Chapter 10
The Importance of Polymers in Medicine and Their FTIR and Raman Spectroscopic Investigations

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ABSTRACT

Polymers are macromolecules with a very high molecular weight that are formed as a result of one or more small molecules bonding to each other, typically by covalent bonds. The concept of macromolecules consisting of many repeating units are published in the article titled "Uber Polymerization," which was first published in 1920 by Hermann Staudinger. The idea of polymers, which have been in our lives for a long time, has thus become an important field of study. Polymers are commonly used in tissue engineering because of their properties such as biocompatibility and biodegradability. In addition, polymers have a wide range of applications in tissue regeneration, drug delivery, and wound healing. Polymers have varying structural properties based on their backbone structure, molecular weight, and crystallinity. For this cause, a great deal of study in the medicine has been based on this category of materials. This work focuses on the importance of polymers in the medicine, 3D printed polymer composites and Fourier transform infrared, and Raman spectroscopic investigations of polymeric structures.

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THE EMERGENCE OF THE POLYMER CONCEPT

The concept of macromolecule consisting of large number of repeating units was first introduced by Hermann Staudinger in an article entitled "On Polymerization" in 1920 (Schubert et al., 2020). In this article, several reactions that produced high molecular weight molecules from repeating covalently bonded units, and called polymerization, were shown. At the end of 1920, Staudinger confirmed that molecular weights were unchanged during the polymerization process, by giving additional evidence based on viscosity measurements. However, despite his substantial empirical evidence, Staudinger had to face criticism from leading organic chemists for nearly twenty years. One of them was Heinrich Wieland, the winner of the 1927 Nobel Prize in Chemistry, wrote that Staudinger should give up the idea of large molecules because organic molecules that have molecular weights higher than 5000 could not exist. The first real breakthrough in industrial production came with the phenolic resin Bakelite, the first synthetic polymer discovered by Leo Hendrik Baekeland (1863–1944) in 1908. No other material is as versatile as polymeric materials, for example, they can be hard, soft or elastic, permeable or impermeable, transparent or opaque. Due to their versatile properties, polymers have large applications in packaging, toys, furniture and fabrics industry, circuit boards, composites for spaceships. Moreover, synthetic polymers have also medical applications in absorbable sutures and implant materials (Mulhaupt, 1999).

Polymer chemistry and physics have become an important research area, and polymers used in many areas have made great progress economically. (Schubert et al., 2020).

NATURAL AND SYNTHETIC BIOMEDICAL POLYMERS

Biomedical polymers are either naturally occurring polymers or synthetic polymers.

Proteins, polysaccharides and nucleic acids are natural polymers (Donnaloja et al., 2020).

Collagen is found in the bones, muscles, skin, and tendons. It is the single most abundant protein in animals. Although, in molecular level, twenty-eight collagen types have been characterized, over 90% of the collagen in the human body is type I collagen (Lodish et al., 2000; Ricard-Blum, 2011).

Another remarkable natural fibrous protein is silk fibroin, obtained from cocoons of silkworm's larvae. It has a unique hierarchical structure and due to this structural property, it has strong mechanical strength and notable biocompatibility. Moreover, silk fibroin is frequently employed as biomaterials for medical purposes due to its tunable biodegradation and slightly aqueous processing capabilities (Nguyen et al., 2019). Silk fibroin is composed of glycine, alanine and serine amino acids that found in other natural biomaterials (Zhang et al., 2019).

Chitosan is a linear polysaccharide obtained from chitin and found in abundance after cellulose. Chitosan offers significant opportunities for the development of biomedical applications (Ibrahim et al., 2015).

Alginate is a natural unbranched anionic polymer, composed of two uronic acid blocks (guluronic acid and mannuronic acid block units). It is extensively used for many biomedical applications for biocompatibility, low toxicity properties, and being relatively low cost (Lee and Mooney, 2012). It shows natural biological affinity for a variety of enzymes (Jain et al., 2006).

Hyaluronic acid (or hyaluronan) is the simplest glycosaminoglycan (a class of negatively charged polysaccharides) found in various tissues and fluids throughout the body and binds to specific cell surface receptors (Hench et al., 2005).

Cellulose is a polysaccharide (Sun et al., 2016; Gupta et al., 2019).