likely due to increased spacing between the base fluid and particles, which influences the intermolecular forces within the microstructure. The findings from this study are expected to enhance the understanding and optimization of drilling operations in offshore wells. The study aims to improve suspension and gravel loading performance while also increasing the fluid's thermal resistance.

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PS-75

Rheological study of CO_2 hydrate suspensions applied to CCS

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Greenhouse gases are mainly responsible for climate change. Humanity's biggest challenge is to zero out greenhouse emissions, as practically all human activities produce this kind of gas. Considering the increase in demand for energy due to population growth, emissions are expected to rise. Although the large-scale development of renewable energies could change this scenario, we will still depend on fossil fuels in the near future. It is, therefore, necessary to find ways to reduce emissions and mitigate their effects. Carbon Capture and Storage (CCS) is a method that consists of capturing CO_2 from industrial processes and the air. CCS can be obtained in various ways, and in this work, we investigated capture through the formation of hydrates. Hydrates are ice-like structures (Figure 1) that can capture a large amount of gas in a small volume. These solids are formed when water and gas molecules are subjected to low temperatures and high pressures. Hydrates are a promising alternative as no chemicals are required, and only appropriate thermodynamic conditions (temperature and pressure) are required. Determining the hydrate suspension rheological properties is essential to develop the necessary technology for CCS from hydrate formation, as hydrates can be transported as suspensions. This work aims to evaluate the rheological characteristics of the CO_2 hydrate suspension. A possible way of forming CO_2 hydrate suspension is by using a rotational rheometer with a pressure cell. We tested different concentrations of CO_2, subcooling, and different shear rates to assess the effect of each parameter on the induction time and rheological properties.

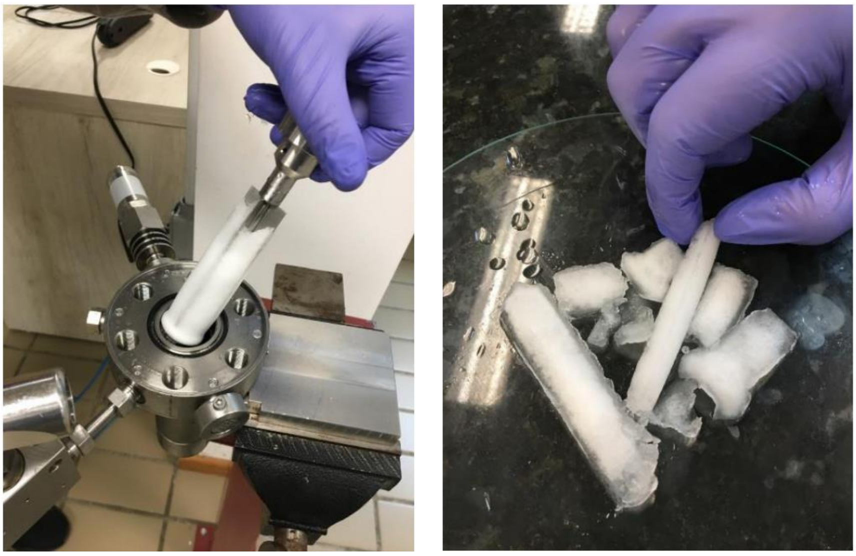

Figure 1 - CO_2 hydrates.

PS-76

Rheological study of the formation of voids in waxy oils applied to flow assurance

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During the production of offshore waxy crude oil, it undergoes a cooling process due to the cold environment of the seabed. As a result, when the wax appearance temperature (WAT) is reached, the paraffins begin to crystallize, and with continuous cooling, a gel is formed, a process known as gelation, which can lead to total or partial obstruction of pipelines. This gel has an elastoviscoplastic and time-dependent nature, showing more complex properties. In addition, during this process, voids are formed due to the crystallization and gelation of paraffins. These properties are very important for studying gelled waxy oil's rheology and flow assurance. Currently, models for predicting the rheological properties and restarting pressure are not very accurate, and these values are often overestimated because they need to consider the void formation. Therefore, this study aims to obtain a model for predicting the start-up pressure of gelled paraffinic oil, considering the formation of voids. To this end, the methodological procedures involved performing computational fluid dynamics (CFD) simulations in the COMSOL Multiphysics software and rheology experiments. The experiments involve cooling the waxy oil in a parallel plate geometry using a HAKEE MARS 60 rheometer, whose interfaces are monitored using photographs to measure the contraction of the gel and check for the occurrence of internal voids to add to the results in the CFD simulations. In the simulation part, voids will be added to pipe geometries to calculate the startup pressure of the pipe and propose a correlation for it. Initially, the contraction of two waxy oils containing 12.5 wt% and 20 wt% of wax was evaluated by imposing a cooling rate of 10 °C/min. A radial volume reduction of 5,5% was verified for the 12.5 wt% oil and 3,3 for the 20 wt%. These results show a lesser radial volume reduction for the 12.5 wt% than for the 20 wt% oil, which can be due to the formation of internal voids for the oil with the greater wax mass fraction. Moreover, this achievement highlights the necessity of measuring the fraction of internal voids. Therefore, future works rely on measuring internal voids using a transparent upper plate and an improved imaging system and coupling these results with the CFD simulations.

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PS-77

Insights on the rheology of fumed SiO_2 nanoparticle suspensions in mineral oil - evaluation of thixotropy and antithixotropy

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Nanofluids are colloidal suspensions comprising particles with nanometer-scale dimensions (less than 100 nm) dispersed within a base fluid. These nanofluids have demonstrated significant potential for a wide range of engineering applications, enhancing the thermomechanical properties of the base fluid. Naturally, the success of these applications hinges on a thorough understanding of their flow properties. Consequently, investigating the rheological behavior of nanofluids is of paramount importance, as it provides insights into the fluidic structure, which is crucial for engineering applications. In this particular study, we examined the influence of SiO_2 nanoparticles, present at various volumetric concentrations, in a Newtonian base fluid (mineral oil). The research explored the rheological characteristics of suspensions across three distinct regions: the liquid regime, solid regime, and the transition between solid and liquid behavior. Additionally, we report a detailed experimental study of the peculiar thixotropic dynamics of smoked silica nanoparticle suspensions in mineral oil, specifically observing the sequential increase in stress followed by decrease at a fixed shear rate in a reducing test. We ascertain that such dynamics, albeit peculiar, stem from a genuine material response rather than experimental artifacts. We also elucidate how this long-term stress decay is associated with antithixotropic structural change, rather than viscoelastic stress relaxation, demonstrating that this antithixotropic response involves shear-induced structuring. We also analyzed the stability of the suspensions over a period of 60 days through sedimentation tests. This comprehensive investigation sheds light on the potential and behavior of mineral oil-based SiO_2 nanofluids, providing valuable insights for practical engineering applications.

PS-78

Numerical simulations of a Newtonian fluid displacing a non-Newtonian one: onset of fingering growth

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The present work investigates the displacement flow between two parallel plates of a generalized Newtonian fluid by injection of a Newtonian one. Both fluids are incompressible and miscible with each other. The developed injection profile of the Newtonian less viscous fluids deforms the diffusive interface between the fluids until a quasi-steady state is obtained. Then a spanwise wavy perturbation of small amplitude is introduced in the third dimension to analyze the early growth of viscous fingers and dispersion relations are calculated. The numerical simulations are conducted by solving the momentum equations coupled to a convection-diffusion equation for a concentration field that captures the evolution of each phase and captures details of the miscible interface. To close the governing equations for miscible displacement flows, one requires a correlation between the viscosity and concentration functions. Until recently, such correlations were only available for different pairs of Newtonian fluids [1-5]. Here, we employ a function that was recently presented in Oliveira and Espinoza [6] that correlates viscosity and concentration values with shear-rates. This function couples the harmonic mean-based viscosity function presented by Siqueira and Mendes [7] with the concentration field. So, it captures several behaviors, including: (i) the constant viscosity of the pure Newtonian phase which is injected to drive the displacement process; (ii) the viscosity dependence on the shear rate for an apparent yield-stress fluid for the pure non-Newtonian displaced phase, and (iii) the rheology of mixture between the fluids as they smoothly mix at the diffusive interface.

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