frontiers | Frontiers in Physics

TYPE Editorial
PUBLISHED 15 August 2024
DOI 10.3389/fphy.2024.1463988

Editorial: Rheology and complex fluids in biomedical applications

Antonio Perazzo[1]*, Simon A. Rogers[2]*, Kelly M. Schultz[3]* and Stefano Guido[4,5]*

[1]Novaflux, Princeton, NJ, United States, [2]Chemical and Biomolecular Engineering, University of Illinois at Urbana-Champaign, Champaign, IL, United States, [3]Davidson School of Chemical Engineering, Purdue University, West Lafayette, IN, United States, [4]Department of Chemical, Materials and Production Engineering, University of Naples Federico II, Naples, Campania, Italy, [5]CEINGE Advanced Biotechnologies Franco Salvatore, Naples, Italy

Check for updates

OPEN ACCESS

EDITED AND REVIEWED BY
Erika Eiser,
NTNU, Norway

*CORRESPONDENCE
Antonio Perazzo,
ant.perazzo@gmail.com
Simon A. Rogers,
sarogers@illinois.edu
Kelly M. Schultz,
kmschultz@purdue.edu
Stefano Guido,
stefano.guido@unina.it

RECEIVED 12 July 2024
ACCEPTED 29 July 2024
PUBLISHED 15 August 2024

CITATION
Perazzo A, Rogers SA, Schultz KM and Guido S (2024) Editorial: Rheology and complex fluids in biomedical applications.
Front. Phys. 12:1463988.
doi: 10.3389/fphy.2024.1463988

KEYWORDS

rheology, soft matter, complex fluids and colloidal systems, biofluids, microrobots, cells, biofilms, rheo-optics

Editorial on the Research Topic
Rheology and complex fluids in biomedical applications

Complex fluids are ubiquitous in biomedical applications, and their mechanical properties are relevant for optimizing products used by patients and healthcare professionals, as well as for conducting research on native biological processes and disease progression to facilitate development of treatments or improve medical practices. This Research Topic sits at the intersection of chemistry, biology, and physics, encompassing fundamental insights, biomedical analytical techniques, and the links between mechanical properties of biological materials such as cells, spheroids, bacterial biofilms, cerebrospinal, and follicular fluids, and their potential medical outcomes.

The motion of micron-sized organisms in a fluid results from the interplay of shape, mechanical motion of other constituents, and responses to chemical stimuli. Inspiration can be drawn from this natural behavior to create micro-particles and micro-robots, optimizing their size, shape, mechanical properties, and energy sources. This field includes extensive studies on the motion of active particles in fluids triggered by mechanical or chemical stimuli. For example, Raj et al. explore how active bent rods combine mechanical movement with chemical modes such as diffusiophoresis, providing insights into controlling particle trajectories in complex fluids.

Moving from artificial constructs to biological entities, cells are the foundation of life, with their morphology and mechanical properties closely linked to medical outcomes. Quantitative phase imaging (QPI) of live cells enables label-free assessment of cell morphology and quantitative estimation of cell thickness and volume. One advanced QPI technique is digital holographic microscopy (DHM), a high-resolution phase imaging method. To analyze a larger number of cells, researchers use holographic flow-cytometry, flowing multiple cells through transparent micron-sized channels. As cells rotate during flow, a three-dimensional refractive index map can be built. However, the motion of 1 cell can influence other nearby cells, potentially altering the imaging. Vitolo et al. use numerical simulations to evaluate the impact of these hydrodynamic interactions on cell imaging through holographic flow-cytometry.

Beyond individual cells, cell spheroids offer a model to study cell-cell and cell-matrix interactions in a three-dimensional microenvironment. Cell spheroids are three-dimensional cell cultures that form sphere-like structures during cell proliferation.

While most research on cell spheroids focuses on their response to static stimuli, recent investigations, such as those by Ferraro et al., examine the effect of flow on spheroids, particularly in the context of tumor invasion. By placing spheroids in a fluid contained between two transparent parallel plates and applying a simple shear flow, Ferraro et al. demonstrate the use of rheo-optics to visualize the evolving morphology and quantify flow effects on the spheroids' structure. Rheo-optics, the study of the optical properties of materials in flow, enables detailed observation and measurement of these dynamic changes, providing deeper insights into the behavior of cell spheroids under mechanical stress.

Another important area of study involves bacterial biofilms, composed of bacteria and a polymeric extracellular matrix, exhibiting viscoelastic properties essential to life and infection control. Common examples include dental plaque. Bhattarai et al. investigate the role of glycoside hydrolases on the rheology of *Pseudomonas aeruginosa* biofilms, providing insights into the material's behavior to inform the development of potential infection control strategies.

Turning to the fluids within the human body, cerebrospinal fluid plays a crucial role in maintaining the central nervous system (CNS) by cushioning the brain, providing nutrients, removing waste, and maintaining homeostasis. Hollister et al. explore how protein and cellular concentration affect the viscosity of cerebrospinal fluid in different flow fields, enhancing our understanding of CNS maintenance.

Similarly, human follicular fluid is essential in the fertilization process, carrying nutrients to the oocyte. Muto et al. characterize the behavior of follicular fluid in various flow fields based on oocyte and albumin content. This research provides valuable insights into its impact on reproductive processes and potential improvements in *in vitro* fertilization techniques.

This Research Topic highlights the importance of understanding the mechanical properties of complex fluids in biomedical contexts, offering insights and potential advancements in medical practices and treatments.

Author contributions

AP: Writing–original draft, Writing–review and editing. SR: Writing–original draft, Writing–review and editing. KS: Writing–original draft, Writing–review and editing. SG: Writing–original draft, Writing–review and editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

A draft of this article was revised with ChatGPT 4.0.

Conflict of interest

AP is an employee of Novaflux Inc. and Advanced Biodevices LLC and is a consultant for Protegera Inc.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Author disclaimer

The views expressed in the articles and editorial published on this Research Topic are those of the authors and do not necessarily reflect the position or policy of Novaflux Inc., Advanced BioDevices LLC or Protegera Inc.