CH245 Jan 3:0

Interfacial and Colloidal Phenomena

Instructor

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Department: Chemical Engineering

Course Time: MWF: 10-11 AM

Lecture venue: Lecture Hall, Chemical Engineering

Detailed Course Page:

Announcements

Brief description of the course

Engineering disciplines today increasingly manipulate particles such as bubbles, drops, macro, micro and nanoparticles, micelles, vesicles, polymer molecules, biological cells, etc. through size control and interactions among them, and interfaces between gas and liquid, liquid and liquid, and solid and liquid/gas. Civil engineers deal with waste water treatment, soil and cement, chemical engineers deal with nanoparticles, nanocatalysts, emulsions, dispersions, foams, and detergents, materials engineers deal with mineral processing, nanocomposites and grain size control, and mechanical engineers deal with friction and tribology. New research often calls for an in-depth understanding of forces between particles, modulated by adsorption of new molecules on interfaces. Engineering students with undergraduate level physics and chemistry find themselves inadequately prepared to handle concepts relating to particles and interfaces. The objective of this course is to fill this gap.

Prerequisites

Senior UG, post graduates

Syllabus

Intermolecular attractive and repulsive forces between neutral molecules: their origin and manifestation as interparticle forces; Coulombic forces between charged entities leading to osmotic pressure driven double layer repulsion between them; net interaction between particles, DLVO theory, stability and kinetics of destabilization; electrokinetic phenomena and equations that explain it; non-DLVO forces, surfactants, thermodynamics of self-assembly leading to micellization, phase diagrams; interfacesâ€”zone of high energy and a surface of tension, Young-Lapace and Kelvin equations, adsorption of surface active molecules; interfacial tension and its measurement; contact angle and wetting.

Course outcomes

After taking this course, a student should be able to quantitatively understand:

1. the constraints on the nature of intermolecular attraction to lead to system size independent intrinsic properties of materials

2. the origin of van der Waals attraction between molecules, and the factors that make it strong/weak

3. how intermolecular forces lead to long range attractive forces between particles, and continuum properties of three phases involved modulate it

4. Double layer formation---distribution of counter-ions and other ions in vicinity of a charged surface in a medium

5. Balance of repulsion between charged surfaces due to osmotic pressure buildup and van der Waals attraction between bodies decides kinetic stability of dispersed phase systems using DLVO theory.

6. Hydrophobic effect which imparts surfactant molecules their special character

7. Cause of formation of self-assembled structures such as micelles of various sizes and shapes, bilayers and vesicles, and link it to 2 and 3 component surfactant phase diagrams

8. The molecular origin of interfacial tension through anisotropic pressure tensor, and excess surface energy

9. Laplace pressure jump across curved interfaces leading to jet breakup and capillarity

10. Consequences through Kelvin equation for particle size dependent properties of small fluid and solid

structures

11. The angle of contact when three phases meet on a contact line: wetting, non-wetting, and partial wetting behavior

12. Contact angle hysteresis through receding and advancing contact angle.

13. And most important, relate all the concepts to day to day observations, manifestations in nature, and in emerging technologies.

14. A student should be able to identify how interparticle and surface forces could be playing a role in a new system, isolate them by reasoning and additional experiments, and make progress towards engineering desired control on it.

Grading policy

Quizes: 25%

Tests: 25%

Project: 20%

Final Exam: 30%

Assignments

Resources

References:

1. Lecture notes given by instructor.
2. Berg,J. C. An Introduction to Interfaces and colloids, The bridge to nanoscience, World Scientific, 2010.
3. Israelachvili, J., Intermolecular and Surface Forces, Academic, Press, 3rd edition, 2011.
4. Hunter, R. J., Foundations of Colloid Science, Vol. I, II Oxford, University Press, 1986.