POLYMER SCIENCE

Syllabus

Unit 1: General - Introduction to polymers with emphasis on important concepts such as -monomer, functionality and physical state (amorphous and crystalline), classification of polymers on the basis of source, elemental composition, heat, pressure, chemical reactivity, chemical/monomer composition, geometry and stereo regularity. Nomenclature of Polymers.

Unit 2.Chemistry and Mechanism of Polymerization - Definition of polymerization, factors affecting polymerization, Addition polymerization (free radical, ionic and co-ordination polymerizations), Condensation polymerization, Ring opening polymerization. Redox Polymerisation, Living radical polymerization,

Copolymerization – Co-polycondensation. Plasma polymerization, Photo polymerization, Electrochemical polymerization, Metathesis polymerization, Group transfer polymerization, ATRP, Reversible addition- fragmentation chain transfer polymerization, dendrimer.

Unit3. Specialty polymers- Functional polymers, LCP, Conducting polymers, degradable Polymers.

Engineering polymers: Unsaturated polyester resin, Epoxy resins, Phenolics, Amino resins, Alkyds. Properties and applications of engineering polymers: Nylons, Polyesters, PAN, PC, PU, ABS, Polyacrylates and allied polymers, Fluoropolymers, modification of industrial polymers.

Unit 4.Concept of polymer molecular weight: importance of molecular weight control. Arthemitic mean-molecular weight average Mw, Mn, and Mv. Molecular weight distribution and its importance from the point of applications.

Determination of molecular weight - End group analysis, cryoscopic method, ebulliometric metric methods, membrane osmometry, vapour phase osmometry, light scattering, ultracentrifugation & viscometry.

Unit 5.: Polymer Processing

Processing of Polymers: Moulding – compression moulding, injection moulding, blow moulding, rotational moulding, thermoforming. Extrusion – coextrusion, film extrusion, pultrusion, calendering, casting, coating.. Reaction Injection Moulding (RIM)- Principle and Application Structural reaction injection molding, resin transfer molding, foaming, laminates. Moulding of DMC and SMC and other thermoset processing operations.

Unit 6.Polymer Testing

Mechanical properties :

Tensile properties, compression properties, flexural properties, shear properties, impact resistance, toughness, tear resistance, abrasion resistance and hardness.creep, stress relaxation, fatigue properties, flexing, and resilience

Flammability properties: oxygen index, critical temperature index, smoke density flammability test, ignition properties, and surface burning characteristics.

Electrical properties: insulation resistance, volume resistivity, surface resistivity, break down voltage, dielectric strength, arc Resistance, dielectric constant, power factor.

Optical properties: gloss, haze, refractive index, and degree of yellowness, transmittance, photoelectric properties, and color.

Miscellaneous properties: MFI, MVI, specific gravity, bulk density, ESCR, weathering properties, toxicity, resistance to chemicals, abrasion, tearing, Co-efficient of friction, VST, HDT, Nondestructive testing methods.

Unit 7.: Spectroscopic methods: **UV-Visible spectroscopy - Principle & theory**

Applications- qualitative and quantitative analysis, purity, cis-trans-conformation, molecular weight determination, polymer degradation analysis.

Fourier transform infrared spectroscopy: principle & theory,

Applications – Establishment of chemical structure of polymers, reaction kinetics, polymer linkages, hydrogen bond formation, purity, copolymerization, qualitative and quantitative results.

Nuclear magnetic resonance: (^{1}H and ^{13}C NMR) principle, theory, applications-stucture (chemical), purity, tacticity, etc.

Unit 8.Thermal methods:

DSC: theory, principle & interpretations of DSC thermogram, Applications- heat of fusion and degree of crystalanity or isotacticity. Random copolymer structure. Block copolymer structure. Polymer mixture melting point depression by diluents, crystallization, melt crystalisation, cold crystalisation. Tg, Tm, determination of blend composition,purity, identification of unknown, degree of crystallization, degree of cure, rate of cure studies (kinetics of curing) plasticizer effect, (Broido method, Kissinger method , Ozawa method, B&D method)

Thermogravimetric analysis: principle, theory, Applications- purity, fiber content, composition of copounded rubber, identification of polymers and rubbers, thermal stability, thermal degradation, kinetics of thermal degradation, IPDT, etc,

Principles of DMA and TMA-applications.

Unit 9.Chromatographic technique: Gel permeation chromatography- theory, principles, Applications- qualitative and quantitative analysis, molecular weight determination and molecular weight distribution, purity, composition, polymerization kinetics, depolymerization, identification of unknown, etc.

X-ray diffraction: SAXS, WAXS, theory, principle, Application- Chain conformation, chain packing, disorder in crystals, degree of crystalinity, microstructural parameters, degree of orientations.

Principles of optical microscopy, SEM, TEM, AFM. Applications - Morphology of polymers, crystalization behavior, phase separation.

Unit 10: Structure-property relationship

Polymer properties- Approach and the concept. Chemical structure of polymers – Introduction, shapes and energy consideration, copolymers, heteroatomic polymers. Physical structure of polymers – introduction, melt viscosity, interchain and intrachain forces; glass transition temperature; crystallinity; elastomers, fibers, plastics and their correlation with Tg and Tm (structural features). Physical properties of polymers in relation to chemical structure: volumetric properties – volume and density, thermal expansion; calorimetric properties – heat capacity, enthalpy and entropy; transition temperatures – Tg, Tm, and relationship between Tg and Tm of polymers; solubility – the solubility parameter, solubility limits.