Research Journal of Medical Sciences
[E-ISSN: 3078-2481 | P-ISSN: 3078-2473]
Available on: https://rjmsonline.com/
Volume: 06 | Issue: 01, 2024

Research Article *Open Access*

POLYMER AND APPLICATIONS:A REVIEW

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Source of support: Nil.
Conflict of interest: None

Received: 04-04-2024
Accepted: 10-05-2024
Available online: 11-06-2024

Abstract

Polymers are a broad class of materials made up of several tiny molecules. Cotton, wool, rubber, Teflon(tm), and all plastics are polymers that are employed in almost every industry. Many biological, synthetic, and hybrid polymers are used in medicinal applications. A variety of polymers are available, and they have the added benefit of being adjustable in physical, chemical, and biological properties to meet the needs of certain applications. Polymeric delivery systems are designed primarily for regulated or sustained medication delivery. Polysaccharides have also been used to target medications to the colon following oral delivery. Polymeric materials have a great deal of potential for interesting new uses in the near future. Polymer applications are being explored in a wide range of fields. Nanotechnology provides a broad platform for innovation and diversity; nanocosmeceuticals have grown exponentially. Nanocosmeceuticals such as nanogels, nanoemulsions, liposomes, niosomes, solid lipid nanoparticles, and others have become popular due to their targeted distribution of active ingredients, customization in form, size, and colour, penetration into the skin, controlled release delivery of actives, and other benefits. This study provides a quick summary of the introduction, polymer kinds, qualities, and advances of polymers in medicine in general, focusing on initially stable polymers, then polymers with degradability as a primary biological function, and finally numerous other functional and responsive polymers.

Key Words: *Polymers, biological, synthetic, and hybrid polymers.*

INTRODUCTION

Polymers and polymeric materials have played an essential role in the development of innovative gadgets, paving the way for the replacement of obsolete materials. The twentieth century saw an explosion of activity in this field. As a result, new disciplines such as molecular electronics, conducting polymers (including synthetic metals), organic semiconductors, and plastic electronics have emerged. Polymers are attracting the attention of the scientific and technological communities due to their diverse range of uses in industrial, pharmaceutical, and medical domains, among others [1]. Polymer is derived from the Greek words poly=many and mers=parts or units of high molecular mass, each molecule consisting of a huge number of discrete structural components linked together in a systematic manner.In other terms, polymers are huge molecules with a high molecular weight, known as macromolecules, that are formed by joining together a large number of tiny molecules, known as monomers. Polymerization is the process through which monomers combine to produce polymers [2]. Polymerization is a chemical reaction that occurs when two or more compounds combine with or without the introduction of anything such as water, heat, or other solvents to form a molecule with a high molecular weight. The finished result is known as a polymer, and the beginning material is known as a monomer. Polymers have appealing qualities such as light weight, good mechanical and optical capabilities, and particular electrical properties, among others.Some polymers will nearly always match our requirements for desired features such as chemical resistance, amenability for quick and mass production, and fabrication into complicated shapes in a wide range of colours. Polymers can be used to create strong solid products, flexible rubber-like masses, soft and resilient foams, smooth and fine fibres, clean and clear glass-like sheets, swollen, jelly-like food materials, and other materials. They can be utilised to connect items, seal joints, fill voids, beat weights, and even power space vehicles and even replace human organs [3].Starch is a basic food group carbohydrate that can be found in cereal grains and potatoes. Because it is a polymer of the monosaccharide glucose, it is also known as a polysaccharide. Starch molecules are composed of two forms of glucose polymers, amylose and amylopectin, with the latter constituting the majority of the starch component in most plants, accounting for around three-fourths of the total starch in wheat flour. Amylase is a straight chain polymer that contains approximately 200 glucose units per molecule [4].

HISTORY

Henri Braconnot began pioneering work with derivative cellulose compounds in 1811, possibly the oldest significant effort in polymer research. Later in the nineteenth century, vulcanization increased the durability of natural polymer rubber, making it the first widely used semi-synthetic polymer. Bakelite, the first totally synthetic polymer, was produced in 1907 by Leo Baekeland by mixing phenol and formaldehyde at precisely controlled temperature and pressure [5]. Bakelite was the first synthetic polymer manufactured in 1909, and it was quickly followed by rayon, a synthetic fibre invented in 1911. The systematic study of polymer science began only approximately a century ago, with Herman Staudinger's pioneering work. Staudinger has defined polymer in a new way. He was the first to propose the idea that high molecular mass compounds were made up of lengthy covalently bound molecules in 1919. The first synthetic polymerdrug conjugate (as depicted in figure 1b) meant to treat cancer was clinically tested in 1994. It was a doxorubicin HPMA (N(2hydroxypropyl) methacrylamide) copolymer conjugate. Anticancer medicines can also be released selectively utilising block copolymer micelles, which can entrap or covalently link to the medication. PEG interferon (an antiviral drug intended to treat chronic hepatitis C and hepatitis B) and PEGGCSF (PEG granulocyte colonystimulating factor) were placed on the market in the 2000s, and five years later the first therapeutic nanoparticles (albuminentrapped paclitaxel) was approved as a treatment for hepatitis C.All of the preceding accomplishments and research were critical in the creation of polymerbased pharmaceuticals, specifically polymeric medications, polymerdrug conjugates, and polymerprotein conjugates. Clinical testing of these new technologies eventually lead to the resolution of many other unforeseen issues that arose, such as the industrial scale manufacture of polymers and the speedy and total solubilization of medications for safe inoculation. These clinical tests are still being optimised (in terms of dosage and frequency) for a wide range of products [6].

CLASSIFICATION OF POLYMERS

Polymers can be categorised in a variety of ways. The most obvious distinction is dependent on the polymer's origin, i.e., natural versus synthetic [7]. Enzymes are responsible for all of the conversion activities that occur in our bodies. Polymers of biological origin include enzymes, nucleic acids, and proteins. In contrast to starch, which is a staple diet in most cultures, cellulose and natural rubber are examples of polymers of plant origin with considerably simpler structures than enzymes or proteins. There are many different types of synthetic polymers, including fibres, elastomers, plastics, adhesives, and so on. Polymers are classed as thermoplastics or thermosettings based on how the polymer chains are bonded together in the solid. The bonds between polymer chains in thermoplastics are weak secondary bonds. When heated, their flexibility increases, resulting in plastic flow. The substance softens and, eventually, dissolves. The melting point of thermoplastics is in the hundreds of degrees Celsius range. The fundamental advantage of thermoplastics is that they can be re-melted and re-molded, allowing them to be recycled, as illustrated in figure 1. Polyethylene, polypropylene, polyvinylchloride, nylon, and other thermoplastics are examples. Thermosetting polymers are those in which a single unit links numerous branches in more than one direction. A three-dimensional network of main covalent bonds is formed by the side chains. When thermosets are heated, a further polymerization reaction begins, and they become hard and brittle after cooling to room temperature. They do not soften when heated after hardening like thermoplastics; instead, they breakdown due to reactivity with ambient oxygen, as seen in figure 2. Vulcanised rubbers, epoxies, and phenolic and polyester resins are examples of thermosets. Polymers are categorised into three types based on their structures: linear polymers, branched polymers, and cross-linked polymers. The'mer' units of linear polymers are bonded together in single chains, as seen in figure 3 (a). Chains are connected by weak van der waal forces. Polyethylene, polyvinylchloride, nylon, and so on. The chain of branched polymers contains sidebranches, as seen in figure 3 (b). Side reactions that occur during synthesis cause the side branches. Because the packing of these polymers is so tiny, they have a low density. Cross linked polymers, as seen in figure 3 (c), have neighbouring linear chains bonded at various points by covalent bonds. This type of cross linking occurs during polymer synthesis or by chemical reactions at elevated temperatures with additional atoms/molecules [8-12].

Classification on the basis of source

(i) Natural polymers: nature contains natural polymers. Ex: Starch, fats, cellulose, nucleic acids, organic rubber.

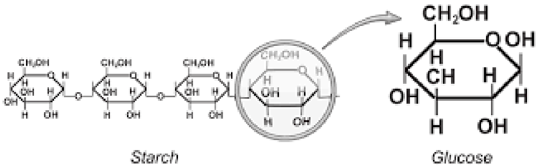

Fig.1 Starch

(ii) Synthetic Polymers: Man-made polymers are synthetic polymers. Ex: Bakelite, Polyvinyl alcohol, Terylene, Polyethylene.

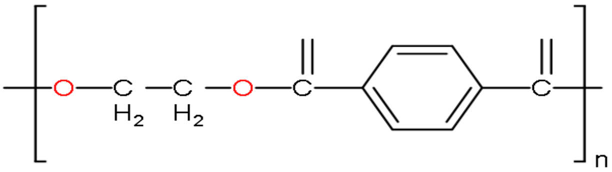

Fig.2 Terylene

Classification on the basis of structure

(i) **Linear Polymers:** Monomeric units in the form of long straight chains are joined in Linear Polymers. Ex: polythene of high density (HDPE), nylon, polyester.

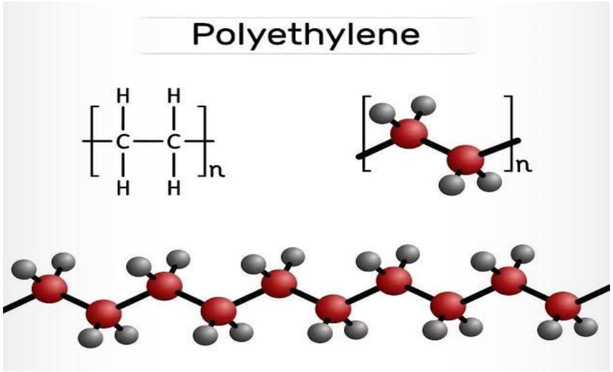

Fig.3 Polyethylene

(ii) **Polymers branched chain**: branched polymers are mainly linear in nature, but they also have branches along the main chain. Ex: Polythene of low density (LDPE), glycogen, amylopectin.

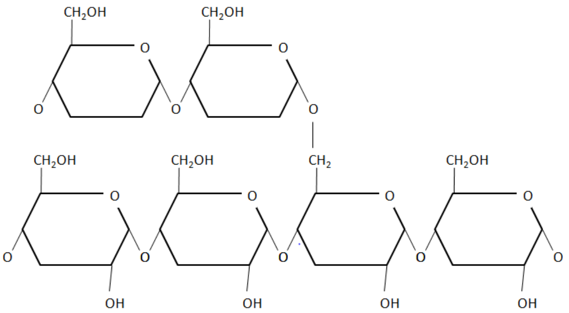

Fig.4 Glycogen

(iii) **Three-dimensional Polymers network:** Three-dimensional polymers network comprise monomer molecules bound by covalent bonds only. These are giant molecules where heavy cross-links prevent the movement of individual monomeric units. Ex: bakelite, formaldehyde of urea, formaldehyde of melamine.

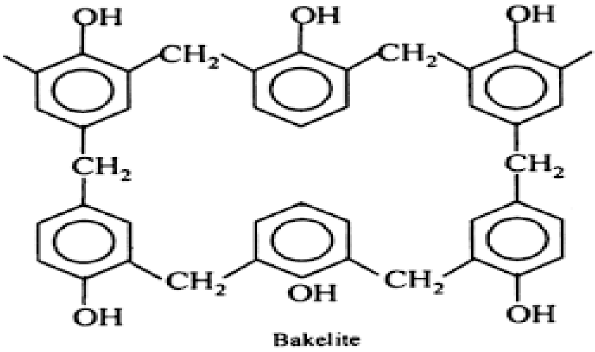

Fig.5 Bakelite

Classification on the basis of their methods of synthesis

The polymers are divided into two groups based on the synthesis modes.

(i) Addition Polymers: Addition Polymers are obtained by an alternative process of polymerization involving the repeated addition of monomers to long chains. Ex: Polyethylene, Polypropylene, Polystyrene, etc.

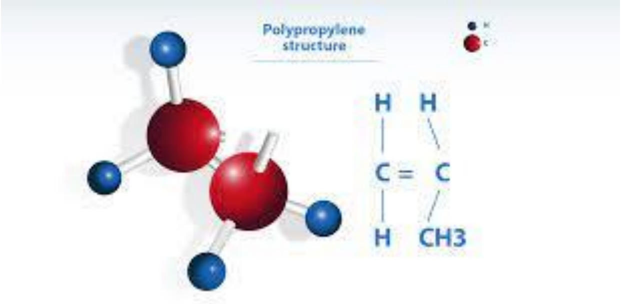

Fig.6 Polypropylene

(ii) Condensation Polymers: Condensation Polymers are obtained through a sequence of condensation reactions involving typically two monomers. Ex: Bakelite, Nylon-6, Polyester, etc. [13]

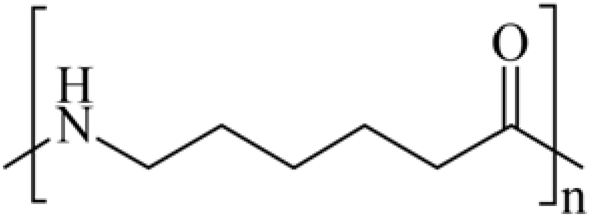

Fig.7 Nylon-6

Classification on the basis of their growth polymer chain

(i) Chain growth polymers: chain growth polymers are formed by the successive addition of monomer units to the reactive intermediate growing chain. Ex: polyethene, polypropylene, polystyrene, etc.

(ii) Step-growth polymers: Step-growth polymers are formed by a series of independent reactions involving the formation of bonds between two separate monomers with loss of small molecules such as H_2O, HCl and NH_3etc.

Classification based on molecular forces

These were divided into four categories based on the strength of intermolecular forces present in polymers.

Thermoplastics

The relatively weak intermolecular forces hold the molecules in a thermoplastic together, so that the material softens when exposed to heat and then returns when cooled to its original condition. Thermoplastics are the bulk of linear and slightly branched polymers. Chain polymerization produces all the major thermoplastics. Food packaging, insulation, vehicle bumpers and credit cards are some examples.

Thermosets

Heating cannot reshape the thermosets. Thermosets are usually three-dimensional networked polymers in which polymer chains have a high degree of cross-linking. The cross linking limits the chains ' movement and contributes to a solid material that makes thermosets strong and robust. They are predominantly used in the automotive and construction industries. They are also used for making toys, varnishes, hulls of boats and glues.

Elastomers

Elastomers are rubbery polymers that can be extended easily to their unstretched length many times and that quickly return to their original dimensions when the pressure is released. Elastomers are cross-linked but have a low density of cross-link. An elastomer must have a glass transition temperature above Tg and a low crystallinity. Elastomers are composed from rubber bands and other elastics.

Fibers

Many of the polymers used in synthetic fibers are the same as in plastics. A fiber is often referred to as having at least 100 aspect ratio. The fiber thickness is represented in denier terms. Denier is a measurement unit of fiber linear mass density. It is known as the weight per 9000 m in grams. Kevlar, carbon, PE, PTFE and nylon are synthetic fibers, while silk, cotton, wool and wood pulp are natural fibers. [14]

PROPERTIES:

Polymer properties are classified into various groups based on the scale at which they are defined as well as their physical basis.The identification of a polymer's constituent monomers is its most fundamental feature. The organisation of these monomers within the polymer at the scale of a single chain is effectively described by a second set of features known as microstructure [15].

Chemical Properties:

At the nanoscale, chemical characteristics describe how the chains interact through distinct physical forces. They describe how the bulk polymer interacts with various chemicals and solvents at the macro-scale. The attractive forces between polymer chains play a significant role in shaping the characteristics of a polymer. Because polymer chains are so long, interchain forces are amplified considerably beyond the attractions between ordinary molecules. Dipoles in monomer units can influence intermolecular interactions in polymers. Polymers with amide or carbonyl groups can create hydrogen bonds between neighbouring chains; partially positively charged hydrogen atoms in one chain's N-H groups are strongly attracted to partially negatively charged oxygen atoms in another chain's C=O groups [16,17].

Physical properties:

Density: There are hundreds of optical glass forms. Glass catalogue types span a broad variety of mechanical, physical, thermal, and chemical qualities. The density ranges from approximately 2.3 g/cm3 to approximately 6.3 g/cm3. The heaviest optically viable polymer has a density of only around 1.4 g / cm3, whilst the lightest of these materials may easily float in air with a density of 0.83 g / cm3. All else being equal, the total number of elements in an optical system can often be reduced by using non-spherical surfaces. Overall, polymer optical systems can be produced significantly less substantial than glass counterparts, especially if aspheric technology is applied to optical polymer trains.

Hardness: While cosmetic flaws rarely affect final image quality, optical surfaces are normally expected to be free of scratches, pits, and the like. Ordinary use, particularly cleaning processes, would almost certainly result in some scratching over time. Many common optical glasses are durable enough that, with a little care, they are relatively resistant to injury. Polymeric optical materials, on the other hand, are frequently so fragile that they are permanently imprinted by a determined fingernail. Polymer optics hardness is difficult to quantify because it is not only material-dependent but also process-dependent.It is sufficient to state that in a polymer layer, particularly a thermoplastic, handling operations that would cause little or no damage to a glass component may cause significant abrasion. Indeed, the compressibility of most thermoplastic polymers is such that support for hard surface coatings is relatively low to give just superficial abrasion protection. However, if the faulty surfaces are internal and thus unavailable, these flaws are unimportant.

Rigidity: The elastic module, often known as Young's unit, is a characteristic that is strongly related to hardness. This number, along with the yield elongation factor, are determinants of impact resistance, a quality criterion in which the polymers outperform the lenses. These attributes, once again, are reliant on the polymer alloy selected, any additives present, and the polymer's production history, and cannot be quoted reliably. Certain qualities that provide good impact resistance become liabilities when an optical component is subjected to torsion or compressive stress. Because optical surface profiles are frequently required to preserve subwavelength accuracy, an incorrect thickness / diameter ratio or excessive compression by retaining rings may result in unsatisfactory optical figure deformations. Polymer chemistry is most likely a difficult subject that should be avoided.

ELECTRICAL PROPERTIES OF POLYMER:

None Conducting materials include glass, ceramics, polymers, and bio composites. They obstruct the flow of current via them. When these nonconducting materials are placed in an electric field, they affect the electric field and experience significant changes, causing them to behave as electrical charge storage. When charge storage is the primary function, materials are referred to as dielectrics. A material must be an insulator in order to be a good dielectric. Polymers have great dielectric characteristics because they are good insulators. Many writers have published theoretical and experimental research on these features. The following sections go through the most frequent electrical qualities of interest.

Polarisation of dielectrics

Internal polarisation is the displacement of charge particles within a material caused by the introduction of an electric field, resulting in the formation of dipoles. Electronic, orientational (dipolar), space charge, and barrier polarisation are examples of internal polarisations. When a high electric field (105 V/cm) is applied between the electrodes in close contact with the dielectric, it can be charged directly. Charges are sprayed or deposited in the tiny air space between the electrode and the dielectric as a result of corona discharge or dielectric breakdown. If the injected charge in the surface has the same sign as the electrode in contact, it is referred to as homo-charge; if it has the opposite sign, it is referred to as heterocharge. The sum of internal and exterior polarisation produces total polarisation. P = Pint + 1.5 Pext When polymers are subjected to field-temperature treatment, they are known to hold charge permanently; such quasi-permanently charged dielectrics are known as Electret.

Dielectric tensile strength

It determines the maximum current that may be applied to a plastic before it permits current to pass through. It is expressed as the voltage right before this occurs divided by the sample thickness (in volts/m). Temperature, thickness, how the sample was conditioned, rate of voltage increase, test duration, and contamination are all factors.

Electrical conduction

The electrical conductivity of polymer, x, measures the presence of free ions not connected chemically with the macromolecules. It also depends on presence of low molecular weight impurities that can serve as source of ions. The chemical constitution has only an indirect effect on the mobility of the ions. In glassy state the conductivity of the polymer is approximately 10-13 to 10-19 ohm-1 with increasing temperature, the conductivity of polymer increases according to the exponential law as, x = AeÞU/RT 1.6 Where, A is a Coefficient mainly dependent on temperature, R is Universal gas Constant, and ÞU is the Activation energy (Þ = delta).

Dielectric constant (or permittivity)

Dielectric constant, εǀ, indicates how easily a polymer/plastic can be polarized relative to vacuum. It is defined as the ratio of the capacity of an electric capacitor filled with the substance to that of the same capacitor in vacuum, at a definite external field frequency. This dimensionless number which is important in high frequency applications varies with temperature, moisture, frequency and thickness.

Dissipation factor

These measures the energy dissipated during rapid polarization reversals, as with an alternating current. It can be seen as the ratio of energy lost as heat to current transmitted. It is usually measured at 1 MHz this factor should be low when polymers are used as insulators in high frequency applications such as radar and microwave equipment.

Dielectric loss

Dielectric loss, εǀǀ, measures the part of the energy of an electric field that is dissipated irrecoverably as heat in the dielectric. Dielectric loss in polymeric materials is due to the independent movement of chain sections consisting of large number of monomer units.

Volume resistance

A standard measure of conductivity when a direct current potential is applied across a material is volume resistivity (measured as ohm × area of the smaller electrode/ specimen thickness). Materials measuring volume resistance above 108 ohm-cm are insulators.

Surface resistance

This expresses how well current flows over the surface of a material between electrodes placed on the same side of a specimen. While volume resistance is a property of the material, surface resistance measures how susceptible a plastic is to surface contamination, especially moisture. It is useful when surface leakage may be a problem but since it is not measurable exactly it should be used with wide margin of safety [19-42].

Mechanical properties:

The bulk characteristics of a polymer are frequently of relevance in end-use applications. These are the qualities that govern how a polymer behaves on a macroscopic scale. The tensile strength of a substance quantifies how much stress it can withstand before deforming permanently [43].

Mechanical properties of a thin film polymer:

The mechanical qualities of any polymer blend or composite are also affected by its dimensional size, whether it appears thinner or thicker. Because of the size of the blend, it can be used in a variety of disciplines. Today, polymers are widely utilised in thin-film applications such as film coating, adhesive epoxy under fills to localise stress concentration during thermal expansion, electronic packaging, and so on. The mechanical condition of the polymer within the thin film must vary from point to point, as does the strength of the adhesion between the polymer and the substrate.Even in thin film applications such as electronic packaging, the typical dimensions of the polymer component are substantially bigger than the diameters of individual molecules. At far larger scales, the material's deformation behaviour and bulk tensile characteristics (which change with resin and processing) can properly represent the thin film's time dependent qualities.

Micro hardness of a Polymer

When discussing the mechanical properties of polymer and bio composites, one of the most essential components in mechanical characterisation is the material's hardness; it is commonly defined as "resistance of a material to plastic deformation, usually by indentation." When a load is applied to a material, it has the ability to withstand permanent deformation (bend, break, or have its shape changed). The higher the hardness of the material, the greater its resistance to deformation. Ashby [44] provides one of the finest known definitions, stating that "hardness is a measure of resistance to permanent deformation or damage." Micro hardness is the hardness of a material measured at low loads as Determined by forcing an indenter such as Vickers or Knoop into the surface of the material under 5 g to 160 g load. The indentations are usually so minute that they must be measured under a microscope. Micro indenters function by pressing a tip into a sample and measuring the applied weight, penetration, depth, and cycle time continuously. Nano indentation tests evaluate hardness by indenting with extremely small (on the order of 1 nano -Newton) indentation pressures and measuring the depth of the indentation, which is used to examine various properties of polymers and polymer bio composite blends. A typical hardness test entails applying a fixed force to the indenter and measuring the resulting indentation size. This has been empirically linked to the material's yield stress. This work presents the results of Micro-indentation testing on electrically stressed polymer thin films [45-52].

Transport Property

Diffusivity, for example, refers to how quickly molecules flow across the polymer matrix. These are crucial in many polymer applications such as films and membranes. When applied to polymers, the term melting point refers to the transition from a crystalline or semi-crystalline phase to a solid amorphous phase [53,54].

Optical properties:

Variations: Because most of these goods were initially developed for other purposes, the fact that some of them exhibit advantageous optical characteristics is just coincidental. Products utilised for eyeglass applications and optical data storage are potential outliers. Citation of optical parameters for any polymeric material must be done with caution and qualification, as various melt flow levels may have somewhat variable refractive index qualities. Subtle changes in the parameters of spectral transmission can be caused by additives for adjusting lubricity, colour, and so on.

Spectral Transmission: In general, optical carbon-based polymers are visible-wavelength materials that absorb rather significantly in the ultraviolet and throughout the infrared. Nonetheless, the absorption spectra presented in many literature does not make this clear. These data are typically generated by spectroscopists for the aim of identifying chemical structures in very thin materials. This data clearly establishes the impression that the polymers transmit well over a broad spectral range. Interestingly, although being characterised in the laboratory, the majority of these polymers are not commercially available. For optical design objectives, transmission data from samples with appropriate thickness to be useable for imaging is required [55].

FILM FORMATION METHODS:

Deposition of this film has been received in a variety of physical and chemical approaches throughout the last few years [56]. Thin films are thin material layers ranging in thickness from fractions of a nanometer to several micrometres, and their formation begins with nucleation, followed by coalescence, and subsequent thickness growth in all physical vapour deposition techniques, with nucleation followed by deposition parameters. Film preparation methods are beneficial. varied processes produce films with varied qualities. As a result, the method of film creation is a crucial component. These are as follows:

(a) Thermal Evaporation: Thin films are generated from polymers by thermal evaporation of bulk material. The substance to be deposited is heated to a high temperature under extremely low pressure and in exceptionally clean circumstances before vaporising. The vapour, along with the gaseous portion and solid residue, is then allowed to condense on a substrate. The violent boiling action of the molten polymer, as well as the quick evolution of breakdown products, contaminate evaporated polymer films. Uncontaminated films can be created, however, by using a low evaporation temperature and hence a slow deposition rate, as well as carefully developed thermal evaporation processes, such as a combination of internal baffles and flash evaporation and laser evaporation [57].

(b) Sputtering: The ejection of atoms from the surface of a material by bombardment with energetic particles called sputtering. The ejected sputtered atoms can be condensed on a substrate to form a thin film. The advantage of this method is that the deposition rate remains constant. Various sputtering systems such as glow discharge and r. f. sputtering are based on the effect that the free electrons ejected from the evaporate can be accelerated in an electric field to cause further bombardment of the surface of the target and a self sustaining reaction. Some other systems are based on increasing the electron path lengths so that the self sustained system can work at relatively low pressures.

(c) Glow discharge: The film formed in a glow discharge is pin holes free and possess a numbers of unique and desirable properties. This method is very simple is comparison of other methods. The thin film a glow discharge method or a glow discharge is initiated between the electrodes, in the indirect method; the substrate is placed in the formed.

(d) Gaseous discharge: Thin films of polymers can be obtained when a gas discharge is maintained in the vapors of monomer. Since the pressure maintained is of the order of 1 mm Hg. The discharge is a cold one and no hot cathode emission is necessary. The problems associated with high gas pressures and substrate heating has been minimized by utilizing a longitudinal magnetic field to compress to glow discharge in a tube and r. f. electrode less excitation.

(e) Hot pressing: The first method of film fabrication was hot pressing. In this method the polymer powder is placed in between two ferrotype photographic plates and hot pressed at a temperature 10-150C above the crystalline melting point under pressure. The film is then removed from the press and immediately quenched in ice-water in order to obtain necessary thickness [58,59].

(f) Film from polymer solution: The flawless method for preparing thin films from polymer solution.

(g) Isothermal immersion technique: Solution of suitable concentration is kept at a desirable temperature for a given period of time yield the required film thickness. Polymer solution of non concentration is spread over an optically plane glass plate of non surface area which is made to float in mercury pool. Solvent is allowed to evaporate at a suitable constant temperature and the resulting film detached from the substrate using a blade. Lack of proper instrumentation and precautions may result into the films containing air bubbles and non-uniform thickness. The thickness of film depends upon concentration of the solution.

FILM THICKNESS MEASUREMENT METHODS:

Measurement of thickness of sample with sufficient accuracy is essential so that desired conclusion could be drawn about the electrical properties of polymer samples. Thickness of polymer films can be measured by a various methods. These thickness measurement methods may be divided as mechanical method.

A. Mechanical method: Mechanical techniques are given below.

(a) Stylus method: In this method a fine stylus is moved over a stepped surface formed by the edge of the film and the substrate. This stylus undergoes transverse vibrations at the step which is recorded and amplified after being fed into an electronic circuit [60,61]. This method is unsuitable for the film of non uniform thickness and suffers from low accuracy.

(b) Weighing method: This method uses the relation between the thicknesses, mass, density and area of the film. Since the mass is defined as the density multiplied by the volume and the area and mass of the film can be measured precisely using physical balance and venire calipers. The thickness, t, of the film can be computed using the following formula $t = M/d.\ A$ where, M = mass, d = density and A = area of the film. The sensitivity of the method depends upon the accuracy of the mass and area measurements. Also, it is not always possible to cut the substrate in well defined areas [62,63].

(c) Micrometer gauge method: This is the simplest method of measuring the thickness of a film. A number of observations are averaged to find out the exact thickness.

B. Optical methods: These are given below-

(a) Ellipsoometery: It is a non-destructive method for measuring the thickness of transparent films. It is based on evaluating the change in the state of polarization of light reflected from film and substrate. The method, no doubt an accurate one involves long time consuming complicated mathematical calculation of complex nature. Hence it is not in common use.

(b) Light cross-section: Light cross-section methods a simple optical device which allows the measurements of both transparent and non transparent films in the 1 to 50mm in interval by the contract less method [64,65]. In this method narrow illuminated slit is projected by microscope into the stepped surface formed by the edge of the film and the substrate at the angle of 450 with respect to the film surface. Two images of the slit are observed, one after reflection from the substance and the other from the upper surface of the film, reported accuracy is +5% but the main difficulty of this methods is that it required optically plan films.

(c) Interferometeric: This method includes those devices which make use of interference of light e.g. Newton's rings, Michelson's interferometer and Febry parrot etalon. The method based upon observing the shift of interference fringes on moving from film surface is again prerequisite. Hence we can say first method is every time consuming it is not for common use and remaining two methods are not accurate.

C. Electrical methods: Measurement of capacitance is a simple effective and non-distractive method film thickness measurement. This method may be using both transparent opaque films with the same accuracy. It's specific advantage line in the fact that one gets the thickness of that particular area which is actually involved in investigation. The method consists in measuring the capacitance of the sample by a sensitive L.C.R. Bridge, making necessary composition for the capacitance of assembly etc. [66-68].

APPLICATION

Organic polymers have already been used in optical fibres, micro lenses, and polymer light emitting diodes [69]. Polymers were clearly not found overnight. They are the result of years of research by a group of dedicated scientists whose work has improved people's lives. Today, material scientists have such a profound understanding of polymer chemistry and technology that they can produce an almost infinite number of novel materials. One such example is polycarbonate, a bulletproof material that combines the transparency of glass with the strength of steel. Polymers have also proven useful in bioengineering, where they are used to better understand membranes, neutral signals, biological memory in regeneration, electrical mediation in tissue growth, and other phenomena.It is believed that they will find many other breakthrough uses in medical science and space technology, among other things [70]. Many scientists and engineers used to believe that polymers were electrical insulators, and that this feature limited their applications. The discovery (or synthesis) of polyacetylene in 1977 altered this idea, resulting in the creation of a new class of materials known as semi conducting or conducting polymers [71]. Many polymers have had their conductivity enhanced by several orders of magnitude by the doping process and have been turned into electronic polymers, which have proven extremely important in science and technology [72]. Medicine: Polymers such as Dacron, Teflon, and polyurethane are used in several biomaterials, including heart valve replacement and blood vessels.

Consumer Science: Plastic containers of all shapes and sizes are lighter in weight and less expensive than traditional containers. Other polymers include clothing, floor coverings, garbage disposal bags, and packaging. Automobile parts, fighter jet windscreens, pipelines, tanks, packaging materials, insulation, wood substitutes, adhesive matrices for composites and elastomers are among polymer uses used in industry.

Sports: Playground equipment, various balls, golf clubs. Swimming pools and protective helmets are often produced from polymers [12,73].

Agriculture and Agri-business: Polymeric materials are used to boost aeration, provide much and encourage plant growth and health in and on soil.

Medicine: Many biomaterials are made of polymers such as Dacron, Teflon and Polyurethane, especially heart valve replacements and blood vessels.

Consumer Science: All shapes and sizes of plastic containers are light weight and economically less costly than conventional bottles. Certain polymer uses include clothes, floor coverings, garbage disposal bags and packaging.

Industry: Automotive components, fighter aircraft windshields, tubing, tanks, packaging materials, insulation, wood substitutes, adhesives, composite matrix and elastomers are all plastic products used in the automotive industry.

Sports: Playground equipment, balls, golf clubs, swimming pools and helmets are often made from polymers.

Clear or reflective materials: polymers are used as screens, optical fibres, mirrors, reflectors and clear film sets. [74]

Water-Soluble Synthetic Polymers:[75-77]

- Poly (acrylic acid) Cosmetic, pharmaceuticals, immobilization of cationic drugs, base for Carbopol polymers.
- Poly (ethylene oxide) Coagulant, flocculent, very highmolecular-weight up to a few millions, swelling agent.
- Poly (ethylene glycol) Mw <10,000; liquid (Mw<1000), and wax (Mw >1000), plasticizer, base for suppositories.
- Poly (vinyl pyrrolidone) Used to make betadine (iodine complex of PVP) with less toxicity than iodine, plasma replacement, tablet granulation.
- Poly (vinyl alcohol) Water-soluble packaging, tablet binder, tablet coating.

Cellulose-Based Polymers:

- Ethyl cellulose Insoluble but dispersible in water, aqueous coating system for sustained release applications.
- Carboxymethyl cellulose Super disintegrant, emulsion stabilizer.
- Hydroxyethyl and hydroxypropyl celluloses Soluble in water and in alcohol for tablet coating.
- Hydroxypropyl methyl cellulose Binder for tablet matrix and tablet coating, gelatin alternative as capsule material.
- Cellulose acetate phthalate enteric coating.

Hydrocolloids:

- Alginic acid Oral and topical pharmaceutical products; thickening and suspending agent in a variety of pastes, creams, and gels, as well as a stabilizing agent for oil-in-water emulsions; binder and disintegrants.
- Carrageenan Modified release, viscosifier.
- Chitosan Cosmetics and controlled drug delivery applications, mucoadhesive dosage forms, rapid release dosage forms.

Water-Insoluble Biodegradable Polymers:

- (Lactide-co-glycolide) polymers Microparticle– nanoparticle for protein delivery.

Starch-Based Polymers:

- Starch Glidant, a diluent in tablets and capsules, a disintegrant in tablets and capsules, a tablet binder.
- Sodium starch glycolate super disintegrant for tablets and capsules in oral delivery.

Plastics and Rubbers:

- Polyurethane Transdermal patch backing, blood pump, artificial heart, and vascular grafts, foam in biomedical and industrial products.
- Polyisobutylene Pressure sensitive adhesives for transdermal delivery.
- Polycyanoacrylate Biodegradable tissue adhesives in surgery, a drug carrier in nano- and microparticles.
- Poly (vinyl acetate) Binder for chewing gum.
- Poly (vinyl chloride) Blood bag, and tubing
- Polyethylene Transdermal patch backing for drug in adhesive design, wrap, packaging, containers.
- Poly (methyl methacrylate) Hard contact lenses.
- Poly (hydroxyethyl methacrylate) Soft contact lenses.

ROLE OF POLYMER IN PHARMACEUTICAL DRUG DELIVERY:

❖ Immediate release dosage forms:

• Tablets

Polymers have been used for many years as excipients in conventional immediate-release oral dosage forms, either to aid in the manufacturing process or to protect the drug from degradation upon storage. Microcrystalline cellulose is often used as an alternative to carbohydrates as diluents in tablet formulations of highly potent low-dose drugs. Starch and cellulose are used as disintegrants in tablet formulations, which swell on contact with water, resulting in the tablet "bursting," increasing the exposed surface area of the drug and improving the dissolution characteristics of a formulation. Polymers including polyvinyl-pyrrolidone and hydroxypropyl methylcellulose (HPMC) also find uses as binders that aid the formation of granules that improve the flow and compaction properties of tablet formulations prior to tableting. Occasionally, dosage forms must be coated with a "non- functional" polymeric film coating in order to protect a drug from degradation, mask the taste of an unpalatable drug or excipients, or improve the visual elegance of the formulation without affecting the drug release rate [78].

• Capsules

Capsules are used as an alternative to tablets, for poorly compressible materials, to mask the bitter taste of certain drugs, or sometimes to increase bioavailability. Many of the polymeric excipients used to "bulk out" capsule fills are the same as those used in immediate-release tablets. Gelatine has been used almost exclusively as a shell material for hard (two-piece) and soft (one-piece) capsules. HPMC has recently been developed and accepted as an alternative material for the manufacture of hard (two-piece) capsules.

❖ Modified-release dosage forms

It is now generally accepted that for many therapeutic agents drug delivery using immediate release dosage forms results in suboptimal therapy and/or systemic side effects. Pharmaceutical scientists have attempted to overcome the limitations of conventional oral dosage forms by developing modified release dosage forms.

• Extended release dosage forms

The therapeutic effect of drugs that have a short biological half-life may be enhanced by formulating them as extended or sustained release dosage forms. Extended and sustained release dosage forms prolong the time that systemic drug levels are within the therapeutic range and thus reduce the number of doses the patient must take to maintain a therapeutic effect thereby increasing compliance. The most commonly used water-insoluble polymers for extended-release applications are the ammonium ethacrylate copolymers (Eudragit RS and RL), cellulose derivatives ethylcellulose, cellulose acetate, and polyvinyl derivative, polyvinyl acetate. Eudragit RS and RL differ in the proportion of quaternary ammonium groups, rendering Eudragit RS less permeable to water, whereas ethylcellulose is available in a number of different grades of different viscosity, with higher-viscosity grades forming stronger and more durable films.

• Gastroretentive Dosage Forms

Gastroretentive dosage forms offer an alternative strategy for achieving extended release profile, in which the formulation will remain in the stomach for prolonged periods, releasing the drug in situ, which will then dissolve in the liquid contents and slowly pass into the small intestine. Unlike a conventional extended release dosage form, which gradually releases the drug during transit along the gastrointestinal tract, such a delivery system would overcome the problems of drugs that are absorbed preferentially from specific sites within the gastrointestinal tract (for example, many drugs are absorbed poorly from the distal gut, where an extended- release dosage form may spend the majority of its time), producing nonuniform plasma time profile delivery systems do not relay on polymers present, to achieve gastroretention mucoadhesive [79-83] and low-density [84,85] polymers have been evaluated, with little success so far, for their ability to extend gastric residence time by bonding to the mucus lining of the stomach and floating on top of the gastric contents respectively.

CHARACTERISTICS OF POLYMERS:

Most of the polymers created are thermoplastic, which means that it can be heated and recycled over and over again once the polymer is formed. This property allows fast sorting and makes recycling easier. It is not possible to rewind the other band, the thermosets. Upon the formation of these polymers, reheating can ultimately cause the product to degrade but not melt. The characteristics of each polymer are very different, but most polymers have the following general attributes.

1. **Polymers can be very resistant to chemicals.** Remember all the plastic-packed cleaning fluids in your house. Reading the warning labels about what happens when the chemicals come into contact with skin or eyes or are swallowed can demonstrate the need for chemical resistance in the plastic packaging. While some plastics are easily dissolved by solvents, others provide durable, non-breakable packaging for aggressive solvents.
2. **Polymer can be both thermal and electrical insulators.** That idea will be strengthened by a walk through your house when you find all appliances, cables, electrical outlets and wiring made and coated with polymeric materials. Thermal resistance is visible in the kitchen with silicone pot and pan handles, coffee pot handles, refrigerator and freezer foam base, separated cups, coolers, and microwave cooking utensils. The thermal clothing most skiers wear is made of polypropylene or acrylic and polyester is the fiberfill in winter jackets.
3. Generally, polymers are very light in weight with significant degrees of strength. Note the range of applications, ranging from toys to space station frame construction, or from delicate pantyhose nylon fiber to Kevlar used in bulletproof jackets. Several polymers are floating in water while others are sinking. But all plastics are lightweight materials relative to the strength of rock, cement, steel, copper, and aluminum.
4. **Polymers can be processed in various ways.** Extrusion allows thin fibers or large tubes or films or bottles of water. Molding by injection can create very complex parts or large sections of the car body. For adhesives and paints, plastics can be formed into drums and blended with solvents. Elastomers are elastic and some plastics are very flexible. Many plastics, like soft drink bottles, are stretched in storage to maintain their form. Compared to polystyrene (StyrofoamTM), polyurethane and polyethylene, other polymers can be foamed.
5. Polymers are materials with a seemingly limitless range of characteristics and colors. Polymers have many intrinsic properties that can be further improved to expand their uses and applications by a wide range of additives. Polymers can be made to imitate fabrics of cotton, silk and wool; marble and porcelain; and aluminum and zinc. Polymers can also make possible things, such as transparent sheets and elastic films, that do not easily come from the natural world. [86]

POLYMERS IN PHARMACEUTICAL DRUG DELIVERY SYSTEM:

❖ Rosin

Rosin a film-forming biopolymer and its derivatives have been extensively evaluated pharmaceutically as film-coating and microencapsulating materials to achieve sustained drug release. They are also used in cosmetics, chewing gums, and dental varnishes. Rosin has been used to prepared spherical microcapsules by a method based on phase separation by solvent evaporation. Rosin combination with polyvinyl pyrrolidone and dibutyl phthalate (30 % w/w) produces smooth film with improved elongation and tensile strength.[87-89]

❖ Chitin and Chitosan

Chitin a naturally abundant muco polysaccharide and consist of 2-acetamido-2- deoxy-b-D-glucose. Chitin can be degraded by chitinase. Chitosan is a linear polysaccharide composed of randomly distributed β-(1- 4)-linked D-glucosamine (deacetylated unit) and N-acetyl- D glucosamine (acetylated unit). The most important property of chitosan with regards to drug delivery is its positive charge under acidic conditions. This positive charge comes from protonation of its free amino groups. Lack of a positive charge means chitosan is insoluble in neutral and basic environments.[90]

❖ Zein

Zein an alcohol-soluble protein contained in the endosperm tissue of Zeamais, occurs as a by-product of corn processing. Zein has been employed as an edible coating for foods and pharmaceuticals for decades. Zein is an inexpensive and most effective substitute for the fast- disintegrating synthetic and semi synthetic film coatings currently used for the formulation of substrates that allow extrusion coating.[91]

❖ Collagen

Collagen is the most widely found protein in mammals and is the major provider of strength to tissue. It not only has been explored for use in various types of surgery, cosmetics and drug delivery, but in bioprosthetic implants and tissue engineering of multiple organs.

❖ Starches

It is the most common type of carbohydrate reserve in green plants, notably in seeds and subterranean organs. Starch is found in the form of granules (starch grains), the shape and size of which are unique to the species, as is the ratio of the main ingredients, amylose and amylopectin. A number of starches have been approved for use in pharmaceuticals. Maize (Zea mays), rice (Oryza sativa), wheat (Triticum aestivum), and potato (olanum tuberosum) are among them. Microcapsules containing a protein and a proteinase inhibitor were created to deliver proteins or peptidic medicines orally. Interfacial crosslinking with terephthaloyl chloride was used to create starch/bovine serum albumin mixedwalled microcapsules. The microcapsules were loaded with native or amino- protected aprotinin by incorporating protease inhibitors in the aqueous phase during the cross-linking process. The protective effect of microcapsules with aprotinin for bovine serum albumin was revealed in vitro.

❖ Polycaprolactone

Polycaprolactone (PCL) is biodegradable polyester with a low melting point of around 60°C and a glass transition temperature of about −60°C. PCL is prepared by ring opening polymerization of ε-caprolactone using a catalyst such as stannous octanoate. The most common use of polycaprolactone is in the manufacture of speciality polyurethanes. Polycaprolactones impart good water, oil, solvent and chlorine resistance to the polyurethane produced.

FUTURE TRENDS

Despite the widespread usage of synthetic polymers, the demand for natural biodegradable polymers to deliver pharmaceuticals remains an active research subject. Natural polymers have various advantages over synthetic polymers, including the fact that they are readily available and relatively inexpensive, are natural products of living organisms, and allow for chemical manipulation. The most intriguing potential in polymer drug delivery are in the field of responsive delivery systems, which will allow drugs to be delivered in reaction to a measured blood level or precisely to a specified spot. The synthesis and use of these responsive polymers with carefully defined macroscopic and microscopic structural and chemical properties is the focus of much of the research of innovative materials in controlled medication delivery. Such systems include:

- Copolymers with desirable hydrophilic/hydrophobic interactions.
- Complexation networks responding via hydrogen or ionic bonding.
- Polymers as nanoparticles for immobilization of enzymes, drugs, peptides, or other biological agents.
- New biodegradable polymers.
- New blends of hydrocolloids and carbohydrate- based polymers.

In the future, the design and production of innovative polymer combinations will broaden the possibilities of new drug delivery methods. This will certainly necessitate the incorporation of a large amount of new knowledge regarding the chemical nature and physical structure of these novel materials. A growing number of scientists and engineers are working to reduce the environmental impact of polymer composite manufacture. Life cycle evaluation is critical at all stages of a product's life cycle, from initial synthesis to final disposal, and a sustainable society requires ecologically safe ingredients and processing procedures.[92]

CONCLUSION

Nature has chosen biological polymers as the material of choice, and mankind will choose polymeric materials as the material of choice. Humans have advanced from the Stone Age to the Bronze, Iron, and Steel Ages, and now to the Age of Polymers. A time when synthetic polymers are and will continue to be the material of choice. Polymerbased medications are becoming recognised as critical components in the treatment of many lethal diseases that impact a large number of people, such as cancer and hepatitis. Although excipients were traditionally used in formulations as inert substances to add volume and aid in the manufacturing process, they are increasingly being used in dosage forms to perform specialised functions for improved drug delivery because many new drugs have unfavourable physicochemical and pharmacokinetic properties. The new conducting polymer-based technologies will be used in all aspects of life on Earth and in space. Conducting polymers are lighter, take up less space, and are less expensive to produce than other existing technologies.

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