POLYMERS: CONCEPTS, PROPERTIES, USES AND SUSTAINABILITY

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PRE-REQUISITES : First year courses in Maths, Physics and Chemistry, and Engineering Thermodynamics

INTENDED AUDIENCE : Students, practitioners and researchers who want to learn basics of polymers

INDUSTRY SUPPORT : Plastics processors, FMCG companies,Automotive companies, Biotech firms

COURSE OUTLINE : Polymers in solar cells, rubbers in soft robot, polymer composite in ISRO launch vehicle –these are some examples of cutting edge applications of polymeric materials. On the other hand, we see other examples of polymeric materials such as plastics and fiber reinforced plastics (FRP) all around us. What is so special about polymers, and why/how can they be used in such diverse applications? This course will introduce basic concepts related to polymeric materials; engineering estimations about their properties; various applications;and their impact on sustainability.

ABOUT INSTRUCTOR : Prof. Abhijit P. Deshpande is a Professor of Chemical Engineering at IIT Madras. His research focus is on polymeric systems, more specifically their aggregation and gelation behaviour. In his group, polymeric materials such as hydrogels and membranes are being investigated for applications in electrical, electromehcanical and electrochemical devices. His teaching interests include specialized courses in polymers, fluid mechanics, rheology and continuum mechanics; and core chemical engineering courses such as mass transfer and thermodynamics

COURSE PLAN :

Week 1: What are polymers? What are their unique features? - Why are polymers so common?;Polymers: Molecular structure and synthesis;Polymers: basic terms;Biopolymers;Molecular weight and distribution; Polymerization; Renewable sources

Week 2: Simple concepts related to single macromolecule, Renewable sources for polymers, Polymerization / depolymerization, States of interest, Application based terms, Reuse and repurpose, Molecular conformations, Size, mobility and flexibility, Polyelectrolytes

Week 3: Molecular arrangements and states of polymers, Structures in biopolymers, Amorphous / crystalline states, Orientation, Interactions, Kinetics of crystallization, Glass transition

Week 4: Polymeric systems of different kind, States in environment, Liquid crystalline polymers, Copolymers, Blends

Week 5: Blends, copolymers and composites, Microstructure in polymers, Composites, Stress strain response, Additives for polymeric systems, Blends / composites in recycling, Physical / chemical crosslinking, Mechanical
properties

Week 6: Physico-chemical, mechanical and electrical properties of polymers, Physical and chemical aging, Solutions: properties, Conducting polymers, Dielectric response, Plasticity, Properties of composites

Week 7: Viscoelasticity in polymers, Viscoelasticity: introduction, Thermal response, Viscoelasticity: characterization, Viscoelasticity – simple models, Dynamic mechanical analysis, Damping Applications, Time Temperature, superposition, Impact and energy absorption

Week 8: Viscoelasticity in polymers / Interaction of polymers with other materials, Testing for applications, Properties of blends, Biomimetic polymers, Advanced mechanics, Viscoelastic response: examples, Polymer packaging, Porous polymers / membranes, Polymer at interfaces, Diffusion in polymers

Week 9: Interaction of polymers with other materials / Polymers processing and recycling, techniques, Compatibilizers, Biopolymer applications, Adhesives and Paints, Dissolution and recovery, Polymerization kinetics, Polymerization reactors, Polymer processing

Week 10: Polymers processing and recycling techniques, Flow simulations, Processing for recycling, Recycle, up-down cycling, Flow behaviour - rheology, Crosslinking, Conversion of polymers

Week 11: Polymers processing and recycling techniques, Rheology and entanglement, Rheological models, Rheology and processing, Absorption and leaching, Swelling of polymers, Viscosity for polymer processing

Week 12: Polymeric materials in nature, Microplastics, aerosols, sediments, Biodegradation of polymers, Biodegradable polymers