Bhaskaracharya College of Applied Science

B.Sc. (Honours) Polymer Science

Category I

DISCIPLINE SPECIFIC CORE COURSE – 7:

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 ADDITIVES (DSC-7-RA)	4	3	0	1	Passed Class XII with Physics, Chemistry, Maths	NIL

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows:

- To enable the students to know about need for additives in compounding of rubber
- To understand the different types of ingredients in compounding.
- To know about property modification by vulcanization
- To enrich knowledge on testing of compounded rubber

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After completing the course, the students

- Will understand concept of rubber compounding.
- Will modify the properties of rubber by incorporation of additives.
- Will develop rubber compound for required end use application.
- Will modify the strength by varying vulcanizing agents.
- Will do testing of rubber and asses quality of rubber compound.

SYLLABUS OF DSC-7

THEORY COMPONENT-

UNIT – I **(09 Hours)**

FILLERS AND PROCESSING AIDS

Fillers: Carbon black, Non carbon black, Colors and Pigments,Plasticizers, Process aids, Softeners and Extenders.

UNIT – II (9 Hours)

OTHER ADDITIVES FOR RUBBERS

Vulcanizing agents (sulphur, peroxide and metal oxide, phenolic curatives, benzoquinone derivatives, bismaleimides), accelerators (benzothiazoles, benzothiazolesulfenamide, dithiocarbamates, amines), lubricants, retarders (pre-vulcanized inhibitor), activators,

UNIT – III (06 Hours)

ANTIDEGRADATION AND MISCELLEOUS ADDITIVES

Uv stabilizers, Heat stablizers, Antioxidants, Antiozonants- Mechanism of degradation – Mechanism of ozone attack. Special purpose additives: Chemical blowing agents – Flame retardants – Antistatic agent – Abrasives -Integral bonding additives – stiffening agents. antioxidants, thermal), softners, tackifying agents, blowing agents, surface property modifiers etc.

UNIT – IV (06 Hours)

INDIVIDUAL RUBBER FORMULATIONS

Formulating for natural and synthetic rubbers and typical recipes for a few rubber products, Implications of FDA Regulations - Toxicity and environmental issues.

UNIT – V (12 Hours)

FORMULATION FOR PERFORMANCE REQUIREMENTS

Compounding to meet different Hardness requirements – Iow compression set – For damping application – Compounding to meet bonding requirements with metals and textiles– Compounding to meet processing – Economics of compounding – Cost estimation.

PRACTICAL COMPONENT- 60 Hours

- Mastication of NR on two roll mill
- Mixing of rubber compounds
- Compression moulding of rubber compounds
- Preparation of dry rubber products – play ball
- Preparation of dry rubber products – Hawaii sheet
- Preparation of dry rubber products – M.C Sheet
- Preparation of dispersions for compounding of latex
- Preparation of latex products: i. Hand Gloves ii. Balloon iii. Rubber band iv. Thread
- Compression moulding of fabric/rubber composite
- Preparation of rubber blends

ESSENTIAL/RECOMMENDED READINGS

- John S Dick, Rubber Technology- Compounding and Testing for Performance Hanser Publishers, 2001.
- C. Hepburn, Rubber Technology and Manufacturing, Butterworth-Heinemann, 2009
- Brendon Rodgers, Rubber Compounding- Chemistry and Applications, Taylor and Francies, 2016.

SUGGESTIVE READINGS

- Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
- Roger Brown, Physical Testing of Rubber, Chapman and Hall, 3rd Edition, 1996.

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

DISCIPLINE SPECIFIC CORE COURSE – 8

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		
PLASTIC ADDITIVES (DSC-8-PA)	4	3	0	1	Passed Class XII with Physics, Chemistry and Mathematics	NIL

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows:

- **To introduce the basics of polymer additives and their significance**
- **To study different additives and their representative formulations**

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

- Understand the role of various compounding additives used for plastics and rubbers
- Describe various steps & variables for mixing and blending of additives
- Utilize understanding of compounding additives and methods for modification of polymer properties

SYLLABUS OF DSC- 8

THEORY COMPONENT-

UNIT – I (12 Hours)

INTRODUCTION TO ADDITIVES AND COMPOUNDING

Importance of additives and their selection criteria for commercial polymers and technical requirements of additives, limitation of polymer additives, physical behavior of polymer additives (solubility etc.), limitation of polymer compounding, two roll mill, high speed mixer, internal batch mixer, single screw & twin screw extruders

UNIT – II (15 Hours)

ADDITIVES FOR PLASTICS

Plasticizers, theories of plasticization, types of plasticizer (phthalate, polymeric, hydrocarbon oil, vegetable oil, phosphates trimellitic etc.), methods of incorporation, fillers, introduction, classification, selection criteria (particle size, shape & geometry, packing fraction, hardness and abrasiveness, optical properties), impact of fillers on properties (mechanical properties, thermal properties, moisture content and electrical properties), Foaming agents, blowing agents, stabilizers (UV, heat, antioxidants and light), metal deactivators, Colorants (Dyes and pigments, coloring properties, classification of pigments, inorganic and organic pigments, method of incorporation (dispersion, pre mixing, agglomerate breakdown, compaction and wetting)

UNIT – III (09 Hours)

ADDITIVES FOR SPECIAL NEEDS

Flame retardants (halogen based, metal oxides, hydrated salts etc.), impact modifiers, lubricants & flow promoters, dry bonding agent and antistatic agents, conductive additives, biodegradation additives

UNIT – IV (09 Hours)

CASE STUDY

Compounding techniques with illustration of few formulations like:

- Rigid PVC pipes
- Clear bags and flexible films
- Acrylic sheet and display board
- Rubber sole
- Air water hose
- Conveyor belt

PRACTICAL COMPONENT- 30 Hours

- Determination of bulk density of fillers.
- Determination of pore size and net size of fillers.
- Determination of thermal stability of polymer stabilized by heat stabilizer.
- Measurement of flash point of a plasticizer.
- Identification of additives using chromatography.
- Determination of the plasticizer and filler content in plastic materials.
- Evaluate the bleeding and blooming properties of an additive.
- Evaluate the effect of fillers/plasticizers on the properties of a plastic/rubber.
- To prepare a PVC masterbatch.
- Identification of a pigment by spot test.
- Estimation of Iodine value of Castor oil
- Determination of DBP value and sieve analysis of Carbon black.

ESSENTIAL/RECOMMENDED READINGS

- Lutz J.T., (2001), Polymer Modifiers and Additives, Marcel Dekker.
- Zweifel H., Amos S.E., (2001) Plastics Additives Handbook, Hanser.
- Gachter R., Muller H., (1987) Plastics Additive Handbook, Hanser Publishers.

SUGGESTIVE READINGS

- Mascia L., (1974) The Role of Additives in Plastics, Edward Arnold Publishers Ltd., U.K.
- Murphy J., (2001) Additives for Plastics Handbook, Second Edition, Elsevier Advanced Technology, Oxford.
- Gerard J. F., (2001) Fillers and Filled Polymers, Wiley-VCH verlag GmbH

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

DISCIPLINE SPECIFIC CORE COURSE – 9:

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 DEGRADATION (DSC-09-PD)	**4**	**3**	**0**	**1**	**Passed Class XII with Physics, Chemistry and Mathematics**	**NIL**

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows:

- To familiarize with the utility and importance of polymer degradation
- To learn about the conditions and the reactions of degradation of polymers

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

- Explain the factors responsible for degradation
- Understand the handling of various polymers without affecting the properties
- Evaluate degradation of polymers by various methods

SYLLABUS OF DSC-9

THEORY COMPONENT-

UNIT – I (12 Hours)

CONCEPT OF DEGRADATION

Introduction to degradation, classification of degradation based on

a. Pattern of degradation:
   i. Random degradation
   ii. Side chain degradation
   iii. Chain end degradation

b. Cause of degradation (mechanism, factors affecting thermal degradation, example)

i. Thermal degradation
ii. Oxidative degradation
iii. Degradation by radiation
iv. Mechanical degradation
v. Chemical degradation
vi. Biological degradation

UNIT – II (21 Hours)

DEGRADATION OF A FEW THERMOPLASTICS

Different types of degradation patterns with mechanism of the polymers:

- Polyolefins (PE and PP)
- PVC
- Polyamides
- PMMA
- Cellulose
- Polyacrylonitrile (PAN)
- Polystyrene (PS)
- PET

UNIT – III (6 Hours)

DEGRADATION OF ELASTOMERS

i. PU **ii.** Natural rubber **iii.** SBR

UNIT – IV (6 Hours)

QUANTITATIVE AND QUALITATIVE EVALUATION OF DEGRADATION

Degradation studies using DSC, TGA

PRACTICAL COMPONENT- 30 Hours

- To study biodegradation of polymers.
- To study mechanical degradation of polymers and its effect on properties.
- To study thermal degradation of polymers under various conditions.
- To study thermal analysis of a given polymer by DSC/ TGA.
- To study photo-degradation of PVC.
- To evaluate chemical degradation of PET.
- To determine environmental stress cracking resistance of polymers.
- To evaluate chemical degradation of Nylon 66.
- To study epoxidation of Natural Rubber Latex.
- To study the effect of degradation on properties like: Mechanical strength, hardness, solubility, viscosity etc.

ESSENTIAL/RECOMMENDED READINGS

- Pesce W.J., (2007) Encyclopaedia of Polymer Science and Technology, Wiley.
- Turi E.A., (1997) Thermal Characterization of Polymeric Materials, Academic Press.
- Glaser, J. A. (2019). Biological degradation of polymers in the environment (Vol. 1, p. 13). London, UK: IntechOpen.
- Gilbert, M. (2017). Cellulose plastics. In Brydson's Plastics Materials (pp. 617-630). Butterworth-Heinemann.

- Krasowska, K., Heimowska, A., & Rutkowska, M. (2015). Environmental degradability of polyurethanes. Thermoplastic Elastomers—Synthesis and Applications; IntechOpen: London, UK, 75-94.

SUGGESTIVE READINGS

- Hamid S.H., Amin M.B., (1992) Handbook of Polymer Degradation, Marcel Dekker.
- Ehrenstein G.W., Riedel G., Trawiel P., (2004) Thermal analysis of plastics, Hanser.

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DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-1)

Credit distribution, Eligibility and Pre-requisites of the Course

COMMON POOL OF DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE) COURSES OFFERED IN ODD SEMESTERS BY THE DEPARTMENTS

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
ADVANCED ANALYTICAL TECHNIQUES (DSE-01-AAT)	**4**	**2**	**0**	**2**	**Passed 12Th with Science**	**NIL**

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows:

- **To acquaint the students with the modern instrumental techniques and their applications in characterization of polymeric materials**
- **Students will be able to determine a chemical property and identify a chemical substance in a polymer.**

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

- Interpret NMR, raman, mass and IR–spectra for characterization of molecular structure of polymeric materials