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Prelude

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 colloidal systems 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, oil-recovery, flotation, nucleation, bio-surfaces, chromatography, paints, composite materials; foams, emulsions, aerosols and other colloidal 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, 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: (a) appreciate and understand much of the otherwise specialized contemporary published research, and (b) apply these themes to their own research problems effectively.

Prerequisites

Introductory courses (one basic course) in Fluid Mechanics and Thermodynamics.

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Topics at a Glance:

1. 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; 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 flows

2. Intermolecular 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.

3. Mesoscale & Surface thermodynamics:

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

4. Mesoscale phenomena in soft matter and applications:

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

5. Stability of colloidal dispersions:

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

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Learning Objectives

1. Understanding of basic nomenclature, concepts and tools of colloid and interface science and engineering.
2. A clear understanding of differences between the surface and bulk dominated regimes and behavior.
3. Appreciation of how these concepts and tools translate into a variety of applications from processes to materials.

Some Reference Texts

1. Principles of Colloid and Surface Chemistry, Paul C. Hiemenz, Marcel Dekker, any edition starting with the 2nd edition, 1986 or PRINCIPLES OF COLLOID AND SURFACE CHEMISTRY. 3rd Ed. (P. C. Hiemenz and R. Rjagopalan) Marcel Dekker, New York, 1997.
2. Physical Chemistry of Surfaces, Arthur W. Adamson, 5th edition, Wiley, 1990.
3. Foundations of Colloid Science, Robert J. Hunter, Clarendon, Oxford, Volumes 1 & 2, 1989.
4. Colloidal Dispersions, W. B. Russel, D. A. Saville and W. R. Schowalter, Cambridge University Press, 1989.
5. Intermolecular and Surface Forces, Jacob N. Israelachvili, Academic Press, 1992 or later editions.
6. Interfacial Forces in Aaqueous Media, Carel J. van Oss, Marcel Dekker or Taylor & Francis, 1994.
7. Drew Myers, Interfaces, and Colloids: Principles and Applications, Wiley, Second Edition, 2002.

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Some Important Journals devoted to Colloids and/or Surfaces (Advanced and Ongoing Reading!)

Owing to a highly multidisciplinary and interdisciplinary nature and applications of colloids and surfaces, the publications related to these themes are found in MANY journals spanning almost all areas of science and technology from engineering, physics, chemistry, materials and biomedical sciences. However, contents of some of the journals center rather exclusively around fundamentals of colloids and interfaces. Some of these journals are listed below for specialized reading.

ACS Applied Materials and Interfaces

Colloids and Surfaces A: Physicochemical and Engineering Aspects

Colloids and Surfaces B: Biointerfaces
Journal of Colloid and Interface Science
Langmuir

Many interesting and modern applications of colloids and surfaces are in nanosciences and nanotechnology (interfaces are the most ubiquitous nano-entities! And colloids are mostly interfaces!!). Some of surface related nanotechnology is covered in the following journals:

ACS Nano
Nanoletters
Nanotechnology
Nature Nanotechnology
Small

Assorted applications are also in microfluidics/nanofluidics and materials. Some good sources are:

Advanced Materials
Advanced Functional Materials
Lab-on-a-Chip
Microfluidics and Nanofluidics
Nature Materials
Soft Matter

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