

Interfacial Engineering - Web course

COURSE OUTLINE

This course deals with the engineering aspects of fluid-fluid and fluid-solid interfaces. Being an interdisciplinary subject in which chemical engineers, chemists and biotechnologists are involved, this course aims to impart fundamental knowledge of the interfaces to the students and explain their applications. Based on the basic principles of thermodynamics, fluid mechanics, mass transfer and reaction engineering, this course covers some frontiers of chemical engineering.

COURSE OUTLINE

Introduction to the engineering of interfaces; Definitions of fluid-fluid and fluid-solid interfaces; Occurrence of interfaces in science and engineering; Overview of industrial applications of various interfacial phenomena; Colloidal materials; Properties of colloidal systems; Experimental characterization of colloidal dispersions

Surface and interfacial tension; Theoretical methods for the calculation of surface and interfacial tension; Experimental techniques for the determination of equilibrium and dynamic tension; Shape of the surfaces: curvature and radius of curvature; Young-Laplace equation; Kelvin equation; Pendant and sessile drops; Adams-Bashforth equation; Characterization of fluid-solid interfaces; Contact angle and wetting phenomena; Young-Dupre equation; Measurement of equilibrium and dynamic contact angles; Deposition of thin films; Mechanism of film nucleation; Chemical vapor deposition, molecular beam epitaxy, sputtering and atomic layer deposition techniques; Applications of fluid-solid interfaces in crystallization, development of ceramic materials, catalysts, electronic products and nanomaterials.

Introduction to intermolecular and surface forces; van der Waals forces; Electrostatic double layer force; Disjoining pressure; DLVO theory; Non-DLVO forces.

Adsorption at fluid-fluid and fluid-solid interfaces; Adsorption of surfactants; Gibbs and Langmuir monolayers; Gibbs adsorption equation; Surface equation of state; Surface pressure isotherm; Langmuir-Blodgett films and their applications; Radiotracer and neutron reflection techniques for studying adsorption at fluid-



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Chemical Engineering

Pre-requisites:

Knowledge of chemical engineering, particularly thermodynamics, fluid mechanics, mass transfer and reaction engineering

Coordinators:

Dr. Pallab Ghosh
Department of Chemical Engineering IIT Guwahati

fluid interfaces; Henry, Freundlich, Langmuir, Frumkin and Davies adsorption isotherms; Brunauer-Emmett-Teller theory of adsorption; Adsorption hysteresis; Characterization of adsorption at fluid-solid interfaces by vacuum and non-vacuum techniques.

Interfacial rheology and transport processes; Surface shear viscosity; Surface dilatational viscosity; Boussinesq number; Interfacial tension gradient and Marangoni effect; Gibbs and Marangoni elasticity; Boussinesq-Scriven model; Interfacial turbulence; Motion of drops in a liquid; Thin liquid films; Disjoining pressure and body-force models; Stability of thin liquid film; Black films.

Emulsions: Preparation, characterization and applications; Ostwald ripening; Flocculation and coalescence; Microemulsions: characterization and properties; Stability of microemulsions; Foams: preparation, characterization and stability; Structure of foams.

Interfacial reactions; Reactions at fluid-solid interfaces; Langmuir-Hinshelwood model; External and internal transport processes; Interfacial polycondensation reactions; Fast and instantaneous reactions at fluid-fluid interfaces; Reactions at biointerfaces; Micellar catalysis; Phase transfer catalysis.

Biological interfaces; Adsorption of proteins at interfaces; Biomembranes; Interfacial forces at biointerfaces; Adhesion and fusion phenomena; Biomaterials.

Nanomaterials: classification and preparation; Self-assembly; Nanoparticles; Nanowires, nanorods and nanotubes; Microporous and mesoporous materials; Lithographic techniques; Toxic effects of nanomaterials.

| Sl. No. | Topic | No. of Hours |
|---------|--|--------------|
| 1 | Introduction to the engineering of interfaces; Definitions of fluid-fluid and fluid-solid interfaces; Occurrence of interfaces in science and engineering; Overview of industrial applications of various interfacial phenomena; Colloidal materials; Properties of colloidal systems; Experimental characterization of colloidal dispersions. | 06 |
| 2 | Surface and interfacial tension; Theoretical methods for the calculation of surface and | 05 |

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| | <p>interfacial tension; Experimental techniques for the determination of equilibrium and dynamic tension; Shape of the surfaces: curvature and radius of curvature; Young-Laplace equation; Kelvin equation; Pendant and sessile drops; Adams-Bashforth equation; Characterization of fluid-solid interfaces; Contact angle and wetting phenomena; Young-Dupré equation; Measurement of equilibrium and dynamic contact angles; Deposition of thin films; Mechanism of film nucleation; Chemical vapor deposition, molecular beam epitaxy, sputtering and atomic layer deposition techniques; Applications of fluid-solid interfaces in crystallization, development of ceramic materials, catalysts, electronic products and nanomaterials.</p> | |
| 3 | <p>Introduction to intermolecular and surface forces; van der Waals forces; Electrostatic double layer force; Disjoining pressure; DLVO theory; Non-DLVO forces.</p> | 05 |
| 4 | <p>Adsorption at fluid-fluid and fluid-solid interfaces; Adsorption of surfactants; Gibbs and Langmuir monolayers; Gibbs adsorption equation; Surface equation of state; Surface pressure isotherm; Langmuir-Blodgett films and their applications; Radiotracer and neutron reflection techniques for studying adsorption at fluid-fluid interfaces; Henry, Freundlich, Langmuir, Frumkin and Davies adsorption isotherms; Brunauer-Emmett-Teller theory of adsorption; Adsorption hysteresis; Characterization of adsorption at fluid-solid interfaces by vacuum and non-vacuum techniques.</p> | 04 |
| 5 | <p>Interfacial rheology and transport processes; Surface shear viscosity; Surface dilatational viscosity; Boussinesq number; Interfacial tension gradient and Marangoni effect; Gibbs and Marangoni elasticity; Boussinesq-Scriven model; Interfacial turbulence; Motion of drops in a liquid; Thin liquid films; Disjoining pressure and body-force models; Stability of thin liquid film; Black films.</p> | 04 |
| 6 | <p>Emulsions: Preparation, characterization and applications; Ostwald ripening; Flocculation and coalescence; Microemulsions: characterization and properties; Stability of</p> | 05 |

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| | microemulsions; Foams: preparation, characterization and stability; Structure of foams. | |
| 7 | Interfacial reactions; Reactions at fluid-solid interfaces; Langmuir-Hinshelwood model; External and internal transport processes; Interfacial polycondensation reactions; Fast and instantaneous reactions at fluid-fluid interfaces; Reactions at biointerfaces; Micellar catalysis; Phase transfer catalysis. | 05 |
| 7 | Biological interfaces; Adsorption of proteins at interfaces; Biomembranes; Interfacial forces at biointerfaces; Adhesion and fusion phenomena; Biomaterials. | 03 |
| 8 | Nanomaterials: classification and preparation; Self-assembly; Nanoparticles; Nanowires, nanorods and nanotubes; Microporous and mesoporous materials; Lithographic techniques; Toxic effects of nanomaterials | 03 |
| Total hours | | 40 |

References:

Text books:

- Adamson, A. W. and Gast, A. P., Physical Chemistry of Surfaces, John Wiley, New York, 1997.
- Ghosh, P., Colloid and Interface Science, PHI Learning Pvt. Ltd., New Delhi, 2009.
- Hiemenz, P. C. and Rajagopalan, R., Principles of Colloid and Surface Chemistry, Marcel Dekker, New York, 1997.
- Stokes, R. J. and Evans, D. F., Fundamentals of Interfacial Engineering, Wiley-VCH, New York, 1997.

Reference books:

- Baszkin, A. and Norde, W., Physical Chemistry of Biological Interfaces, Marcel Dekker, New York, 2000.
- Edwards, D. A., Brenner, H. and Wasan, D. T., Interfacial Transport Processes and Rheology, Butterworth-Heinemann, Boston, 1990.
- Hunter, R. J., Foundations of Colloid Science, Oxford University Press, New York, 2005.
- Israelachvili, J., Intermolecular and Surface Forces, Academic Press, London, 1992.
- Slattery, J. C., Interfacial Transport Phenomena, Springer-Verlag, New York, 1990.

