PhD course "Basics of interfacial thermodynamics"

SYLLABUS

1. Lecturer Information

Prof. Epameinondas Leontidis
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2. Title of the course

Basics of interfacial thermodynamics

3. Course outline

The course discusses the fundamental equations of interfacial thermodynamics, and shows their applications in a multitude of phenomena in physical and biophysical chemistry, and colloid science. After a brief description of the interfacial regions in a variety of systems, the course discusses the fundamental property of surface/interfacial tension. Surface tension plays a major role in the three fundamental equations of interfacial thermodynamics, which are the Gibbs adsorption equation, the Young-Laplace equation and the Young equation that defines the contact angle. Applications of these equations in adsorption phenomena, phase transitions, nucleation and growth of crystals, and various aspects of capillarity and wetting are discussed in some detail. The course finally discusses how surface/interfacial tension can be measured, and how "cavity" surface tension determines macromolecular solvation and micellization.

4. Course content detailed per lesson of two hours (possibly with dates and room, real and virtual)

Tentative outline (in person/real):
Lecture 1: The nature of an interface. Definitions of surface/interfacial tension. The Gibbs adsorption equation
Lecture 2: The Young-Laplace equation and its applications in phase transitions, capillary phenomena and nucleation.
Lecture 3: The Young equation and various aspects of wetting. The concepts of contact angle, and line tension. The combination of contact angle and Young-Laplace pressure difference in a number of phenomena (AFM tips, pore penetration, capillary rise through the soil).

Lecture 4: Measuring interfacial tension. Cavity surface tension and its contribution to macromolecular solvation and surfactant aggregation.

Note: Interaction with students is encouraged and desired through the processing of worksheets and question papers.

5. Suggested reading

R. Defay, I. Prigogine, Surface Tension and Adsorption (Longmans, London, 1966)
A.W. Adamson, A. Gast, Physical Chemistry of Surfaces (6th ed., J. Wiley, New York, 1997, pbk 2012)
R.J. Hunter, Foundations of Colloid Science (2nd ed., Clarendon Press, Oxford UK 2001)
J.C. Berg, An Introduction to Interfaces and Colloids (World Scientific, Singapore, 2010)

6. Learning objectives

• The students will understand in depth the concept of surface/interfacial tension and its importance in various branches of physical chemistry and biophysics.
• The difficulties associated with the concepts of contact angle and line tension will be explained.
• The students will be able to appreciate in which phenomena surface/interfacial tension plays a role, and when more than one basic equations of interfacial thermodynamics play a role.

7. Knowledge and skills to be acquired

General knowledge
• Fundamental aspects of interfacial thermodynamics
• Knowledge of methods used to measure surface/interfacial tension, contact angle, line tension

Specific skills
Transfer of knowledge for people working with colloids in general, protein aggregation, nucleation and crystallization and many aspects of soft matter science.

8. Prerequisites

Basic undergraduate physical chemistry, especially solution chemistry and chemical thermodynamics

9 Teaching Methods

Lectures delivered in-person and remote with simultaneous recording on the Google-MEET platform.

10. Further Information

The powerpoint presentations will be complemented by writing on the blackboard, or even better on a tablet.

11. Type of Assessment

The final evaluations will be acquired no later than 1 month after the end of the course. Evaluation sheets will be handed out directly after the course.

12. Period

October 26, October 30, October 31, November 2, 2023 - 3 CFU/ECTS - 12 h including the final exam.

CURRICULUM VITAE

Dr Epameinondas Leontidis
Professor – Department of Chemistry, University of Cyprus
Dean, School of Natural Sciences, University of Cyprus
Past President, European Colloid and Interface Society (ECIS)
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Born in the town of Samos, Samos Island, Greece, in 1961. Undergraduate studies in the Department of Chemical Engineering of the National Technical University of Athens, Greece (1979-1985). PhD in Chemical Engineering, Department of Chemical Engineering of the Massachusetts Institute of Technology (MIT-USA) (1990).

Career

Postdoctoral researcher in the Department of Materials Science of the Federal Technical University of Zürich (ETH-Switzerland, 1/1992 – 12/1994). Assistant Professor (1/1995 - 4/2002) in the Department of Chemistry of the University of Cyprus (UCY). Associate Professor in the same Department (4/2002 till 12/2010). Full Professor since 1/2011. Vice-Chairman (3/2002 – 3/2004) and Chairman (3/2006 – 3/2008) of the Department of Chemistry. Currently Dean of the School of Pure and Applied Sciences of UCY (2020-today). President of the Pancyprian Union of Chemists (PUC) (2007-2015). Member of the executive committee of EuCheMS (European Chemical Society) between 10/2004 and 3/2010.Vice-President, President and now Past President of ECIS (2019-today).

Research supervision

Supervision of about 70 undergraduate diploma theses, 9 MSc (awarded) and 9 PhD degrees (awarded) from 1998 until today.

Research Interests

Basic research in Colloid Science of Soft Matter, but also applications of Colloid Chemistry in Materials Science. Films of molecules and inorganic nanoparticles on surfaces and the study of their optical properties. Studies of specific salt effects on model systems with emphasis on lipid monolayers and micelles. Lanthanide interactions with phospholipids. Multilayer emulsion formulations towards antioxidant action. Stability of colloids in aqueous phases.

Published work – Conference presentations

So far published 60 articles in international peer-reviewed journals (current H-index = 28), and 4 book chapters. 112 oral and poster presentations in international conferences, 26 in

Greek-speaking conferences, and 29 invited seminars in various European Universities and Research Centers. Reviewer for ca. 50 international scientific journals (frequent reviewer for 13 of those), reviewer for the Research Foundation of Ireland and the Italian Research Foundation, member of several academic promotion committees in Greece and Malaya.

10 publications related to the present course

Leodidis* E.B., Bommarius A.S., Hatton T.A., "Amino Acids in Reversed Micelles. 3. Dependence of the Interfacial Partition Coefficient on Excess Phase Salinity and Interfacial Curvature", *J. Phys. Chem.* **95**, 5943-5956 (1991)

Leodidis* E.B., Hatton T.A., "Amino Acids in Reversed Micelles. 4. Amino Acids as Cosurfactants", *J. Phys. Chem.* **95**, 5957-5965 (1991)

Zemb Th., Belloni L., Dubois M., Aroti A., Leontidis E., "Can we use area per surfactant as a quantitative test model of specific ion effects?", *Curr. Opin. Colloid Int. Sci.* **9**, 74-80 (2004)

Aroti, A., Leontidis, E., Dubois, M., Zemb, T., "Effects of monovalent anions of the Hofmeister series on DPPC lipid bilayers. Part I. Osmotic Stress experiments and in-plane equation of state", *Biophys. J.* **93**, 1580-1590 (2007)

Leontidis, E., Aroti, A., Belloni, L., Dubois, M., Zemb, T., "Effects of monovalent anions of the Hofmeister series on DPPC lipid bilayers. Part II. Modelling the perpendicular and lateral equation of state", *Biophys. J.* **93**, 1591-1607 (2007)

Leontidis E., Aroti, A., Belloni, L., "DPPC liquid-expanded monolayers as model systems to understand the anionic Hofmeister series. 1. A tale of models", *J. Phys. Chem. B* **113**(5), 1447-1459 (2009)

Leontidis E., Aroti, A., "DPPC liquid-expanded monolayers as model systems to understand the anionic Hofmeister series. 2. Ion partitioning is mostly a matter of size" *J. Phys. Chem. B* **113**(5), 1460-1467 (2009)

Leontidis, E., Christoforou, M., Georgiou, C., Delclos, T., "The ion-lipid battle for hydration water and interfacial sites at soft-matter interfaces", *Curr. Opin. Colloid Int. Sci*. **19**, 2-8 (2014)

Leontidis, E., "Investigations of the Hofmeister series and other specific ion effects using lipid model systems", *Adv. Colloid Int. Sci.* **243**, 8-22 (2017)

Sofroniou, C., Chazapi, I., Leontidis, E., "Binding of lanthanide salts to zwitterionic phospholipid micelles", *J. Colloid Int. Sci.* **557**, 568-579 (2019)