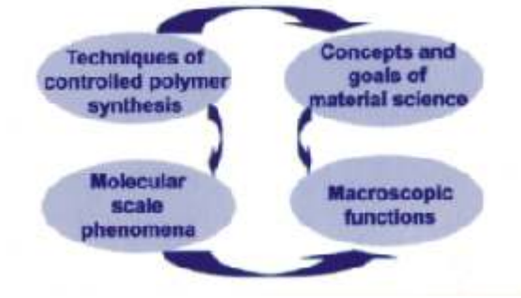
POLYMER CHEMISTRY & MATERIALS

The major theme of research in the area of Polymer Chemistry and Materials is to relate the methods of synthesis of organic macromolecules to the goals and objectives of material science. This involves synthesis of well defined macromolecular structures using several chemistries (radical, anionic, metal catalyzed polymerizations, step growth polymerizations) and study their structure, molecular and supra molecular properties with the ultimate objective of deriving structure-property relationships.



Mission & Goals

- To explore synthesis of polymers with controlled molecular structures, sequences and morphology using a diverse range of chemistries.
- To examine the solution as well as the solid state properties of polymers
- Design monomers and polymers for specific end applications

Competencies

Research competency in polymer chemistry and materials include polymer synthesis, solution characterization of polymers by GPC and light scattering, structure determination by solution and solid state NMR, thermal and dynamic mechanical analysis, study of crystallization phenomena, study of structure & morphology by X-ray diffraction, thermal analytical system and optical as well as scanning/ transmission electron microscopy.

Facilities

The group has excellent infrastructure for both synthesis and analytical characterization. The synthesis group has abilities to polymerize gaseous as well as liquid monomers and handling of cationic, metal catalyzed polymerizations, ring opening polymerizations and step growth polycondensation. In addition, the group has full complement of facilities such as GPC with multiple detectors capable of operation up to 200 C, dynamic light scattering spectrometer, thermal analytical system, XRD and dynamic mechanical analyzer. Capabilities for high and low pressure parallel synthesis of polymers are planned for the near future.

Glimpses of Current Research

Functional polymers via controlled polymer synthesis

Techniques of controlled polymer synthesis (living free radical, living anionic, group transfer and metallocene catalyzed polymerizations) has been explored for the synthesis of several functional polymers, block and graft copolymers macromonomers and hyperbranched polymers. Several functional polyolefins and ampiphilic block copolymers have been synthesized and characterized.

Synthesis of polymer nanoparticles via dispersion polymerization

Synthesis of polyurethane and polyamide nanoparticles has been accomplished by dispersion polymerization using well defined steric stabilizers synthesized using the technique of controlled polymer synthesis.

Study of environmentally degradable and durable polymers

Several approaches to environmentally degradable polymers have been explored. These include polymers derived from hydroxy carboxylic acids (lactic, 12-hydroxystearic), aliphatic polyesters and sugar grafted vinyl polymers. Methods of generating high value cellulose for thermoplastic applications derived from agricultural by-products are under investigation. Experimental methods of examining durability of polymers in applications and their stabilization have been explored. Chem. Commun. 2002, 2884

Study of structure and morphology of semicrystalline polymers

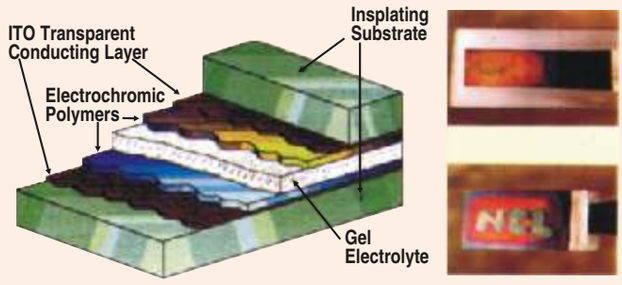
Structure and morphology define the properties of semicrystalline polymers. Several experimental tools such as, SAXS, HT WAXS, DSC and HT FTIR are used to characterize and understand the structure and morphology, The crystalline transitions in nylons and syndiotactic polystyrene (sPS) have been studied extensively using in-situ HT-WAXS and HT-FTIR measurements.

Synthesis of novel monomers

New monomers for specialty applications such as, interlayer dielectrics, alignment films for liquid crystal displays and gas separation membranes have been developed. Novel difunctional monomers starting from readily available raw materials as well as utilization of renewable resource materials for the synthesis of new monomers and polymer additives have been explored.

Functionlized conducting polymers and their applications

Chromatic effects in materials such as thermochromism, electrochromism, solvatochromism, etc., have become important for many applications, such as, thermal indicators, sensors, display devices and so forth. Conducting polymers exhibit a number of these effects which can be further sensitized for enhanced colour ranges, contrast and fast response. Dye sensitization of conducting polymer has resulted in the development of new materials having excellent properties for applications in optoelectronic devices. These polymers after incorporation of functional dyes show large changes in optical spectra when exposed to organic solvent vapours, humidity etc. which can be effectively used for optical fiber based sensors having very fast response time.



Essential parts of electrochromic device (left) and polypyrrole based devices sensors, 2002, 2 185

Tailored polymer architectures for enhanced protein ligand interactions

Binding between substrates and ligands plays an important role in various biological processes, especially, attack of influenza virus on red blood cells. Polymers containing sialic acid have been reported to bind competitively with the virus, thus, inhibiting binding to red blood cells. With a view to delineate the contribution of binding constants and steric control and enhance the binding between lysozyme and -acetyl glucosamine (NAG), a wide range of tailored polymer architectures, oligomers, and macromers, random , di and triblock polymers containing (NAG) and lysozyme imprinted polymers were synthesized. The binding constants were enhanced with increase in the number of NAG units in juxtaposition with one another and the steric control increased with increasing molecular weight of the polymer. The competitive binding experiments in presence of Biebrich scarlet show that NAG units in juxtaposition occupy the catalytically active site of lysozyme. The results provide guidelines for designing polymers to enhance protein carbohydrate interactions, which can be used in medicine and biotechnology.

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