On-Site Research Seminar Syllabus

1. Overview

<table>
<tr><td>Title</td><td colspan="3">Introduction to Polymer Chemistry</td></tr>
<tr><td>Targeted Students</td><td colspan="3">Course suitable for university students with physics/ chemistry/engineering background, who are considering graduate school</td></tr>
<tr><td rowspan="2">Prerequisites</td><td rowspan="2">College Students</td><td>Required course/Knowledge</td><td>Physics/chemistry/chemical engineering background.
An introductory level of organic chemistry would be helpful.</td></tr>
<tr><td>Recommended Materials for preparing for the course</td><td>Principles of Polymerization, 4th Edition, G. Odian, 2004, John Wiley & Sons would be a good book/e-book to have access to throughout the course.</td></tr>
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2. Program Introduction and Objectives

Course Description	**Background** Plastics have an impact on every aspect of our daily lives. The chemistry and uses of polymers and other large molecules have undergone a revolution in the last twenty years. New synthetic techniques can deliver unparalleled control in the size, shape, and properties of macromolecules. Novel applications are being developed every day including displays, drug delivery, sensors, and electronics. **Aim** The aim of this course is to provide an introduction to the field of polymer chemistry **Description** The course will introduce the fundamental aspects of polymers, how they are synthesized and characterized and will illustrate their usefulness by considering a range of applications. This course assumes a baseline knowledge of organic chemistry. By the end of the course students will be able to: • Define what a polymer is • Classify polymers based on chemistry and structure • Learn how macromolecules can be synthesized • Examine chain vs. step polymerizations with regard to reaction mechanisms and kinetics • Understand the role of tacticity and chirality in polymers • Investigate living polymerizations and block copolymers • Recognize the different methods of characterization relevant to polymer chemistry • Explore some applications of functional polymers

3. Program Schedule

Part		Lecture	Mentor Session (lab/case study, etc.)	Assignment
1	Topic	History and introduction to polymers / step-growth polymerization / polydispersity	*The first mentor session will occur one week after the first lecture*	Question subset 1
	Detail	Overview of the history of polymer chemistry and basic nomenclature, details of step-growth polymerizations and gel point equations		
2	Topic	Chain growth/addition polymerization ove rview; radical polymerization	Question subset 1 and how to read a journal article	Question subset 2
	Detail	Overview of various chain growth polymerization mechanisms and details on radical polymerization and copolymerization	The first set of problems will be worked through in this session and the second set of questions will be provided. The Mentor will discuss how to successfully digest chemical literature	
3	Topic	Cationic, anionic and group transfer polymerization	Question subset 2	Question subset 3
	Detail	Mechanistic study of cationic and anionic polymerization and variations on the above (ring opening, GTP, etc.)	The second set of problems will be worked through in this session and the third set of questions will be provided	
4	Topic	Overview of polymer tacticity and metal mediated polymerization and Supramolecular polymers	Question subset 3	Question subset 4
	Detail	Introduction to the concept of tacticity in polymers; transition metal-mediate polymerization and introduction and overview to non-covalent chemistry enabling aggregation into polymeric material	The third set of problems will be worked through in this session and the fourth set of questions will be provided	

5	Topic	Research Workshop I (check the progress of milestone goals for students)	Question subset 4 and further information on tacticity	Question subset 5
	Detail		The fourth set of problems will be worked through in this session and the fifth set of questions will be provided. The mentor will discuss polymer tacticity in greater detail.	
6	Topic	Research Workshop II (check the progress of milestone goals for students)	Question subset 5	N/A (working on final project)
	Deatil		The fifth set of problems will be worked through in this session and some advice for preparing a good presentation will be given.	
	Detail		The mentor will talk about how to give a good oral presentation and discuss the work done in the Scherman research group.	N/A (working on final project)
7	Final Oral Presentation			

Oral Project Topics:

- **Di/Triblock Copolymers**

Di/Triblock copolymers comprise of two/three homopolymers linked by a covalent bond(s). They have several industrial applications, for instance styrene-butadiene-styrene (SBS) is a thermoplastic elastomer that exhibits both elasticity and resilience. Several synthetic routes are possible to make block copolymers but some are more industrially relevant than others. Discuss the synthetic methods used to prepare block copolymers in industry and give some specific examples block copolymers, their chemical structure, and their uses.

- **Renewable/Sustainable Polymers**

Sustainable polymers can be harvested from organic matter. For instance, cellulose can be prepared from grass fibers. Several extraction and processing protocols exist for different sustainable polymers. Discuss a range of bio-derived polymers specifically regarding their chemical composition, extraction methodology and some examples of how they are formulated for practical use. Compare and contrast your selected polymers with one another.

- **Condensation polymers**

Condensation polymers are useful for several applications. Research what the five most important condensation polymers produced worldwide today are based on their production volume and state what their chemical structures are and what their major uses are. Examine which companies are making these polymers and consider which companies using the same polymers for different applications

- **Depolymerisation strategies**

Depolymerisation strategies are of significant interest in the current climate due to their potential applications for the recyclability of polymeric materials. Industrially, polymer chains are often end-capped with another monomer to stop depoolymerisation occurring by heat or UV exposure however, as we're trying to move away from single use plastic and into closed-loop recycling, depolymerisation will only grow in importance. Consider and discuss which polymeric structures can be readily depolymerised from household plastics and commodity materials and also how new technology (for instance the inclusion of specific functional groups) may allow for triggered depolymerisation.

- **Branched polymers**

Polyethylene (PE) is the most commonly used plastic in use today. It’s properties vary widely based on the branching density and molecular weight of the chains from tough ultra-high-molecular-weight polyethylene (UHMWPE) to the flexible Low-density polyethylene (LDPE) used in plastic bags. Discuss the different catalysts used to prepare PE and the varying properties and uses of PE at different chain lengths and branching densities.

- **Polymeric micelles/ Polymersomes**

Polymersomes are synthetic vesicles in the size range of 50 nm to several microns. They have several promising biotechnology applications including their potential use as drug delivery vehicles. Discuss the polymeric structures that have been used to prepare micelles and vesicles with regards to how they are synthesized and the resulting morphology of the micelles (spherical, vesicular worm-like etc.) and the exciting potential applications of these structures.

- **Adhesives**

also known as glues, adhesives have been used by humans for more than 200,000 years. Reactive adhesives, specifically use chemical crosslinking to harden over time. In ‘one-part’ glues an environmental trigger must be used to kick-start the curing process, for instance UV, heat, air or moisture. Research several methods for the activation of one-part glues and discuss the chemistry involved and the applications that his makes each adhesives most suited for. For instance, contact with moisture in the air allows cyanoacrylate (CA) glues to begin polymerising in situ – the basis of most ‘super-glues’.