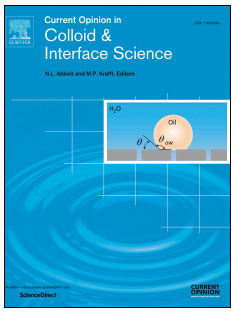
Journal Pre-proof



Editorial Overview: Electrokinetics 2022

Martin Z. Bazant, Carsten Werner

PII: S1359-0294(22)00082-6

DOI: https://doi.org/10.1016/j.cocis.2022.101643

Reference: COCIS 101643

To appear in: *Current Opinion in Colloid & Interface Science*

Please cite this article as: Bazant MZ, Werner C, Editorial Overview: Electrokinetics 2022, *Current Opinion in Colloid & Interface Science*, https://doi.org/10.1016/j.cocis.2022.101643.

Editorial Overview: Electrokinetics 2022

New directions in electrokinetics: A tribute to Hans Lyklema

Martin Z. Bazant[a] and Carsten Werner[b]

[a] Massachusetts Institute of Technology, Cambridge, MA, USA
[b] TU Dresden, Dresden, Germany

This current Article Collection provides – as the previous ones – a collection of review articles on recent research developments in the field of electrokinetic phenomena. Sadly, however, this collection is the first to be published after our long-term co-editor Johannes Lyklema passed away in 2017. We would like to take this opportunity to acknowledge his seminal scientific contributions and broad educational impact.

The life and work of Professor Lyklema were recently honored by the electrokinetics community. There was a special session on Fundamentals of Colloid Science and a memorial dinner held in his honor at the 13th International Electrokinetics Symposium (ELKIN) held at the Massachusetts Institute of Technology in June 2019. At the next ELKIN meeting held in July 2022 at Tel Aviv University, held under the auspices of the newly founded International Electrokinetics Society (IES), we announced the creation of the IES Johannes Lyklema Early Career Award in Electrokinetics to recognize major research contributions by junior scientists, whom Professor Lyklema particularly encouraged and inspired. We look forward to building on his work through the IES by supporting scientists and growing the field of electrokinetics into new areas from its deep roots in colloid science.

This topical issue exemplifies the diversity of ideas and applications in recent research in electrokinetics. Several articles focus on new aspects of electrophoresis of complex colloids. Aditya Khair reviews advances in nonlinear electrophoresis of charged, dielectric colloidal particles, i.e., systems with a ratio of the electrophoretic speed of the particle to the magnitude of the applied electric field is not independent of the field strength. A contribution by Jerome Duval summarizes certain theoretical approaches to electrophoresis, going beyond the classical zeta potential concept based on the theory by Smoluchowski. He reviews theoretical alternatives for capturing electrosurface features of soft colloids of practical interest (e.g., bacteria and engineered particles) in terms of the 3D distribution of their structural charges, a finite permeability to ions and/or flow.
Ralf Zimmermann and coauthors review approaches to gain quantitative insights into electrostatics and structural features of polymer brushes based on microslit electrokinetic experiments. The article focuses on theories for the electrohydrodynamics at soft surfaces and covers the respective methodology as well as examples of practical interest. As an example of the relevance of electrokinetics for the understanding and engineering of living matter, Gilad Yossifon and coauthors report on recent progress in synthetic electrically driven colloids, an emerging area of soft matter physics. The topic is of importance for non-equilibrium statistical mechanics, basic principles of self-organization and emergent phenomena, assembly underlying life as well as for applications in biomedicine and metamaterials.

Other reviews discuss important applications of electrokinetic phenomena in nanotechnology, microfluidics, separations, and electrochemical systems.
The article by Orlin Velev and coauthors covers progress in the development of active particles driven by alternating-current electrokinetic effects, i.e. propelled by asymmetrically energy dissipation. It is highlighted that alternating-current fields can trigger several electrohydrodynamic mechanisms depending on the field frequency and amplitude in ways to control particle-particle interactions and collective behavior.
Isaak Rubinstein and Boris Zaltzman provide a linear stability analysis of electrodeposition, tackling on of the long standing problems in the field, to capture effects of the electric double layer on pattern selection in dendritic growth. Focusing on the impact of the finite width of the electrical double layer and the finite electrode reaction rate, they identify the fastest growing perturbation mode to be one of a wavelength equal to the geometric mean of the Debye length and the reaction-diffusion length. Daosheng Deng and coauthors review recent advances in understanding electroconvection in microstructures and shock electrodialysis in porous media. They focus on the origin of electroconvection and shocks for complex geometries with curved electrodes by a combination of theory and experiments. Matthew Suss reviews electrical double layer models used for predicting the ion selectivity in water purification by capacitive deionization, a (typically) membraneless water treatment technology based on electro-swing adsorption of ions in metallic electrode micropores. The article explains ion selectivity mechanisms based on ion size and charge, as described by mean-field theories with local density approximations, as a means of understanding selective adsorption from complex, multicomponent electrolytes. These contributions show how the classical principles of colloidal electrokinetics are finding new engineering applications.

BIOGRAPHIES

Martin Z. Bazant is the E. G. Roos (1944) Professor of Chemical Engineering and Mathematics at the Massachusetts Institute of Technology. After a Ph.D. in Physics from Harvard University in 1997, he joined the MIT faculty in Mathematics in 2000 and then Chemical Engineering in 2008, where he served as Executive Officer from 2016 to 2020. He is a Fellow of the American Physical Society, the Royal Society of Chemistry, and the International Society of Electrochemistry and the first President of the International Electrokinetics Society. His awards include the Alexander Kuznetsov Prize in Theoretical Electrochemistry (ISE), the Andreas Acrivos Award in Chemical Engineering (AIChE) and the MITx Prize for Teaching and Learning in MOOCs. He also serves as the Chief Scientific Advisor for Saint Gobain Research North America and Chief Scientist of Lithios, Inc.

Carsten Werner is Professor for Biofunctional Polymer Materials at TU Dresden and Scientific Director of the Leibniz Institute of Polymer Research Dresden (IPF), Germany. After receiving a diploma in chemistry (University of Würzburg) and a doctoral degree in physical chemistry (TU Dresden) in 1999, he established a biomaterials program at IPF and held an Adjunct Professorship at the Institute of Biomaterials of the University of Toronto, Canada (2000-2018). Since 2008 he is a full professor at the Faculty of Chemistry and the Center of Regenerative Therapies of TU Dresden. His research aims at recapitulating functionalities of living matter in engineered polymer materials and includes studies on studies on electrosurface phenomena, hemocompatible interfaces and cell-instructive materials platforms. Carsten Werner is elected member of the German National Academy of Science and Engineering and the Leibniz Association. His research has been recognized with several awards, including the MaterialVital Award of the German Federal Ministry of Science and Education, and resulted in several patented technologies and spin-off companies.