Electrokinetics of Complex Soft (Bio)Colloids: from Fundamentals to Applications in Biophysics & Environmental Physical-Chemistry

OVERVIEW

Interface and colloid science is an important branch of science having many applications in *e.g.* medicine, cosmetics, pharmacy, biotechnology, environment, agriculture, nanotechnology or chemical industry. Part of this science elaborates (i) the fundamental physicochemical processes driving the reactivity of (bio)colloids and (nano)particles (size 1 nm to 1μm) and more generally that of surfaces and interfaces in aqueous solution, (ii) the basics of the interactions between colloids and surfaces under various dynamic or static conditions, as well as (iii) their response to various hydrodynamic or externally applied electric fields. The mandatory prerequisite for a proper understanding of the reactivity and behavior of (bio)colloids, nanoparticles or surfaces in aqueous phases, is the evaluation of their hydrophobic/hydrophilic balance, their characteristic size, or their electric charge, this list being of course non exhaustive. In that respect, electrokinetic phenomena, such as AC/DC electrophoresis, streaming current or streaming potential, have proven to be very useful for apprehending on a quantitative level key aspects of colloidal interfaces, in particular their zeta-potential (or electrokinetic potential) commonly used as an indicator of the electric charge carried by the colloids, (nano)particles or surfaces. The so-obtained zeta-potential value is subsequently widely employed in various theoretical formalisms on *e.g.*(bio)particle adhesion, particle rheology, particles assembly manipulation in electric fields or toxicity of nanoparticles toward bacterial cells. However, despite its established applicability for the case of so-called hard particles, *i.e.* particles that are impermeable to ions and flow, the physical meaning of the zeta-potential concept is questionable for soft particles that consist partly or entirely of charged permeable polymeric materials. Paradigms of such ubiquitous systems in the environment and in industrial applications are viruses, bacteria, core-shell particles, smart polyelectrolyte-coated surfaces or bio-functionalized polymer matrices. Recent theoretical and experimental studies demonstrated that the classical formalisms used to address the electrostatic features of such (bio)colloidal systems *via* electrokinetics need to be profoundly revisited. The goal of this course is (I) to provide a critical description of past and recent theoretical developments in the field of particle and surface electrokinetics with an emphasis on the differentiated electrokinetic behavior of hard and soft colloids, (II) to discuss how the obtained electrokinetic properties of colloids/surfaces are fundamental (or not) to evaluate their reactivity in the contexts of cell adhesion to surfaces, dynamic complexation of metal ions by colloids and nanoparticles, and transfer of metal ions to and across biointerfaces. In part (I) of the course, emphasis will be given on DC electrophoresis, streaming current and streaming potential and a detailed description of associated theories will be provided together with discussion of concrete examples from recent literature on soft particulate and planar surfaces. Part (II) of the course will go beyond the electrokinetic framework detailed in part (I) and will focus on a comprehensive description of colloidal reactivity within the contexts detailed above. We shall highlight the importance of electrokinetics and electric double layer properties for adequate understanding of the processes governing the examined colloidal reactivity.

The course will be documented by recent theoretical and experimental illustrations taken from literature and by a basic description of the fundamental knowledge required for understanding the key message to be delivered during the course.

OBJECTIVES

At the end of the course, the audience is expected to

- Understand the basics of electric double layers at colloid/solution interfaces and the basics of interactions between hard colloids;
- Understand the basics of electrokinetic phenomena (DC electrophoresis, streaming current, streaming potential), and the fundaments of the theories required for a proper interpretation of electrokinetic data collected on hard, soft particulate and planar surfaces (appreciation of the conditions that warrant adequate application of the theories);
- Understand the origin of the 'unconventional response' of soft surfaces to applied electric fields and applied tangential flow;
- Be able to formulate a proper experimental plan for measurements of soft particle/surface electrokinetics;
- Understand the basics of cell adhesion to surfaces and the useful (or not) information derived from electrokinetic studies;
- Understand the basics of metal transfer dynamics to biointerfaces, and the necessity to address electrokinetic properties of the involved colloidal interfaces in this context;
- Understand the basics of dynamic complexation of metal ions by colloids and nanoparticles and the necessity to address electrokinetic properties of the involved colloidal interfaces in this context.

Modules	**A: Duration : April 9-13, 2018 (Total 12 hours lectures and tutorials)** **B: Venue : Department of Mathematics, NIT Patna** **Number of participants for the course will be limited to fifty (50).**
You Should Attend If…	**This course is intended for undergraduate, postgraduate, doctoral and postdoctoral students as well as confirmed researchers in the fields of physical chemistry of interfaces and colloids, biophysics or material science.**
Fees	The participation fees for taking the course is as follows: **Participants from abroad : US $500** **Industry/ Research Organizations: Rs. 5000/-** **Academic Institutions: `** Faculty Member **: Rs. 3,000/-** Students **: Rs. 1,000/-** The above fee include all instructional materials, computer use for tutorials and assignments, laboratory equipment usage charges, 24 hr free internet facility. The participants will be provided with accommodation on payment basis.

The Faculty

Prof. J.F.L. Duval is CNRS Research Director in the Laboratoire Interdisciplinaire des Environnements Continentaux (UMR 7360 CNRS-Université de Lorraine) in Nancy. His current research interests include (i) physical-chemistry of complex biotic and abiotic interphases (*e.g.* bacteria, viruses, polymer-coated surfaces) with an emphasis on their electrokinetic and nanomechanical properties, (ii) biophysical determinants of cell adhesion to surfaces, (iii) dynamics of reactive transfer of metallic cations and nanoparticles to biological surfaces, (iv) chemodynamics of complexes formed between metal ions and colloids, and (v) development of AFM-based strategies for assessment of nanoparticle and metal toxicity at the single cell level. He was awarded the CNRS Bronze Medal in 2011 for his academic achievements in environmental physical chemistry, the Researcher Award in the Lorraine region (France) in 2012, the 2012 Standing Ovation prize delivered by Nancy authorities for chairing and organizing the International Conference 'Interfaces against Pollution' (June 2012), and he was granted in 2010-2013 subsidies by CNRS for excellency in research. Since 2008, he is a nominated member of the International Advisory Boards associated with the biennial international conferences on electrokinetic phenomena (ELKIN), and on the theme 'Interfaces Against Pollution'(IAP). Since 2016, he is the nominated Chair-President of the IAP advisory board and leader of the research group 'Physical chemistry and reactivity of surfaces and interfaces' in the CNRS laboratory LIEC (Nancy, France). He is an elected member of the national CNRS jury (section 30) in charge of CNRS researchers& laboratories evaluation and of researcher recruitments. He has (co)authored 115 peer-reviewed papers in renown international journals and delivered over 30 invited presentations at international conferences.

More information at:
-Personal webpage:http://duvaljfl.webnode.fr/
-Laboratory website:http://liec.univ-lorraine.fr/
-Google scholar records:https://scholar.google.fr/citations?user=HiVen9QAAAAJ&hl=fr&oi=ao

Co-ordinator

Dr. Partha Pratim Gopmandal is an Asst. Prof. in the Department of Mathematics, National Institute of Technology Patna. He has received his Ph. D degree from the Department of Mathematics, Indian Institute of Technology Kharagpur. His current research interest includes the mathematical modeling and numerical methods development for electrokinetically driven flows.

More information at:-Google scholar records--
https://scholar.google.co.in/citations?hl=en&user=RwysmhsAAAAJ&view_op=list_works&sortby=pubdate

Course Co-ordinator

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