MS(R) in Polymer Science and Technology

The MS(R) programme in Polymer Science and Technology has been designed to provide a rigorous background on the theoretical as well as practical aspects of sustainable polymers. With enormous renewable feedstock available in Northeast India, the students of this programme will be in a unique position to harness this benefit and offer innovative deliverable solutions for the development and application of sustainable polymers. Additionally, this geographical advantage would also provide them an avenue to explore entrepreneurship opportunities and contribute to the development of this region.

Course Curriculum Structure

Semester 1:

Course Name	**L-T-P-C**
SP 501: Introduction to Sustainable Polymers	3-0-0-6
SP 502: Polymer Processing and Rheology	3-0-0-6
SP 503: Polymer Synthesis and Characterization	3-0-0-6
SP 511: Polymer Processing and Rheology Laboratory	0-0-3-3
SP 512: Polymer Synthesis and Characterization Laboratory	0-0-3-3
	Total Credits: 24

Semester 2:

Course Name	**L-T-P-C**
XX XXX: Elective-I	3-0-0-6
XX XXX: Elective-II	3-0-0-6
SP 697: Project - I	0-0-12-12
	Total Credits: 24

Semester 3:

Course Name	**L-T-P-C**
SP 698: Project - II	0-0-24-24
	Total Credits: 24

Semester 4:

Course Name	**L-T-P-C**
SP 699: Project - III	0-0-24-24
	Total Credits: 24

Several existing courses will be available to the students for electives, such as:

- Biomaterials: Design and Applications – ME 671
- Composite Materials – CL 630
- Molecular Simulation: Principles and Application – CL 622
- Polymer Science and Technology – CL 623
- Solid and Hazardous Waste Management – CE 525
- Bioprocess Engineering – BT 609

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Introduction to Sustainable Polymers

Course Number & Title: SP 501: Introduction to Sustainable Polymers	
L-T-P-C: 3-0-0-6	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular Letter Grades	
Kind of Proposal (New Course / Revision of Existing Course): New Course	
Offered as (Compulsory / Elective): Compulsory for MS(R) of Centre for Sustainable Polymers, elective for PhD	
Offered to: MS(R), PhD	
Offered in (Odd/ Even / Any): Odd	
Offered by (Name of Department/ Center): Centre for Sustainable Polymers	
Pre-Requisite: Nil	
Preamble / Objectives (Optional): It is well known that fossil-based polymers being non-degradable in nature are creating enormous environmental problems in terms of increasing carbon footprint, which in turn is creating significant environmental damage. Hence, there is a need to understand the fundamentals related to alternate bio-based & biodegradable polymers for multifaceted applications including commodity, engineering and medical application in a holistic manner.	
Course Content/ Syllabus: Introduction to bio-based and biodegradable plastics, and sustainability; Renewable raw materials; Synthesis of biodegradable polymers (polylactic acid, polycaprolactone, polybutylene succinate, polybutylene adipate terephthalate, polyhydroxyalkanoates etc.) and their copolymers; Polymer reaction kinetics; Biopolymers from renewable resources; Biocompatibility requirements; Structure and properties of natural biopolymers: proteins (silk, wool, hair, collagen etc.), polysaccharides (cellulose, starch, chitosan etc.); Bionanocomposites; Migration studies on bioplastics; Polymer toxicology; Structural aspects of natural fibre-reinforced polymer (FRP) composites; Design and analysis of FRP composite structures; Microplastics; Recycling, degradation, composting; Environmental/ecological economics and life cycle assessment analysis of bioplastics.	
Books (In case UG compulsory courses, please give it as "Text books" and "Reference books". Otherwise give it as "References".	
Text Books/References: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year)	
1.	M. Chanda, *Introduction to Polymer Science and Chemistry*, 2nd Ed., CRC Press, 2013.
2.	S. Dumitriu and V. Popa, *Polymeric Biomaterials: Structure and Function*, Vol. 1, CRC Press, 2013.
3.	V. Katiyar, A. Kumar and N. Mulchandani, *Advances in Sustainable Polymers: Synthesis, Fabrication and Characterization*, Springer, 2020.
4.	V. Katiyar, R. Gupta and T. Ghosh, *Advances in Sustainable Polymers: Processing and Applications*, Springer, 2019.
5.	V. Katiyar, *Sustainable Polymers for Food Packaging: An Introduction*, De Gruyter, 2020.
6.	V. Katiyar and P. Dhar, *Cellulose Nanocrystals: An Emerging Nanocellulose for Numerous Chemical Processes*, De Gruyter, 2020.
7.	V. Katiyar, *Bio-Based Plastics for Food Packaging Applications*, Smithers Rapra, 2017.
8.	V. Katiyar and T. Ghosh, *Nanotechnology in Edible Food Packaging*, Springer, 2021.

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Polymer Processing and Rheology

Course Number & Title: SP 502: Polymer Processing and Rheology	
L-T-P-C: 3-0-0-6	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular Letter Grades	
Kind of Proposal (New Course / Revision of Existing Course): New Course	
Offered as (Compulsory / Elective): Compulsory for MS(R) of Centre for Sustainable Polymers, elective for PhD	
Offered to: MS(R), PhD	
Offered in (Odd/ Even / Any): Odd	
Offered by (Name of Department/ Center): Centre for Sustainable Polymers	
Pre-Requisite: Nil	
Preamble / Objectives (Optional): Polymer processing is the conversion of polymeric materials to finished products of desired shape, size and properties. An understanding of the rheological behaviour of polymer melts is necessary for the successful processing of polymers into useful products. This course will cover the theoretical aspects of the rheology of polymers, the measurement of rheological properties, various polymer processing techniques and the significance of polymer rheology in polymer processing operations.	
Course Content/ Syllabus: Introduction: fluid properties, examples of polymeric materials and processes; Principles of rheology: stresses, strains, rate of strain, equations of fluid motion, constitutive equations, Newtonian and non-Newtonian fluids, shear thinning and shear thickening fluids, viscoelastic and time-dependent fluids; Linear viscoelasticity: Kelvin and Maxwell models, relaxation spectrum, oscillatory shear, generalized Maxwell model; Rouse and Zimm model; Tube model; Rheometry: Measurement of viscosity and normal stresses, wall slip, shear and extensional rheometry, stress relaxation, creep test; Rheology of polymeric fluids: Effect of temperature, concentration and molecular weight on polymer rheology; Molecular theories of polymer rheology; Non-Newtonian flow behaviour of polymer melts; Thermal transport; Viscoelastic behaviour in biopolymer processing; Mixing; Extrusion; Extrusion dies: sheet and film dies, annular dies, profile extrusion dies; Multilayer extrusion; Extruders: extruder types; Fibre spinning; Film blowing; Moulding and forming: Injection moulding, thermoforming; Processing of biopolymer nanocomposites.	
Books (In case UG compulsory courses, please give it as "Text books" and "Reference books". Otherwise give it as "References".	
Text Books/References: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year.)	
1.	R.P. Chhabra and J.F. Richardson, *Non-Newtonian Flow and Applied Rheology*, 2nd Ed., Elsevier, 2008.
2.	M.T. Shaw, *Introduction to Polymer Rheology*, Wiley, 2012.
3.	D.G. Baird and D.I. Collias, *Polymer Processing: Principles and Design*, 2nd Ed., Wiley, 2014.
4.	M. M. Denn, *Polymer Melt Processing: Foundations in Fluid Mechanics and Heat Transfer*, Cambridge University Press, 2014.
5.	F. Rodriguez, C. Cohen, C.K. Ober, and L.A. Archer, *Principles of Polymer Systems*, 6th Ed., CRC Press, 2015.
6.	R.B. Bird, C.F. Curtis, R.C. Armstrong and O. Hassager, *Dynamics of Polymeric Liquids*: Vol 1 and 2, Wiley, 1991.
7.	Z. Tadmor and C.G. Gogos, *Principles of Polymer Processing*, 2nd Ed., Wiley, 2006.

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Polymer Synthesis and Characterization

Course Number & Title: SP 503: Polymer Synthesis and Characterization	
L-T-P-C: 3-0-0-6	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular Letter Grades	
Kind of Proposal (New Course / Revision of Existing Course): New Course	
Offered as (Compulsory / Elective): Compulsory for MS(R) of Centre for Sustainable Polymers, elective for PhD	
Offered to: MS(R), PhD	
Offered in (Odd/ Even / Any): Odd	
Offered by (Name of Department/ Center): Centre for Sustainable Polymers	
Pre-Requisite: Nil	
Preamble / Objectives (Optional): Chemistry is at the heart of the modern polymer synthesis. Chemical synthesis will continue to play an essential role in the synthesis of sustainable/biodegradable polymers using the renewable sources. The course will cover all the modern aspects regarding the synthesis of biodegradable polymers and their characterization using various experimental techniques.	
Course Content/ Syllabus: Methods of polymer synthesis; Methods of molecular weight determination: colligative properties, osmometry, light scattering, dilute solution viscometry, size exclusion chromatography; Methods of thermal analysis; Polarimetry; Vibrational spectroscopy; NMR spectroscopy; X-ray diffraction and scattering; Optical microscopy; Electron microscopy; Measurement of mechanical properties; Interfacial properties; X-ray photoelectron spectroscopy; Electrical and dielectric properties.	
Books (In case UG compulsory courses, please give it as "Text books" and "Reference books". Otherwise give it as "References".	
Text Books/References: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year.)	
1.	R.J. Young and P.A. Lovell, *Introduction to Polymers*, 3rd Ed., CRC Press, 2011.
2	P. J. Flory, *Principles Of Polymer Chemistry*, Asian Books, 2006.
3.	M. Chanda, *Introduction to Polymer Science and Chemistry*, 2nd Ed., CRC Press, 2013.
4.	A. Kumar and R. K. Gupta, *Fundamentals of Polymer Engineering*, 3rd Ed., CRC Press, 2018.
5.	G. Odian, *Principles of Polymerization*, 4th Ed., Wiley, 2007.
6.	F. Rodriguez, C. Cohen, C.K. Ober, and L.A. Archer, *Principles of Polymer Systems*, 6th Ed., CRC Press, 2015.

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Polymer Processing and Rheology Laboratory

Course Number & Title: SP 511: Polymer Processing and Rheology Laboratory	
L-T-P-C: 0-0-3-3	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular Letter Grades	
Kind of Proposal (New Course / Revision of Existing Course): New Course	
Offered as (Compulsory / Elective): Compulsory for MS(R) of Centre for Sustainable Polymers	
Offered to: MS(R)	
Offered in (Odd/ Even / Any): Odd	
Offered by (Name of Department/ Center): Centre for Sustainable Polymers	
Pre-Requisite: Nil	
Preamble / Objectives (Optional): Polymer processing is the conversion of polymeric materials to finished products of desired shape, size and properties. An understanding of the rheological behaviour of polymer melts is necessary for the successful processing of polymers into useful products. This course will involve laboratory sessions to provide hands-on exposure to the students on polymer processing and rheology.	
Course Content/ Syllabus: Melt and solution rheology of biopolymers: Steady and dynamic shear flow rheology; Film extrusion of bioplastics; Compounding of nanocomposites; Injection moulding of bioplastics; Thermoforming; Mechanical testing: tensile and bending test of bioplastics; Heat distortion temperature and softening point; Tear testing and impact strength; Hands-on exercise on software related to polymer processing and rheology.	
Books (In case UG compulsory courses, please give it as "Text books" and "Reference books". Otherwise give it as "References".	
Text Books/References: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year)	
1.	R.P. Chhabra and J.F. Richardson, *Non-Newtonian Flow and Applied Rheology*, Elsevier, 2008.
2	M.T. Shaw, *Introduction to Polymer Rheology*, Wiley, 2011.
3.	D.G. Baird and D.I. Collias, *Polymer Processing: Principles and Design*, 2nd Edn., Wiley, 2014.
4.	F. Rodriguez, C. Cohen, C.K. Ober, and L.A. Archer, *Principles of Polymer Systems*, 6th Ed., CRC Press, 2014.
5.	Laboratory Manuals.

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Polymer Synthesis and Characterization Laboratory

Course Number & Title: SP 512: Polymer Synthesis and Characterization Laboratory	
L-T-P-C: 0-0-3-3	
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular Letter Grades	
Kind of Proposal (New Course / Revision of Existing Course): New Course	
Offered as (Compulsory / Elective): Compulsory for MS(R) of Centre for Sustainable Polymers	
Offered to: MS(R)	
Offered in (Odd/ Even / Any): Odd	
Offered by (Name of Department/ Center): Centre for Sustainable Polymers	
Pre-Requisite: Nil	
Preamble / Objectives (Optional): This course will include laboratory sessions on various polymerization methods for the synthesis of biodegradable polymers and on the characterization of polymers through various experimental techniques.	
Course Content/ Syllabus: Condensation/step-growth polymerization; Addition/chain-growth polymerization; Dilute solution viscometry; Size exclusion chromatography; Fourier-transform infrared spectroscopy; Thermogravimetric analysis; Differential scanning calorimetry; ICP-MS; Optical microscopy; Microtomy; Contact angle measurement, surface energy & surface tension; Measurement of gas/vapour transmission properties.	
Books (In case UG compulsory courses, please give it as "Text books" and "Reference books". Otherwise give it as "References".	
Text Books/References: (Format: Authors, *Book Title in Italics font,* Volume/Series, Edition Number, Publisher, Year)	
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2.	P. J. Flory, *Principles Of Polymer Chemistry*, Asian Books, 2006.
3.	M. Chanda, *Introduction to Polymer Science and Chemistry*, 2nd Ed., CRC Press, 2013.
4.	Laboratory Manuals.