Introduction to Colloid and Interface Science and Engineering - Web course

COURSE OUTLINE

Colloids (including nanoparticles) and interfaces (surfaces) are the two most fundamental, widespread and useful nano-entities.

Study of colloids and interfaces is highly multidisciplinary in nature combining both the concepts and applications from such diverse domains as chemical engineering and manufacturing.

Analytical and physical chemistry, biochemistry and molecular biology, environmental science, materials science including biomaterials and advanced materials,petroleum engineering and finally, nanotechnology.

The word 'colloid' refers to particles in micron to sub-micron ranges where surface properties and interactions (rather than the bulk properties) become increasingly important with declining size or separation distance.

In contrast to the 'bulk' systems, the properties and behavior of small particles depends strongly on the system SIZE and inter-particle distances.

Thus understanding of colloids and interfaces is central to even such classical phenomena and applications such as (to name very few): adhesion, particle-aggregation, wetting, detergency, oilrecovery, flotation, nucleation, bio-surfaces, chromatography, paints, composite materials.

Foams, emulsions, aerosols and other (nano) particulate dispersions.

This course will aim at introducing the basic concepts and tools for the analysis of colloidal and interfacial properties.

Behavior and interactions together with brief introduction to some advanced topics such as self-assembly, meso-patterning of soft materials, functional materials, nano-composites, super-hydrophobicity, super-glue, etc. which have attracted increasing attention recently.

The overall aim of this course is to develop a broad background in colloids and interfaces which will enable students to:

1. Appreciate and understand much of the otherwise specialized contemporary published research in nanoparticles and surfaces.
2. Apply these themes to their own research and development problems effectively.

This course will be very useful to undergraduate students, post-graduate students, teachers and practitioners from a wide variety of backgrounds: chemical, mechanical, civil, materials and electrical engineering; chemistry and physics; and materials science.

A number of problems will be solved to illustrate the concepts clearly and updated reviews and research papers will also be referred in addition to the standard textbooks.

Contents

Surface Tension, Adhesion and capillarity:

Effects of confinement and finite size; Concepts of surface and interfacial energies and tensions; Apolar (van der Waals) and polar (acid-base) components of interfacial tensions.

Young-Laplace equation of capillarity; examples of equilibrium surfaces;

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Chemical Engineering

Pre-requisites:

Undergraduate fluid mechanics and thermodynamics.

Additional Reading:

1. Physical Chemistry of Surfaces, Arthur W. Adamson, 5th edition, Wiley, 1990.
2. Foundations of Colloid Science, Robert J. Hunter, Clarendon, Oxford, Volume 1, 1989.
3. Colloidal Dispersions, W. B. Russel, D. A. Saville and W. R. Schowalter, Cambridge University Press, 1989.
4. Intermolecular and Surface Forces, Jacob N. Israelachvili, Academic Press, 1992 or later editions.
5. Interfacial Forces in Aqueous Media, Carel J. van Oss, Marcel dekker or Taylor & Francis, 1994.

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multiplicity, etc.

Stability of equilibrium solutions; Contact angle and Young's equation; Determination of apolar (van der Waals) and acid-base components of surface/interfacial tensions.

Free energies of adhesion; Kinetics of capillary and confined flows.

Intermolecular, nanoscle and interfacial forces in organic, polymeric, biological and aqueous systems

Van der Waals, Electrostatic double layer, Acid-base interactions including hydrophobic attraction and hydration pressure.

Mesoscale thermodynamics:

Gibbs treatment of interfaces; concept of excess concentration; variation of interfacial tensions with surfactant concentration.

Mesoscale phenomena in soft matter and applications:

Adhesion, wetting, nucleation, flotation, patterning of soft material by self - organization and other techniques.

Stability of nanoparticle dispersions:

DLVO and DLVO like theories and kinetics of coagulation plus general principles of diffusion in a potential field/Brownian movement.

Nanofluidics:

Stability of thin (< 100 nm) films; self-organization in confined systems; meso-patterning.

Advanced and Functional Interfaces:

Superhydrophobicity, functional coatings, structural colors, nano-adhesives; nanocomposites.

Learning Objectives

1. Understanding of basic nomenclature, concepts and tools of colloid and interface science and engineering; multi-phase nano-systems; mechanics and thermodynamics on small scales.
2. A clear understanding of differences between the surface and bulk dominated regimes and behavior and exploitation of nano-behavior.
3. Appreciation of how these concepts and tools translate into a variety of applications from processes to materials.

COURSE DETAIL

S.No	Topics	No. of Hours
1	Introduction, aims, scope and applications.	2
2	Surface Tension, Adhesion and capillarity: molecular to meso-scopic concepts; theories and applications.	8
3	Intermolecular, nanoscale and interfacial forces in organic, polymeric, biological and aqueous systems. van der Waals, electrostatic, acidbase, depletion interactions, entropic effects.	10

4	Nanoscale, Mesoscale and surface thermodynamics.	4
5	Stability and utilization of nanoparticle dispersions: DLVO and DLVO like theories and kinetics.	2
6	Nanomechanics and nano-fluidics.	6
7	Mesoscale phenomena in soft matter and industrial applications.	8
	Total	40

References:

Principles of Colloid and Surface Chemistry, Paul C. Hiemenz, Marcel Dekker, any edition starting with the 2nd edition, 1986.