The Importance of Teaching Polymer Chemistry in College Chemistry Classes

LIBERTY UNIVERSITY

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Background

Introduction

Polymers are large molecules composed of repeating subunits. They have a wide range of properties such as flexibility, strength, durability, and heat resistance. [1] Properties can be tailored by adjusting the molecular structure and processing conditions. Polymer chemistry has real world applications and plays a fundamental role in various aspects of daily life such as clothing, plastic bags, food preparation, rubber, development of new materials, and drug delivery. [2] As shown in Figure 3, the polymer market is expected to have an annual growth rate of 5.4% from 2023-2032. [3] There are natural polymers that are isolated by mankind such as starches, wool, silk, and rubber. But there are also synthetic polymers which are created through chemical processes, included among these are nylon, low density polyethylene, and silicone. Polymer chemistry focusses on the synthesis, properties, and structure of polymers. Polymers are unique in their diversity of use and their ability to be applied to different concepts within foundational chemistry courses. [4] Teaching polymer chemistry at an undergraduate level is important because 50% of chemists work with polymers at some point during their career. [5] The American Chemical Society requires undergraduate chemistry programs to include polymer science within foundational courses or as a separate course. [6]

Biblical Connection

Intermolecular forces hold polymers together, through bonding and is essential to the structural integrity and functionality of polymers as seen in Figure 3. Similarly, God is the intermolecular force that brings people together through love, faith and community. Ephesians 4: 13 says that we are united through faith in God. God's children are like polymers, bonded through a force stronger than themselves.

Research Question

This study will investigate the importance of polymer chemistry in undergraduate chemistry classes and proposes the implementation of 1-2 polymer lab experiments, suitable for an undergraduate chemistry labs, tailored to Liberty University

Methods

Background Research

An initial preliminary search of polymers produced a total of 446 articles using the keyword *polymer* as shown in Figure 1. A more in-depth investigation found a total of 16 relevant articles about polymer chemistry at an undergraduate level, shown in Figure 4.

Experiment Research

Polymer experiments were limited to publication date between 2010 to today. A total of 40 experiments were found and categorized based on topic as shown in Figure 5.

Funneling of Research

The selection was further funneled by the amount of time the experiment is estimated to take. Any experiment that required more than one laboratory period was eliminated. One laboratory is defined as 3 hours, and is easier to implement within a course compared to several lab sessions. Additionally, any experiment that required the use of an H-NMR was eliminated as Liberty University does not have one. Next, cost and interdisciplinary concepts were analyzed, and experiments were narrowed to under $350 per lab and contains at least 2 or 3 interdisciplinary concepts.

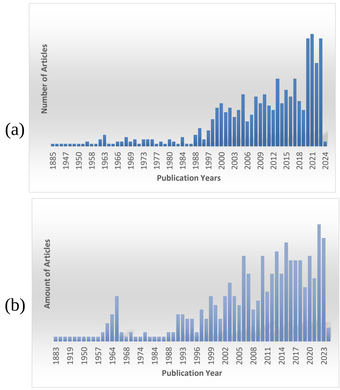


Figure 1. SciFinder results (a) total 452 references from the search of polymer chemistry in college chemistry classes with the filters polymer and laboratory. Scifinder search (b) had a total of 742 articles from search of polymer chemistry at the undergraduate level with the filter's polymer and college

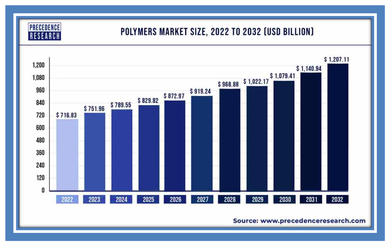


Figure 2. Precedence Research [3] found that polymer market totaled 716.83 billion in 2022 and is projected to be 1,207 billion by 2032. That is an annual growth rate of 5.4% from 2022-2032.

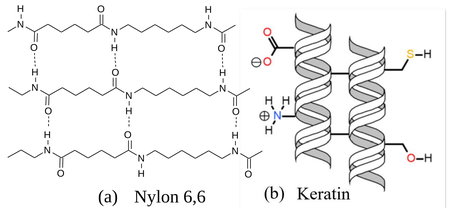


Figure 3. Polyamides nylon 6.6 (a) and wool (b) are examples of natural vs synthetic polymers. They serve as a reminder of the functionality and complexity of God-created polymers. Picture of keratin was taken from [7].

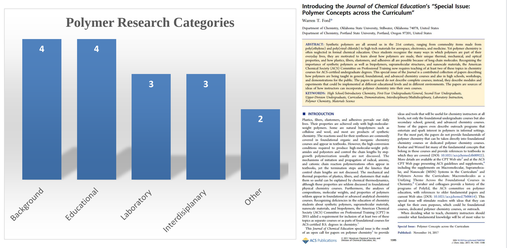


Figure 4. Preliminary research produced 16 relevant articles that were separated into 5 categories. Research of one of the main articles was done in the United States which has 29% evangelicals. Image shown is an example of one of the articles found [5].

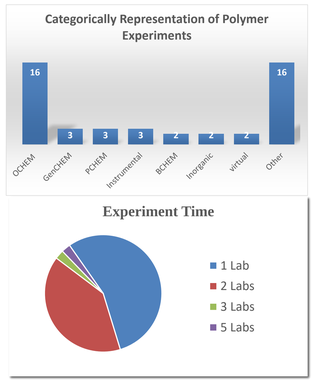


Figure 5. Graphs depict the 40 polymer experiments found by class and amount of time the experiment takes.

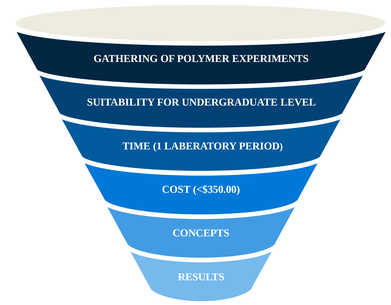
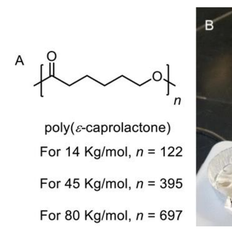


Figure 6. Funnel depicts the process of finding a suitable polymer experiment for the undergraduate level with a focus on cost, time, and interdisciplinary concepts.



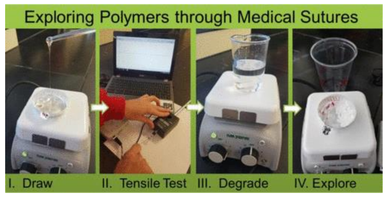


Figure 7. Image is taken from [8]. This lab explores polymeric medical sutures and explores polymers from a medical standpoint.

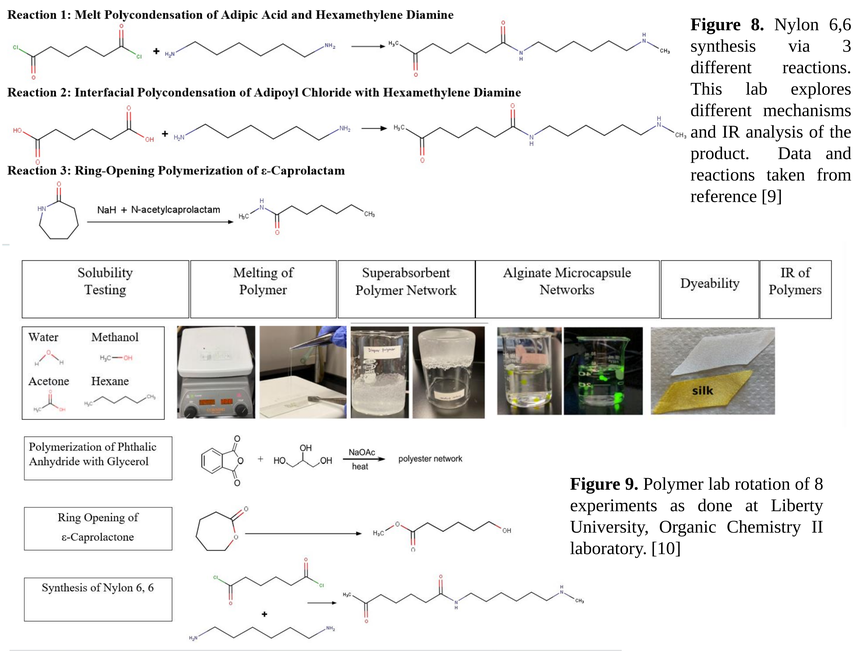


Figure 8. Nylon 6,6 synthesis via 3 different reactions. This lab explores different mechanisms and IR analysis of the product. Data and reactions taken from reference [9]

Figure 9. Polymer lab rotation of 8 experiments as done at Liberty University, Organic Chemistry II laboratory. [10]

Results and Conclusions

The research and selection of a suitable experiment produced three suitable options for undergraduate organic chemistry class as shown in Figures 7, 8, and 9.

- **Experiment 1** consists of the creation of medical sutures through the melting of poly(ε-caprolactone). This lab draws threads, tests the strength of the suture along with commercial sutures, and explores the degradation of polymers. The lab is only requiring 2-3 hours to complete [9] and would cost roughly $350. The interdisciplinary concepts it teaches is melting point, degradation, functional groups and polymers. This lab would be most suitable for the organic chemistry laboratory because the class has a majority of pre-med students.
- **Experiment 2** consists of three reactions to synthesis the polyamide Nylon 6, 6. The reactions are ones that are discussed in organic chemistry lecture and therefore applicable to the class. Some of the interdisciplinary concepts include melt condensation, polymerization, ring opening reactions, and functional groups. The cost of this lab would be roughly $250.00.
- **Experiment 3** is a relatively inexpensive polymer lab rotation done at Liberty University. It consists of 9 experiments all done within one lab period or can be broken up and performed during the down time of other labs. The rotations include IR of polymers, solubility, absorption, dyeability, melting, and three different polymer reactions.

Future Work

This research will lead to the implementation of more polymer labs within undergraduate chemistry classes. And potentially the creation of more polymer experiments. Including the possibility of publishing Liberty University's polymer rotation lab. [10]

References and Acknowledgments

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