SEMESTER –IV

BSc. (Polymer Science)

Bhaskaracharya College of Applied Science

DISCIPLINE SPECIFIC CORE COURSE – 10

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 TESTING AND SPECIFICATIONS (PTS)	4	2	0	2	Class 12th with Physics, Chemistry, Mathematics	NIL

Learning objectives

The Learning Objectives of this course are as follows:

- To learn about the fundamentals of polymer testing
- To understand testing standards of polymeric materials on various testing instruments

Learning outcomes

The Learning Outcomes of this course are as follows:

After completing the course, the students

- Perform tests of polymeric materials on testing instruments
- Establish the structure property correlation (mechanical, thermal, optical, electrical) of polymers
- Elucidate stability of various polymers and their properties on the basis of their thermo mechanical transitions.

SYLLABUS OF DSC- 10

THEORY COMPONENT-

UNIT 1: (12 Hours)

TESTING STANDARDS AND MECHANICAL ANALYSIS OF POLYMERS

Principles of standardization, preparation of sample, different standards: BIS and ASTM standards (thermal and mechanical analysis), testing methods, evaluation of errors in polymer testing, correction of errors

a. Short term strengths: tensile, flexural, hardness, impact strength, tear resistance, abrasion, etc.

b. Long term strengths: Creep and fatigue properties, isochronous stress strain curve compression set.

UNIT 2: **(4 Hours)**

ELECTRICAL AND OPTICAL PROPERTIES

Dielectric strength, surface and volume resistivity, electro active properties, Refractive index, Haze and gloss, yellowness index.

UNIT 3: **(6 Hours)**

GAS BARRIER AND ENVIRONMENTAL ASSESSMENT

Permeability to gases and moisture: Standard methods of measuring the permeability of gases, Environment resistance: Cause of deterioration of polymer by aging & weathering, assessment of deterioration, natural and artificial weathering, chemical resistance.

UNIT 4: **(8 Hours)**

THERMAL AND FIRE RESISTANT PROPERTIES

Thermo-mechanical Properties, Melt flow index, thermal conductivity, thermal diffusivity, specific heat capacity, linear thermal expansion, brittleness temperature etc. Burning behaviour, flammability tests (UL-94, limiting oxygen index, critical temperature index, smoke density).

PRACTICAL COMPONENT **(60 Hours)**

- To determine the melt flow index of LLDPE, PP etc.
- To evaluate limiting oxygen index (LOI)/ UL-94 of plastic samples: PVC, PE, PP etc.
- To determine the heat distortion temperature (HDT) & vicat softening point (VSP) of polymers.
- To measure the abrasion resistance of polymer sheets.
- To measure the dielectric strength of polymer films/sheets.
- To determine the coefficient of friction of polymeric samples.
- To determine the Izod impact strength of polymeric samples.

- To determine the environment stress cracking resistance of PE/PP.
- To calculate weight percentage of inorganic and organic ingredients in polymeric compounds.
- Measure the Thermo-mechanical transition.
- Determine the water vapor transition rate for polymeric film.
- Determine the thermal conductivity of a polymer sheet.

ESSENTIAL/RECOMMENDED READINGS

- Shah V., (2007) Handbook of Plastic Testing & Technology, Wiley-Inter science.
- Hylton D., (2004) Understanding Plastic Testing, Hanser publication
- Grellmann W., Seidler S., (2013) Polymer Testing, Hanser publication.
- Willard H.H., Merrit L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
- Seidel, A. (Ed.). (2008). Characterization analysis of polymers. Wiley-Interscience.
- Pethrick, R. A., & Viney, C. (2003). Techniques for polymer organization and morphology characterisation. Wiley.
- Frick. A., Stern. C. , Muralidharan V. (2019) Practical Testing And Evaluation Of Plastics, Wiley,

SUGGESTIVE READINGS

- Berins M. L., (1991) SPI Plastic Engineering Hand book, Springer.
- Ward I.M., Sweeney J., (2004) An Introduction to the Mechanical Properties of Solid Polymers, Wiley.
- Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.

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

DISCIPLINE SPECIFIC CORE COURSE – 11

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 PROCESSING TECHNOLOGY	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry, Mathematics**	**---**

Learning objectives

- To learn about the various processing techniques and their components
- To learn the fundamentals of extrusion and different extrusion processes of thermoplastics.

Learning outcomes

After studying this paper, students will be able to

- Explain the significance of the single screw and multiple screw extruder systems
- Apply the fundamentals of injection and compression molding process and interpret processing variables for upgradation of quality of products

SYLLABUS OF DSC- 11

THEORY COMPONENT-

UNIT 1: **(6 Hours)**

EXTRUSION

Extrusion process, the extrusion die, classification of extrusion dies: film and sheet extrusion, multi-layer extrusion, Spider die, Pipe and Tube die, offset die, etc. Die swell and die defects

UNIT 2: **(10 Hours)**

INJECTION & BLOW MOLDING

Principles, material used, injection molding cycle, injection molding machine, some aspects of product quality, reaction injection molding (RIM), blow molding, extrusion blow molding,

injection blow molding, stretch blow molding, blow moulding of PET, trouble shooting operations.

UNIT 3: **(4 Hours)**

THERMOFORMING

Thermoforming process: Principles, materials used, types and applications

UNIT 4: **(4 Hours)**

COMPRESSION & TRANSFER MOLDING

Compression moulding process, transfer moulding process: introduction, material used, types and applications

UNIT 5: **(6 Hours)**

MISCELLANEOUS PROCESSING METHODS

Casting and rotational moulding processes: principles, material used, types and applications
Casting, rotational moulding, machining and joining processes: principles, material used, types and applications

PRACTICAL COMPONENT **(60 Hours)**

- To prepare a polymeric sheet/ specimen by compression molding.
- To prepare polymeric specimens by transfer molding.
- Preparation of polymeric specimens/product by injection molding.
- To process a polymer using extruder and to determine the production rate & residence time
- To prepare polymer film/ membrane by solution casting method.
- To prepare thermo formed polymeric products.
- To cast various products using polyester resin/epoxy resin/latex.
- Industrial/lab visit.

ESSENTIAL/RECOMMENDED READINGS

- Strong A.B., (2005) Plastics: Materials & Processing, Prentice Hall.
- Rosato D.V., Rosato D.V., (2000) Injection Moulding Handbook, CBS Publisher.
- Morton-Jones D.H., (2007) Polymer Processing, Chapman & Hall.
- Griff A. L., (2021) Plastics Extrusion Technology, Creative Media Partners, LLC

- Gogos, C. G., & Tadmor, Z. (2013). Principles of polymer processing. John Wiley & Sons.
- Berins, M. (Ed.). (1991). Plastics engineering handbook of the society of the plastics industry. Springer Science & Business Media.

SUGGESTIVE READINGS

- Chan I. Chung, Hanser Verlag (2000) Extrusion of Polymers: Theory and Practice,
- R. J. Crawford, Rotational Molding of Plastics ABS, Research Studies Press Ltd.
- Crawford R.J., (1998) Plastic Engg, Butterworth-Heinemann.
- J.L. Throne (1987) Thermoforming Hanser Publishers.
- Rosato (1987) Blow Molding Handbook, Hanser Publishers.
- Harper, C. A., & Petrie, E. M. Plastic materials and processes: a concise encyclopedia. 2003.

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

DISCIPLINE SPECIFIC CORE COURSE – 12

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		
RECYCLING AND WASTE MANAGEMENT	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry, Mathematics**	**NIL**

Learning objectives

- To introduce the concept of life cycle analysis
- To learn about the solid waste management policies
- To learn about various sources of polymer waste generation and their management
- To understand various waste disposal and treatment methods

Learning outcomes

After studying this paper, students will be able to

- Explain the policies and legislations related to polymeric waste management and their impact on environment
- Apply the 4 R's approach (reduce, reuse, recycle, recover) for solid waste management

SYLLABUS OF DSC-12

THEORY COMPONENT-

UNIT 1: (10 Hours)

INTRODUCTION TO WASTE MANAGEMENT

Introduction to the concept of life cycle analysis, four pillars of LCA, plastic wastes and litter, social and environmental challenges of plastic waste recycling in India, Main features of Plastic waste management regulations in India, sorting techniques and classification (density - float sink and froth floatation methods, selective dissolution, optical, spectroscopic, sorting by melting temperature, triboelectric separator etc.).

UNIT 2: (6 Hours)

CLASSIFICATION OF WASTE MANAGEMENT

Thermoplastic waste management: 4 R's approach (reduce, reuse, recycle, recover), recycling classification - primary, secondary, tertiary, quaternary recycling with examples (mechanical, chemical and thermal processes)

UNIT 3: (4 Hours)

DISPOSAL AND WASTE TREATMENT TECHNIQUES

Controlled tipping, pulverization, composting, incinerators, pyrolysis, gasification, on-site disposal methods, compacting and baling

UNIT 4: (5 Hours)

THERMOPLASTIC RECYCLING

Recycling of polyolefins, PVC, PET, polystyrene, polyamides (nylon-6 and nylon-6, 6) etc.

UNIT 5: (5 Hours)

WASTE MANAGEMENT OF THERMOSET

Recycling of thermosets, reclaiming of rubber, tire retreading, uses of recycled rubber

PRACTICAL COMPONENT (60 Hours)

- Primary recycling of various waste collected from the environment.
- Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.
- To study composting of natural/biopolymers.
- Separation of polymer mixture by sink flotation technique.
- Separation of polymer mixture by selective dissolution technique.
- To recover BHET from PET by chemical recycling process
- To recover adipic acid from nylon 66 by chemical recycling technique
- To study the effect of vulcanized rubber at varying ratio (in powder form) on mechanical properties of rubber vulcanizate
- To study the effect of vulcanized rubber at varying ratio (in powder form) on thermal properties of rubber vulcanizate
- To study the effect of vulcanized rubber at varying ratio (in powder form) on physical properties of vulcanized rubber

ESSENTIAL/RECOMMENDED READINGS

- Hawkins W. L., (1984) Polymer Degradation and Stabilization, SpringerLink.
- Reich L., Stivala S. S., (1971) Elements of Polymer Degradation, McGraw-Hill.
- Niti Aayog (2021), Undp Handbook on Sustainable Urban Plastic Waste Management
- Saha N. C., Garg M., Sadhu S. D., Ghosh A. K., (2022) Food Packaging-Materials, Techniques and Environmental Issues, Springer.
- Chandra R., Adab A., (2004) Rubber and Plastic Waste: Recycling, Reuse and Future Demand, CBS Publisher.
- NIIR Board of Consultant and Engineers, (2007) Medical, Municipal and Plastic Waste Management Handbook, National Institute of Industrial Research.
- Goodship V., (2007) Introduction to plastics recycling, Rapra.

SUGGESTIVE READINGS

- Maharana, T., Negi, Y. S., & Mohanty, B. (2007). Recycling of polystyrene. Polymer-Plastics Technology and Engineering, 46(7), 729-736.
- Caillol, S. (2014). Lifecycle assessment and green chemistry: a look at innovative tools for sustainable development. Environmental Impact of Polymers, 65-89.

- Klöpffer, W. (Ed.). (2014). Background and future prospects in life cycle assessment. Springer Science & Business Media.
- Dimitris, S., & Achilias, L. (2014). Recent advances in the chemical recycling of polymers (PP, PS, LDPE, HDPE, PVC, PC, Nylon, PMMA). Mater. Recycl. Trends Perspect, 3, 64.
- La Mantia, F. (2002). Handbook of plastics recycling. iSmithers Rapra Publishing.
- Braun, D. (2002). Recycling of PVC. Progress in polymer science, 27(10), 2171-2195.
- Scheirs J., (1998) Polymer Recycling, John Wiley & Sons.
- Blow S., (2000) Handbook of Rubber Technology, Hanser Gardner.
- Bandrup J.E., (1996) Recycling and Recovery of Plastics, Hanser Gardner.

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