Electrokinetic and Colloid Transport Phenomena

By Jacob H. Masliyah and Subir Bhattacharjee, Wiley Interscience, 2006, 707 pages, $137.

Electrokinetics is a subject of longstanding scientific and technological interest, which plays an important role in both established and emerging areas in Chemical Engineering. Laboratory scale separation techniques for biological molecules, reverse osmosis for drink water preparation and colloid characterization using the zeta potential have all become essential elements of the industrial practice. Also in more recent applications, such as flow control in micro- and nanofluidics, or in the creation of functional gradient materials by electrodeposition, electrokinetics are a key factor. The book *Electrokinetic and Colloid Transport Phenomena* is a timely contribution, building on an earlier text (Electrokinetic Transport Phenomena), but extending and revising it drastically, including recent evolutions in the understanding of both highly charged and concentrated suspensions.

One of the goals of this textbook is to provide a concise and complete treatment of the subject of electrokinetics. To this end, the authors have tried to bring together a systematic overview of the two fundamental disciplines be hind electrokinetics, i.e. electrostatics and transport phenomena. Electrostatics is rigourously introduced in chapter 3, followed by some pedagogical examples which are calculated in detail. This is followed by an in-depth discussion of the electric double layer, and the merits, inherent limitations and possible pitfalls of the different approaches for the electrostatic interactions are discussed in detail. Interestingly, mass transport is introduced before momentum transport and fluid mechanics. The discussion on the fundamentals of suspension hydrodynamics is rather brief and dense, and the later chapters on coagulation and deposition could have benefited from a more detailed analysis of the suspension fluid mechanics at this point. Instructors using the text might find it useful to complement this part of the text with the references indicated in the text.

After having setup the fundamentals in a systematic and consistent manner, the second part of the book focuses on the discussion of specific electrokinetic phenomena. Given its importance for flow in microchannels, electroosmotic flows are rigourously analyzed in chapter 8, where the concept of the streaming potential is also introduced. The link between transport and electrokinetic transport phenomena is at the heart of the chapter on electrophoresis. Starting with simple models for single colloids, the complexity is gradually increased by considering high-surface potentials, concentrated suspensions and suspensions containing nonspherical particles. Chapter 10 focuses on the sedimentation of charged particles, both in dilute and concentrated suspensions. In order to analyze coagulation and deposition of colloidal particles, the colloidal interactions need to be considered in more detail. Chapter 11 focuses on London — van der Waals forces and the DLVO theory, as well as its shortcomings. Other types of interactions, such as hydration or polymer induced steric repulsion and depletion forces are not addressed. The coagulation and deposition of particles, both in the presence and absence of flow is treated in detail in the next two chapters.

Chapter 14 may be viewed as the third part of this book, in which the difficulties associated with the combined numerical simulation of electrostatics, fluid flow and mass transport are addressed. Some specific illustrations are provided how typical electrokinetic problems can be solved through finite element methods. Rather than focusing on the numerics, the authors present examples of how problems need to be formulated and evaluated using currently available simulation packages. The book concludes with a chapter using some selected applications of electrokinetic phenomena in various technological areas: flow in porous media, waste control and bitumen extraction, flotation and drug delivery are some of the examples treated here.

The book is designed to provide a fundamental perspective of electrokinetic and colloid transport processes, emphasizing the underlying physics. The authors have done a nice job of keeping the mathematical treatment digestible for most practicing professionals, senior undergraduate and graduate students, while maintaining the necessary rigor which this field requires. Throughout the book, the authors provide useful links to those who want to go deeper into a specific topic. The book fills a nice gap in reviewing the theoretical base underlying electrokinetic phenomena and will prove very valuable to anyone working in this field. The authors have produced a very useful and complete textbook for graduate education. The book is available both as a hardcopy and online e-book.

Jan Vermant
Chemical Engineering
Katholieke Universiteit Leuven
Belgium
E-mail: jan.vermant@cit.kuleuven.be

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