SEMESTER –VI

POLYMER SCIENCE

Category I

(B.Sc. Honours in Polymer Science in four years)

DISCIPLINE SPECIFIC CORE COURSE – 16

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
POLYMER BLENDS AND COMPOSITES	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry, Mathematics**	**-**

Learning objectives

- To gain knowledge of polymer composites and its basic construction
- To learn about preparation, properties and characterization of polymer blends.

Learning outcomes

After studying this paper, students will be able to

- Understand various techniques for preparation of polymer blends
- Understand the types and forms of reinforcement materials used in composites
- Apply different production techniques for fabrication of polymer composites

SYLLABUS OF DSC-16

THEORY COMPONENT-

UNIT 1: **(6 Lectures)**

BASIC CONCEPT OF BLENDS

Definition of blends, types of blends (plastic-plastic, rubber-rubber and plastic-rubber blends), differences between: copolymer and IPNs, blends, alloys and composites; concept of miscibility, concept of free energy of mixing, phase equilibria, Flory-Huggins theory, spinodal, binodal and critical phase, Gibb's phase rule

UNIT 2: **(6 Lectures)**

PREPARATION AND PROPERTIES OF BLENDS

Methods of blending, compatibilizers, methods of compatibilization, factors affecting miscibility of polymer blends, effect of composition on properties (rheology, morphology, mechanical and thermal)

UNIT 3: **(6 Lectures)**

CHARACTERIZATION TECHNIQUES OF BLENDS

Applications of the following techniques: IR, microscopy (TEM, SEM and optical), TGA, DSC, DMA, viscosity, refractive index

UNIT 4: **(6 Lectures)**

POLYMER COMPOSITES

Definition; classification of composites; dispersed phase: (reinforcing fillers, non-reinforcing fillers), and (particulate matter, fibrous structure and platelet structures), continuous phase: thermoset matrix, thermoplastic matrix and high-performance resins, mechanism of reinforcement, various factors affecting reinforcements

UNIT 5: **(6 Lectures)**

DESIGN AND FABRICATION OF COMPOSITES

Fabrication techniques: Prepreg technology, injection and compression molding, vacuum bag molding, hand-lay-up process, spray-up technique, filament winding process, fibre placement process, Pultrusion, reaction transfer molding, laminating techniques, expansion processes, fabrication processes: adhesion, cohesion and mechanical processes & FRPs.

Design of a few polymer composite: basic design practice – material considerations, product considerations and design considerations, rule of mixture

PRACTICAL COMPONENT (60 Lectures)

- To prepare polymer blends by melt, solution and latex blending.
- To check the compatibility of blends by using microscope/DSC
- Determination of Lower and Upper Critical Solution Temperature of a polymer.
- To study the miscibility of the polymer blend using ultrasonic method.
- To study the miscibility of the polymer blend using viscosity method.
- To study the miscibility of the polymer blend using refractive index method.
- Determination of miscibility of polymer blends by density measurement method.
- Preparation of FRP laminates by hand lay-up technique.
- Evaluate the effect of filler loading on mechanical properties of a composite.
- Fabrication of composites by various techniques.
- Characterization (thermal and mechanical) of blends and composites.
- Determine the refractive indices of polymer blends by using abbe's refractometer.

ESSENTIAL/RECOMMENDED READINGS

- Paul D.R., Bucknall C.B., (2000) Polymer Blends Vol. 1 & Vol. 2, Wiley-Interscience.
- Robeson L.M., (2007) Polymer Blends, Hanser Gardner.
- Singh R.P., Das C.K., Mustafi S.K., (2002) Polymer Blends and Alloys, Asian Books Private Limited.

SUGGESTIVE READINGS

- Utracki L.A., (2003) Polymer Blends Handbook Vol. 1 & Vol. 2, Kluwer Academic Pub.
- Bhowmick A.K., De S.K., (1990) Thermoplastic Elastomers from Rubber-Plastic Blends, Ellis Horwood Publishers Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 17

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
POLYMERIC NANOMATERIALS AND NANOCOMPOSITES	**4**	**3**	**0**	**1**	**Class 12th with Physics, Chemistry, Mathematics**	**-**

Learning objectives

- To make students understand the basic concepts of nanomaterials and polymer nanocomposites.
- To learn the effect of shape, size, dispersion and percolation of nanomaterials on polymer nanocomposites
- To understand modification techniques of nanomaterials

Learning outcomes

After studying this paper, students will be able to

- Synthesize polymeric nanomaterials
- Demonstrate the knowledge of properties and structural aspects of polymeric nanomaterials
- Explore various areas of polymeric nanomaterial applications

SYLLABUS OF DSC-17

THEORY COMPONENT-

UNIT 1: (9 Lectures)

NANO-REINFORCING AGENTS

Preparation, structure and properties of nano-reinforcing agents: 1 D, 2 D and 3 D nanomaterials eg. nanoparticles, nanotubes, nano-clays, POSS, carbon nanostructures (CNTS, graphene)

UNIT 2: (21 Lectures)

PROPERTIES AND CHARACTERIZATION OF NANOMATERIALS

Morphology analysis of crystallites in nanocomposites: X-ray scattering & diffraction technique, Analysis of Nanostructure developed in semi-crystalline polymers during deformation, Nanostructure of two component amorphous block copolymers, effect of chain architecture. Factors governing properties of nanocomposites such as loading, dispersion and percolation, influence of size, shape and diameter of nanoparticles nanotubes, functionalization of nanomaterials

UNIT 3: (15 Lectures)

POLYMER NANOCOMPOSITES Basic concepts, preparation, characterization and applications of polymer nanocomposites, technical challenges and understanding of interfacial dynamics using LJ potential and many body problems approach

PRACTICAL COMPONENT (30 Lectures)

- To analyze particle size of nanomaterials (nanoparticles).
- To prepare polymer nanocomposites by solution casting
- To prepare polymer nanocomposite by melt compounding.
- To determine the polymer nanocomposite by in-situ polymerization
- Determination of mechanical properties of nanocomposites.
- To prepare graphene oxide and its nanocomposite.
- Chemical modification of nanoclay and its characterization.
- Characterization (morphology and thermal) of nanocomposites by optical microscope, SEM, TEM, DSC, DMA, TG-DTA etc.
- Determination of electrical properties of nanocomposites.
- To prepare nano metal oxides and nano silica by chemical modification.

ESSENTIAL/RECOMMENDED READINGS

- Koo J.H., (2010) Polymer Nanocomposites, Tata McGraw-Hill.
- Bhattacharya S.N., (2008) Polymeric Nanocomposites-Theory and Practice, Hanser Gardner.
- Michler G.H., Balta F.J., (2005) Mechanical Properties of Polymer based on Nanostructure and Morphology, CRC Press.

SUGGESTIVE READINGS

- Tjong S.C., (2006) Nanocrystalline Materials, Elsevier Science.
- Owens F.J., Papoose C., (2003) Introduction to Nanotechnology, John-Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 18

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RUBBER TECHNOLOY	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry, Mathematics**	**-**

Learning objectives

- To learn about the concept of vulcanization and properties of rubbers

Learning outcomes

After studying this paper, students will be able to

- Apply the knowledge of preparation of rubbers and fibres
- Learn the knowledge of different types curing techniques

SYLLABUS OF DSC-18

THEORY COMPONENT-

UNIT 1: (4 Lectures)

RUBBERS: INTRODUCTION

Properties of rubber: Structure, glass transition temperature, mechanical properties (tensile, % elongation, compression set, fatigue resistance, resilience, hysteresis, hardness etc.)

UNIT 2: (10 Lectures)

PREPARATION, PROPERTIES AND APPLICATIONS

Natural rubber and synthetic rubbers (styrene-butadiene rubber, polybutadiene rubber, ethylene propylene diene rubber, butyl rubber, nitrile rubber, neoprene, silicone rubber, fluorocarbon rubber

Thermoplastic elastomers: Structure, properties, preparation, types and applications

UNIT 3: (6 Lectures)

MIXING OF RUBBERS

Need for compounding - Rubber mixing mechanism -mixing machinery- two roll mill-internal mixer–machine design -mixing in internal mixers &two roll mill, continuous mixers - mixing cycles and procedures, operating variables and mix quality

UNIT 4: (6 Lectures)

VULCANIZATION OF RUBBER

Theory and mechanism of sulphur and non-sulphur vulcanization (with and without accelerators), rheocurve of compounded rubber, pre and post vulcanization processes, properties of vulcanized rubber

UNIT 5: (4 Lectures)

VULCANISATION TECHNIQUES

Importance of vulcanization - vulcanization processes - batch processes - Continuous vulcanization – machinery & process - Reaction injection moulding of PU; silicone injection moulding.

PRACTICAL COMPONENT (60 Lectures)

- To determine tensile strength, modulus, elongation at break of Rubber sheet.
- To determine tear strength, abrasion resistance, heat build-up, resilience, hardness, flex resistance for rubber compounds.
- To determine curing time and physical properties of rubber compounds.

- To determine mooney viscosity of rubber using Mooney viscometer.

ESSENTIAL/RECOMMENDED READINGS

- Martin J.M., Smith W.K., (2007) Handbook of Rubber Technology, CBS Publisher.
- Mark J. E., Erman B., Eirich F.R., (2005) The Science and Technology of Rubber, Elsevier Academic Press.
- Blow S., (2000), HandBook of Rubber Technology, Hanser Gardner.

SUGGESTIVE READINGS

- Morton W.E., Hearle J.W.S., (2008) Physical Properties of Fibres, Woodhead Publishing.
- Blow.C.M. andHepburn.C. Rubber Technology and manufacture, Butterworths, 1982.
- Evans.C.W., Practical Rubber Compounding and processing, Applied Science Publishers, London, 1981.

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