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A Review on Polymer

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ABSTRACT: An "abstract polymer" refers to a mathematical model used to represent complex systems, particularly those involving interactions and constraints, where the "polymers" are abstract objects rather than specific chemical structures. These models are often used in areas like approximation algorithms and statistical physics to study properties like partition functions and critical behavior.

The study of electric transport in polymeric material has gained significant interest in recent years. This is due to the promising potential of these materials for solid-state devices, as well as their contribution to the broader field of polymer physics. In this paper, a theoretical analysis is presented to explore the classification, properties, advantages, disadvantages, and applications of polymers. Polymers are essential components in all dosage forms as additives. They have a significant impact on drug release and must exhibit compatibility, non-toxicity, stability, cost-effectiveness, and other factors. A diverse selection of polymers is accessible and they possess the additional benefit of being adjustable in a broad spectrum of physical, chemical, and biological characteristics to align with the demands of particular applications. The primary function of a polymer is to shield the drug from the physiological environment and extend the drug release to enhance its stability. Drug release from the polymer occurs through diffusion, degradation, and swelling.

KEYWORDS: Polymer, Properties, Electric, Environment.

I. INTRODUCTION

A polymer is a large molecule, sometimes referred to as a macromolecule, composed of several subunits that are repeated. Both natural and synthetic polymers have a wide range of qualities that make them indispensable and commonplace in daily life. Natural biopolymers like DNA and protein which are essential to biological structure and function are examples of polymers. Synthetic polymers like polystyrene are also included in the category of polymer. Numerous tiny molecules known as monomers are polymerized to form polymers both natural and manufactured. Due to their larger molecular mass than small molecule compounds they have physical characteristics such as toughness, and viscoelasticity to form semi-crystalline structures rather than crystals.

Jons Jacob Berzelius first used the term in 1833 but he did so under a different definition from the one that the IUPAC uses today. Hermann Staudinger first presented the contemporary theory that polymers are covalently bound macromolecular structures in 1920. Throughout the following ten years, he conducted experiments to support this theory.¹

Polymers were first used by humans in a variety of naturally occurring forms such as wood, cotton, cellulose, starch, etc. The majority of synthetic polymers are relatively new. They debuted slightly after the radio and airplane. Giant complex compounds known as polymers differ significantly from low molecular weight substances such as regular salt. Other kinds of good materials include polymers. An essential tool for comprehending the physical properties of the polymer is the optical absorption spectrum. Polymers are a broad class of materials made up of many small molecules called monomers that can be linked to form long chains and are therefore called macromolecules. People have been

developing flexible polymers in the form of oil, tar, resin, etc. However, it was not until the Industrial Revolution that the modern polymer industry emerged and started developing. In the late 1830s, Charles Goodyear flourished in producing a useful form of natural rubber undergoes a process called “Vulcanization”.²

II. HISTORY

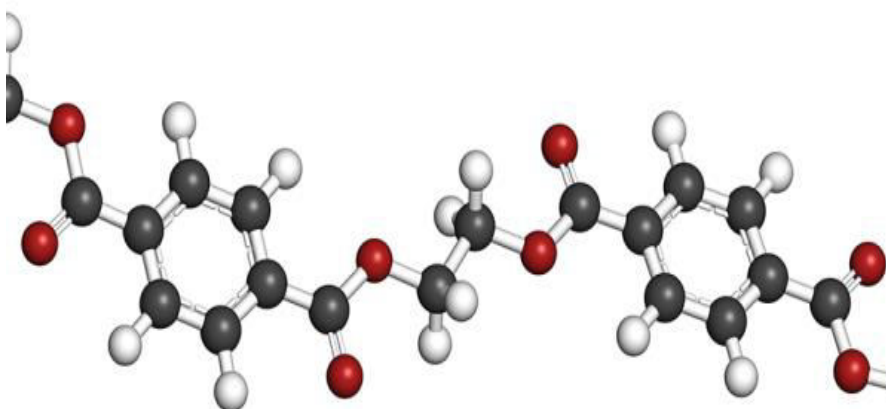
Henri Braconnot began his groundbreaking work in derivative cellulose compound in 1811; this work is arguably the first significant contribution to polymer science. Rubber a natural polymer become more durable with the development of vulcanization later in the 19th century making it the first semi synthetic polymer to gain widespread use. Leo Bakeland reacted phenol and formaldehyde at precisely regulated temperature and pressure in 1907 to produce Bakelite the first fully synthetic polymer. Then in 1909 Bakelite was made available to the public.³

For ages, people have used synthetic organic polymer in the form of shellac and wax. The “cellulose” plant polymer gives natural fibers and ropes their structural strength. By the early 1800s, natural rubber (tapped from rubber tree) was widely used as a medicine granule and polymer.⁴

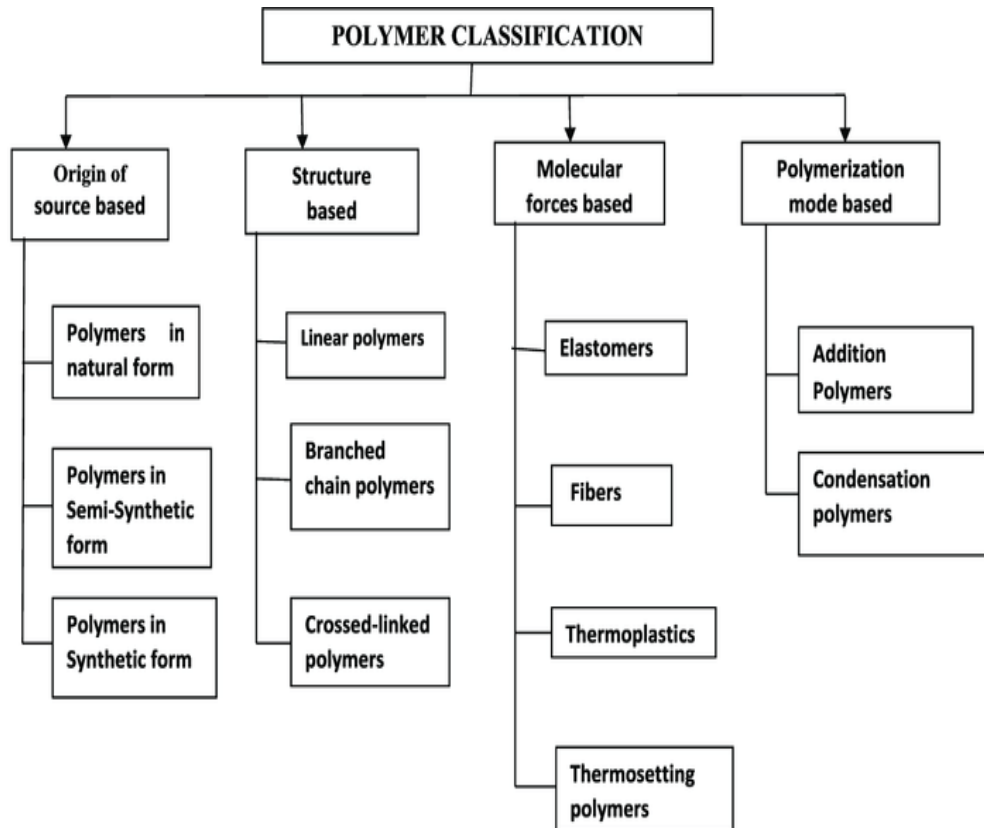
Goodyear’s vulcanized rubber outperformed untreated natural rubber in several key areas including strength, abrasion resistance, flexibility, temperature sensitivity, gas impermeability and chemical and electric current resistance. ⁵

Frank Davis and Abraham Abuchowski discovered the possibility of conjugating poly (ethylene glycol) (PEG) to proteins approximately 10 years later, leading to the development of a process known as PEGylation. PEGylation is the process by which poly(ethylene glycol) polymer chain forms a covalent link with another molecule, typically a therapeutic protein or medication.⁶

The first synthetic polymer drug combination (shown in fig b) intended for cancer treatment underwent clinical testing in 1994. It was based on doxorubicin as an HPMA (N- (2hydroxypropyl) meth acrylamide) copolymer conjugate. By trapping the medication or covalently attaching to it, block copolymer micelles can also be used to create targeted release of anticancer medicine.⁷



III. CLASSIFICATION OF POLYMER



1) Based on source

→ Natural Polymers

Natural polymers are those which are derived from either plants or animals. We refer to them as animal and plant polymer.

Ex : Cellulose, Jute, Silk, Wool, RNA, DNA, Natural rubber.

→ Semisynthetic Polymers

Semisynthetic fibers are polymers made from natural fibers that have gone through chemical processing to enhance certain physical characteristics, like as tensile strength and lustrus nature.

Ex : Cupra ammonium silk, Viscous rayon.

→ Synthetic Polymers

Synthetic fibers are produced in lab through the polymerization of basic chemical components.

Ex : Nylon, Orion, Polystyrene, PVC, Teflon.

2) Based on structure

→ Linear polymers

In these polymer, monomers are interconnected to form an elongated, linear structure. These chains do not possess any additional branches or side chains.

Ex : Polyester, Polyethene

→ Branched Polymers

The straight long chain of molecules is accompanied by various side chain. Due to their irregular packing these molecules exhibit low density, tensile strength and melting point.

Ex : Polypropylene, Amylopectin, Glycogen

→ Crosslinked Polymers

The monomeric units are interconnected to form a three-dimensional framework in which cross link play a crucial role. These cross link contribute to the hardness, rigidity and brittleness of the network structure.

Ex : Bakelite, Formaldehyde resin, Vulcanized rubber

1) Based on molecular force**→ Elastomer**

These polymers are characterized by polymer chains being held together by the weakest attractive force. They consist of randomly coiled molecular chains with minimal cross links. When a strain is applied, the polymer stretches and upon release of the force, it return to its original position. Such polymers exhibit elasticity and are commonly referred to as elastomers.

Ex : Silicone, Natural rubber

→ Fibers

They possess a strong intermolecular attractive force similar to hydrogen bonding. Additionally, they exhibit remarkable tensile strength making them highly valuable in the textile industries.

Ex : Nylon-66, Terlyene

→ Thermoplastic Polymers

Polymers with intermolecular force between elastomer and fibers can be easily shaped by heating and then cooling at room temperature. These polymers may have a linear or branched chain structure.

Ex : Acrylic, Polypropylene

→ Thermosetting Polymer

This polymer exhibit high hardness and remain non melting when exposed to heat. They do not soften when subjected to pressure and cannot be reshaped. Due to their cross-linked structure these polymers are not recyclable.

Ex : Melamine, Silicone, Polyurea

2) Based on Polymerization Addition Polymer**Based on Polymerization Addition Polymer**

Addition polymers are formed by repeatedly adding monomers without removing any byproducts. As a result these polymers consist of all the atom from the monomers making them a multiple of the monomer unit.

Ex : Orion, Teflon

There are two types of addition polymer:

1. Homopolymer

The formation of addition polymers due to the polymerization of single polymeric species is called homopolymer.

2. Copolymer

The formation of addition polymer which occur due to addition polymerization from two different monomer is called a copolymer.

Condensation Polymer

The formation of these compounds occur through the combination of two monomers resulting in the elimination of small molecules such as water, alcohol, or NH₃. Ester and amide linkage are present in their molecular mass does not correspond to an integral multiple of monomer units.⁸

Ex : Polyamide, Polyurethane

IV. PROPERTIES OF POLYMER

1. Chemical Property

The properties of polymer are greatly influenced by the attractive force between its chain. Due to the long length of polymer chain, these interchain forces are significantly stronger compared to the attraction between regular molecules. The intermolecular force in polymer can be influenced by the presence of dipole in the monomer units. Polymers that contain amide or carbonyl group have the ability to form hydrogen bond between neighboring chains. In this bonding the partially positively charged hydrogen atom in N-H groups are strongly attracted to the partially negatively charged oxygen atom in C=O group on other chain.⁹

2. Mechanical Property

The properties of a polymer that are of almost important are its bulk properties. These properties determine the behavior of the polymer on a large scale. The tensile strength of a material measures the amount of stress it can withstand before undergoing permanent deformation.¹⁰

3. Transport Property

The diffusivity of molecules within a polymer matrix is crucial for various application involving films and membranes. In the context of polymer the term melting point signifies a shift from a crystalline or semicrystalline phase to a solid amorphous phase rather than a solid liquid phase transition.¹¹

4. Elasticity

In the case of most elastic materials like the metals utilized in springs the elastic response is a result of bond distortion. When a force is exerted the bond length deviate from their equilibrium state which corresponds to the minimum energy level and electrostatic strain energy is accumulated.¹²

V. TYPES OF POLYMERS

► Natural Polymers

Natural polymers vary significantly by source. In their natural state there can be many variants within a nomenclature that are closely related but can be differentiated by small properties and chemical identifiers. Some of the natural polymers are listed below :

1. Cellulose in Paper and Tress

Cellulose in the cell walls of fibrous growth is a toughening agent that gives cell bulk and allows them to contribute to building tall and strong structure in plants. Various types of cellulose are differentiated by the plant source. Once extracted and refined the raw material loses much of its variety and can be treated as a uniform material.

2. Starches in Plants such as Potatoes and Maize

Starches are abundant biopolymeric material. They are used in plants to store energy in a water stable form consisting of alpha glucose polymers. Natural starches show poor strength and thermal stability. When extracted and purified starches can be used as organic feedstock to manufacture bio sourced polymers such as polylactic acid (PLA). They can also be used as feedstock for industrial alcohol production which can then be used in the manufacture of alcohol based polymers such as polyvinyl alcohol and PVA.

3. Silk from Insects

Silk from the silkworm has long been known as a strong material. It is now understood to be made from two proteins: sericin and fibroin. Spider silk is similar constructed from alanine and glycine. It is impossible to harvest in useful quantities but the synthesis of similar material from plant source matter is suggesting the development of bulk polymer that may be applicable to single use plastic application.

► Synthetic Polymers

Synthetic polymers are materials that are engineered for particular properties and industrially polymerized from synthesized and natural monomers. The polymerization can require high pressure and temperature, catalysts, energetic reaction and large industrial plants in many cases.

Listed below are some examples of synthetic polymers :

1. Nylon

Nylons vary in the manufacturing method , molecular weight and precise monomer class but they are all polymer chains constructed from polyamide. They are tough and chemically resilient engineering polymers with relatively poor cosmetics and a slippery , low energy surface. Most nylon is manufactured as fibers for clothing , ropes and webbing.

2. Polyethylene

Polyethylene like the nylons are differentiated by molecular weight. The difference are generally related to the degree and complexity of side branching in the chains. The monomer is solely ethylene gas. Polythenes range from soft low density material to UHMW (Ultra high molecular weight) engineering grades. Polythene is used for food containers , pipes and engineering parts.

3. Silicone

Silicone rubbers are mostly made as two-part thermoset polymer that undergo a catalytic reaction when mixed. The resultant materials are generally elastomers with low to moderate tear resilience but high compressive strength. They are capable of withstanding high temperatures up to 300 C.

VI. ADVANTAGES AND DISADVANTAGES OF POLYMERS

ADVANTAGES OF POLYMERS

1. Easy and well understood processing method.
2. Localised delivery of drug.
3. Sustained delivery of drug.
4. Decrease in dosing frequency.
5. Reduce side effects.
6. Improve patient compliance.
7. Biodegradable and Biocompatible.

DISADVANTAGES OF POLYMERS

1. Low tensile strength.
2. Ductility and plasticity under load.
3. Thermal sensitivity.
4. Inferior mechanical characteristics.
5. Elevated drug release shortly after intake.
6. Displaying dose dumping phenomenon.¹³

VII. CONCLUSION

Polymers have become indispensable in various sectors and have brought about a significant transformation in the field of materials science. Continuous exploration and advancement in polymer technology are crucial in tackling worldwide issues and promoting sustainable methodologies. Through the utilization of polymers' distinctive

characteristics, we can persistently develop groundbreaking remedies that contribute to the betterment of both society and the natural world. Nature has utilized biological polymers as the preferred material, and similarly, humans will opt for polymeric materials as their material of choice. Advancing from the Stone Age to the Age of Polymers, synthetic polymers have become and will continue to be the favored material. The increasing applications of polymeric materials have led to a significant demand for individuals with specialized training in polymer science and engineering. Those who pursue a career in this field can anticipate both financial gain and personal satisfaction.

Polymer-based pharmaceuticals are becoming recognized as essential components in the treatment of various lifethreatening diseases like cancer or hepatitis that impact a large number of individuals. While excipients have traditionally been added to formulations as inactive substances to primarily increase volume and aid in the

manufacturing process, they are now being incorporated into dosage forms to serve specific functions for enhanced drug delivery due to the unfavorable physicochemical and pharmacokinetic properties of many new drugs. Synthetic polymers can be tailored or adjusted to meet the needs of the formulation by modifying polymer characteristics, while natural pharmaceutical excipients are biocompatible, non-toxic, environmentally friendly, and cost-effective. Numerous polymers have already proven successful as excipients in the development of dosage forms for efficient drug delivery, with ongoing research into additional options.

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