

Harcourt Butler Technical University, Kanpur

Syllabus of the Written Test (in Plastic Technology) for the Post of Assistant Professor (Contractual)

POLYMER CHEMISTRY

Basic concepts and terminology such as monomer, polymer, functionality and structure of polymers. Transitions in polymers, applications of polymers. Classification of polymers, stereochemistry of polymers, general theory of chain growth polymerization. Free radical polymerization, types of initiators. Kinetics of free radical polymerization, auto-acceleration. General characteristics of condensation polymerization, kinetics and mechanism. Carother's equation, development of cross-linked structures. Step polymerization and its utility.

Concept of Molecular weight of polymers, factors affecting molecular weight and molecular weight distribution, polydispersity. Chain transfer reactions, retarders, inhibitors, effect of temperature on polymerization

Copolymerization reactions and its utility. Kinetics of copolymerization, copolymerization behavior and types of copolymers. Stereo-chemistry of polymerization. Ring-opening polymerization.

POLYMERIZATION ENGINEERING

Industrial methods of polymerization such as bulk, solution, suspension, emulsion. Types of polymer production processes and reactors.

Concept of stereo-chemistry of polymers, stereo-specific polymerization. Catalyst – their utility in polymer manufacture, Zeigler Natta, Metallocene and other catalyst systems.

General characteristics of commodity, engineering and high performance polymers.

Manufacturing processes, properties and applications of various polyolefins such as LDPE, HDPE, and their copolymer grades, polypropylene and its copolymer grades, polystyrene, ABS, Polycarbonate, Acetal resins, Nylons, Polyesters, polysulphones, polyether ether ketones, fluorine-containing polymers, polyphenylene, oxide polyurethanes

Production technology, properties and application of polystyrene, poly(vinyl_chloride), and their copolymer grades.

Manufacturing details, properties and applications of various thermosetting resins such as phenol-formaldehyde, urea-formaldehyde and melamine-formaldehyde and preparation of molding powders., epoxy resins and their curing agents, polyimides, thermoset polyester resins and their curing methods

POLYMER PROCESSING

Concepts of Polymer Processing; Concepts of Extrusion process for plastics- basic operation and analysis, solids conveying, drag induced conveying, melting mechanism, power consumption in metering zone. Overall extruder performance, die and screw characteristics curves. Fundamentals of single screw extrusion, twin screw extrusion and co-extrusion operation; Construction of Barrel and screw for commodity, heat sensitive and engineering plastics. Extrusion process details, basic principles, equipment used, and applications for plastic product formations viz. film, pipe, lamination, profiles, wire, cable, etc.; Casting process for films; Reactive extrusion: basic principles, equipment used and applications. Importance and concept of compounding of polymers; compounding additives viz. fillers, plasticizers, colorants, stabilizers, blowing agents, flame-retardants, antioxidants, etc. Mixing, blending and compounding equipments. Finishing of Plastics.

Basic concepts of injection molding of thermoplastics Principle and theory of standard injection molding operation, molding cycle, Process variables, temperature, pressure, injection rate, etc. and

their importance for machine cycle and quality of product. Faults and remedies in injection molding operation. Advances in injection molding
Concept of Injection molding of thermoset polymers and process details. General concept of compression and transfer molding process, the description of various types of compression and transfer molding processes and their utility in processing of thermosetting materials.
Calendaring- description and features of calendaring process, calendar roll arrangements, application of calendaring.

Design of polymeric products, design criteria based upon product functions and geometry, material selection by property assessment, selection of appropriate forming processes. Moulding consideration: Draft, radii, dimensional tolerances, wall thickness, ribs and bosses, inserts, sink marks, undercuts, feeding system, gate location, flow pattern, shrinkage and post moulding shrinkage. Injection mould design: single, multi cavity, semi-automatic and automatic moulds, Types of injection moulds, their applications, detailed structure and working. Materials for mould making & Mould making processes. Design concepts for compression molds and transfer molds. Extradites dies basics, types and general structure.

RHEOLOGY AND TESTING OF POLYMERS

Introduction to polymer rheology, importance of rheology on polymer processing techniques such as extrusion, injection molding, etc., Newtonian and non-Newtonian fluids, time independent and time-dependent fluids, visco-elastic behavior, constitutive equations.

Mechanical models, discussion of models for flow and deformation in polymers and treatment of measurable rheological properties

Measurement of viscosity and normal stresses. Viscous heat generation. Interpretation of time-temperature sensitivity of viscoelastic solids and liquids. Rheometers.

Testing of polymer properties viz. thermal, optical, electrical, and mechanical properties as per standard specifications, viz. ASTM, ISO, etc. and its importance, correlation of these tests with actual performance.

Concepts of thermoforming process and various means of forming. Description of various thermoforming methods. Thermoforming process variables affecting the product quality. Thermoforming faults and remedies. Thermoforming machines

General description of blow molding processes, type of blow molding machines, die shaping, parison control, process variables, blow molding faults and their remedies.

Rotational molding process description and features of rotational molding machines. Process variables in rotational molding process

Stretch blow molding process. Concepts of stretching temperature, transparency, etc. various types of stretch blow molding operation.

Reaction injection molding (RIM) Process, its basic principles, process description and utility. Concept of Casting of polymers, description of process for polymers like epoxy resins, nylons, polyurethanes, etc.

Introduction to polymer characterization by instrumental techniques such as IR, NMR, DSC, TGA, etc.

STRUCTURE AND PROPERTIES OF POLYMERS

Basic structures in polymers, structure-property relationship. Effect of chemical composition and types of bonds in structure of polymer, intermolecular forces. Molecular weight averages and distributions. Determination of molecular weight averages. Polydispersity and MWD. Orientation of crystalline and amorphous zones and study of its effects on polymer properties. Polymer single crystal, dimensions of polymer chain, degree of crystallinity and its measurement.

Polymer-solvent interaction, good and poor solvents, intrinsic viscosity and Mark-Houwink equation, concept of fractionation processes.

Concept of flexibility, various factors deciding flexibility of polymers, polymer properties affected by flexibility, glass transition temperature (T_g), factors affecting glass transition temperature. Effect of copolymerization on properties. Degradation behaviour of polymers.

POLYMER COMPOSITES

Introduction to composite materials, comparison of different materials with composites-advantages and disadvantages. Principles of composite reinforcement. Effect of fibrous reinforcement on composite strength. Types of reinforcement such as natural, glasses, carbon/graphite, aramid fibers boron fibers and their utility in polymer composites various forms of reinforcement and surface treatment of fibers

Thermosetting and thermoplastic material used for the composites and their selection for a particular application. Processing and production techniques like hand-layup, bag moulding, filament winding and pultrusion. Prepegs, their manufacture and characterization. Sheet moulding and dough moulding compounds and their processing. preform and resin transfer moldings.

Hybrid and sandwich-type composites.

Introduction to nano materials, and nanocomposites. Construction of polymer nano-composites, importance of interface between nano fillers and polymer matrix, the advantages and disadvantages and applications of polymer nano-composites Types of nano clay available, Synthesis of nano clay, their structure, properties and utility in polymer nanocomposites, formulation of Polymer clay nanocomposites, their properties and applications, concept of ordered structures, exfoliation, interfaces, surface induced patterns, etc. Carbon nanotubes and carbon allotropes-based polymer composites, types of nano tubes, their synthesis and structure. Methods for synthesis, structures, properties and potential applications of carbon-based polymer nanocomposites. Types of nano metals available and their characteristic properties, Metal-based polymer nanocomposites their synthesis, structure and physicochemical properties and potential applications

TECHNOLOGY OF ELASTOMERS

Definition and characteristics of rubber and elastomer, significance of structure and important features of elastomers. Compounding ingredients and method of compounding, various compounding equipments. Types of fillers, their characteristics and their affect on rubber properties. Mechanism of reinforcement of elastomers. Carbon black its characteristics and methods of production. Mastication of rubbers.

History of natural and synthetic elastomers Production of different grades of natural rubber from latex, modified natural rubber and its derivatives. Application of latex, technically specified rubber, chemistry of vulcanization and various vulcanization techniques.

Manufacturing processes, properties and application of synthetic elastomers viz. styrene-butadiene rubbers, acrylonitrile-butadiene rubber, butyl rubber, polychloroprene rubber. Manufacturing processes, properties and application of ethylene-propylene rubber, polyurethane elastomers, chlorosulphonated polyethylene, polysulphide and silicon rubber, Concept of various types of thermoplastic elastomers and their applications, styrene-butadiene TPE, polyurethane based TPE.

HIGH-PERFORMANCE POLYMERS

Role of polymers for high-tech areas such as aerospace, telecommunication, defense, medical, etc.

Chemistry, preparation, properties and applications of high-temperature resistant polymers like polyetherether ketone (PEEK), etc. Specialty polymers.

Preparation, properties and applications of liquid crystalline polymers, silicone polymer, and other newly developed materials. Nanofillers and nanocomposites, their processing and economics.

Self-reinforced polymer composite. High energy absorbing polymer. Super absorbent polymers. Polymers for biomedical applications.

Polymer blends and alloys, theories of polymer miscibility, various commercial blends and their applications, methods of blending.

POLYMER BLENDS AND ALLOYS

Definition of blends and alloys, reasons for blending, classification of blends; historical outline of industrial development of polymer alloys and blends; how to select blend components fundamental principles for the development of polymer alloys and blends

Definition of miscibility; Miscible Blends and Immiscible Blends - Difference Between Miscible and Immiscible Blends - Properties of Miscible and Immiscible Blends; Phase Equilibria Calculation; Huggins - Flory Theory; Measurement of Polymer/Polymer Interaction Parameter ; Factors Affecting Miscibility of Polymer Blends; concept of Compatibility of polymers

Methods of blending; Types and Role of Compatibilizer; Compatibilization Methods; Mechanism and Properties of Compatibilized Blends; Mechanism and Theory of Toughening;

Blend preparation equipments: mixers' and their various types like banbury, hot and cold mixers, twin screw compounders, and two-roll mills, etc. Toughening of Thermoplastics and Thermosets; Thermoplastic Elastomers; Properties and Uses Interpenetrating polymer network:

Mechanical and thermal properties of polymer blends; Rheological Models for Miscible and Immiscible Blends, Applications of blends and alloys Automotive, Electrical and Electronics, Medical, Building and Construction, Business Machines and Communications,

Packaging

Methods of Measurements of Crystallization, Morphological and Melting Behavior of Polymer Blends, use of SEM, TEM, for characterization of blends

POLYMER ADHESIVES

Definition of adhesives and adhesive bonding, functions of adhesives, classification of adhesives, advantages and disadvantages of joining using adhesives, requirements of a good bond, theories of adhesion, definition of failure modes, mechanisms of bond failure. Surface characterization. Surface preparation and surface treatments for various substrates. Techniques for evaluation of adhesives bond strength. Testing and quality control. Principle of adhesives formulation and production techniques. Adhesives formulation for various industries viz. construction, packaging, textiles, automotive, consumer, abrasives and friction materials, shoes, electrical, aerospace, etc.

Characterization and applications of hot melt adhesives, solvent-activated adhesives, anaerobic and pressure-sensitive adhesives, etc. Bonding of polymeric materials to various substrates. Polymer sealants. Structural adhesives.

POLYMER PACKAGING AND WASTE MANAGEMENT

Concept of plastic packaging, present state of packaging technology, scope of packaging, advantages and disadvantages of polymeric packages over conventional packaging materials. Polymer films for packaging.

Selection criteria of various household and industrial polymeric packages. Printing on polymeric packages. Testing and quality control. Newer developments in polymer packaging.

Global policies and regulations. Social and environmental challenges of plastic waste in India. Plastics and environment. Salient features of the plastic waste management (PWM) rules. Waste treatment of various plastic plants, estimation of power requirement and efficiency of size reduction operation of plastics.

Recycling and recovery of various plastics items/materials-their effect on environment. Waste collection and recycling methods. Comparative study of conversion of plastic waste into value added products.

Biodegradable polymers - prospects & utilization, prospects for biodegradable plastics based on renewable resource polymers. Biodegradable polymers for various applications viz. food packaging, agriculture, etc.