DISCIPLINE-SPECIFIC ELECTIVE COURSE - 19 (DSE-19)

Interfaces, Macromolecules and Biophysical Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Coursetitle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Interfaces, Macromolecules and Biophysical Chemistry (DSE-19)	**04**	**02**	**--**	**02**	—	**--**

Learning Objectives:

- To understand fundamental surface and interfacial phenomena including adsorption, wetting, and catalysis.
- To introduce classification and characterization of polymers, polymerization mechanisms, and molecular weight determination.
- To apply thermodynamics and kinetics to protein folding, ligand binding, and enzyme catalysis.
- To familiarize students with analytical and optical tools used to study biomolecular structure and interactions.
- To bridge molecular understanding with biological function through biophysical chemistry.

Learning outcomes

By the end of the course, students will be able to:

- Explain micellization, surface tension, adsorption isotherms, and thin film properties.
- Describe polymer synthesis, types, and methods for determining molecular weights.
- Analyze biological macromolecules using thermodynamic, kinetic, and statistical models.
- Use key spectroscopic and separation techniques to investigate biomolecular properties.
- Connect experimental methods with structural and functional insights in biophysical chemistry.

SYLLABUS OF DSE 19

Unit-1: Surface and Interface Chemistry (Hours: 8)

Surface-active agents, micellization, hydrophobic interaction, critical micelle concentration (CMC), Krafft temperature.
Packing parameters, thermodynamics of micellization, solubilization, reverse micelles. Electrokinetic phenomena, Young-Laplace and Kelvin equations.
Adsorption: - Gibbs adsorption isotherm, Langmuir and BET isotherms, surface area measurements.
Thin films and Langmuir-Blodgett films.
Catalytic activity at surfaces (overview).

Unit 2: Polymer Structure and Characterization (Hours: 8)

Macromolecules and types of polymerizations, Degree of polymerization, number and mass average molecular masses, Polymer characterization: osmometry, viscometry, light scattering, diffusion.
Glass transition temperature, crystallinity.

Unit 3: Biophysical Chemistry of Macromolecules (Hours: 8)

Isoelectric point of amino acids, Configuration, and conformation of biological macromolecules, Thermodynamics of protein folding/stability, Configurational statistics and conformational transitions, Thermodynamics and kinetics of ligand interactions, Macromolecule-ligand binding and cooperativity (including Hill equation).

Enzyme catalysis: Michaelis-Menten equation (with derivation), Lineweaver-Burk plot, define the turnover number and Michaelis constant, Enzyme inhibition- reversibility and product inhibition

Unit 4: Spectroscopic, Analytical and Separation techniques (Hours: 6)

Basic principles and applications of analytical and optical techniques in biological systems: Absorption and fluorescence spectroscopy (overview only), Isothermal Titration Calorimetry (ITC), Linear and Circular Dichroism (CD), Single and multidimensional NMR spectroscopy. Single molecule spectroscopy.

Methods for the separation of biomolecules: General principles, including Chromatography; Sedimentation, Moving Boundary Sedimentation, Zonal Sedimentation, Electrophoresis, Isoelectric focusing, Capillary electrophoresis, MALDI-TOF.

Practical Component

1. Study of adsorption of Acetic Acid on Charcoal.
2. Conductometric Study of Critical Micellar Concentration.
3. Calculation of the thermodynamic parameters of micellization of SDS surfactant from conductivity/spectroscopic measurements.
4. Determination of pK_a values and the isoelectric point of an amino acid (both acidic and basic) using pH titration against acid and base.
5. Determination of surface area of a surfactant molecule using Gibbs adsorption isotherm.
6. Study of the catalytic efficiency of a non-specific enzyme by measuring the rate of the enzyme-catalysed reaction.
7. Separation of serum proteins using paper electrophoresis/ Ammonium Sulphate fractionation.
8. Molecular docking study for binding interaction of Fluconazole with 14a-demethylase enzyme (lanosterol) of prominent fungal pathogens Candida albicans using protein structure from protein data bank (PDB ID: CYP51) and Open-source software i.e. AutoDock Vina/ Swiss Dock, etc.

Instruction Mode: Demonstration/ Discussion of working principle/ Hands-on with substantial literature analysis/ Laboratory exercise

9. Instruction mode transaction of working principle of CD spectroscopy and demonstrating experimental protocol for determining protein folding and the percent helix, sheet, turns, and random structure change in protein (Bovine Serum Albumin) upon binding with a suitable ligand i.e. Rhodamine B.
10. Instruction mode transaction of working principle of MALDI-TOF instrumentation technique and its application to identify serum proteins (i.e. Bovine Serum Albumin) and their post translational modifications.
11. Instruction mode transaction of working principle of fluorescence spectroscopy and demonstrating experimental protocol for designing fluorescence/phosphorescence-based chemo sensors for detection of amino acid arginine.
12. Experimental Demonstration of the thermodynamics of urea induced denaturation of a protein, bovine serum albumin, by using fluorimetry.

Recommended References and Text Books: (for Theory)

1. Adamson, A. W. & Gast, A. P., Physical Chemistry of Surfaces, 6th Ed., Wiley
2. Somorjai, G. A. & Li, Y., Surface Chemistry and Catalysis
3. Israelachvili, J. N., Intermolecular and Surface Forces
4. Carraher, C. E., Introduction to Polymer Chemistry
5. Odian, G., Principles of Polymerization

6. Cantor, C. R. & Schimmel, P. R., Biophysical Chemistry (3 vols)
7. Wilson, K. & Walker, J., Principles and Techniques of Biochemistry and Molecular Biology
8. Dill, K. A. & Bromberg, S., Molecular Driving Forces
9. Hiemenz, P. C. & Lodge, T. P., Polymer Chemistry
10. Hiemenz, P. C. & Rajagopalan, R., Principles of Colloid and Surface Chemistry.
11 Van Holde, Principles of Physical Biochemistry

Recommended References and Text Books: (for practical's)

1. Voet, D.; Voet, J. G.; Pratt, C. W. Fundamentals of Biochemistry (Fifth Edition), John Wiley & Sons, Inc.
2. Lakowicz, J. R.; Principles of Fluorescence Spectroscopy, Springer Nature; 3rd edition (4 August 2006).
3. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
4. Hiemenz, P. C.; Rajagopalan, R. Principles of Colloid and Surface Chemistry (3rd Edition) MarceldEkkerin, C.
5. Adamson, A. W.; Gast, A. P.; Physical Chemistry of Surfaces, Sixth Editions, John Wiley & Sons, Inc.