



Review Article

MIRACULOUS ADJUVANTS: THE PHARMACEUTICAL POLYMERS

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ABSTRACT

Polymers are formed of repeating structural units which are joined together by covalent chemical bonds. These are having a broad classification on different basis. Use in manufacturing of solid monolithic matrix systems, implants, films, beads, micro-particles, nanoparticle, inhalable and injectable system as well as viscous liquid formulations has specific application of plant derived polymer in pharmaceutical application. Polymers at initial stage for sustained release of drug were used as solubiliser, stabilizers and mechanical supporters. Partial alignment of molecular chains is associated with the process of crystallization of polymers. Light scattering between crystalline and amorphous regions usually causes polymer to be opaque and called as crystalline polymers. When the large number of small molecules link together is termed as monomers, with one another to form macromolecule or polymer molecule from chemical reaction is called polymerization. It can be termed as a process by which low molecular weight are converted into higher molecular compounds. The chemical reaction in which polymer is termed and small molecule and by-product with the lower weight is released is known as condensation polymerisation. When the two or more molecule of monomer attach together to form polymer is called addition polymerization. The rheology of polymer is essential. The two phase system depends, not only on rheological behaviour of the component, but with the size and distribution and the shape and discrete phase droplets dispersed in continuous matrix phase.

KEYWORDS: Sustained release, crystallization, monomers, polymerization, micro-particles, and nano-particles.

INTRODUCTION

Macromolecules (large molecules) composed of repeating structural units which are called as polymer. Covalent chemical bonds serve as a connection media for these subunits. Because of the attractive qualities like economical, easy availability and nontoxic nature. Natural polymers are used for pharmaceutical applications. Both synthetic and natural polymers occur in nature. Natural polymers have the capability of chemical modification; they are potentially biodegradable, biocompatible and have few exceptions.¹ Several potential challenges may be posed by plant origin substances being synthesised in mixtures in small quantities that are structurally complex and may differ in accordance to the location of the plants and other variables such as season.²⁻³

Use in manufacturing of solid monolithic matrix systems, implants, films, beads, micro particles, nanoparticles, inhalable and injectable system as well as viscous liquid formulations has specific application of plant derived polymer in pharmaceutical application.^{4,6}

Life seems very difficult without polymer now a day. Polymers are used by all of us in day to day life; in rubber; in plastic; in resins and in adhesives. Polymer is derived from Greek word poly = many and mers = parts or units of high molecular mass. Each molecular of polymer consists of very large number of

single structure units joined together in a single manner. Giant molecules of high molecular weight are often called as macromolecules, which are formed by joining a large number of small molecules called as monomers. When the monomers are combined together they form a polymer and this reaction is called as polymerisation.⁷

Polymers at initial stage for sustained release of drug were used as solubilisers, stabilizers and mechanical supporters. For solving problems associated with development of drug delivery system polymers are being synthesised specifically as per need. Since, long time has passed away; functionalities of polymer have been changed.⁸

Polymeric material fulfils different roles such as binders, matrix formers or drug release modifiers, film coating formers, thickeners or viscosity enhancers, stabilizers, disintegrants, solubilises, emulsifiers, suspending agents, gelling agents and bio adhesives.⁹

CLASSIFICATION OF POLYMERS

Polymers passes different chemical structure, physical properties, mechanical behaviour, thermal characteristics etc and on the basis of properties of polymer it is being classified in different way in table 1, whereas important and broad classification of polymers are described in next section.

Table 1: Classification of Polymer

S. No.	Basis of Classification	Polymer Type
1	Origin	Natural, Semi synthetic, Synthetic
2	Thermal Response	Thermoplastic, Thermosetting
3	Mode of formation	Addition, Condensation
4	Line structure	Linear, Branched, Cross-linked
5	Application and Physical Properties	Rubber, Plastic, Fibres
6	Tacticity	Isotactic, Syndiotactic, Atactic
7	Crystallinity	Non-crystalline(amorphous), Semi-crystalline, Crystalline

Classification Based on Origin

On the basis of their occurrence in nature, polymers have been classified in three types shown in Figure 1. ¹⁰

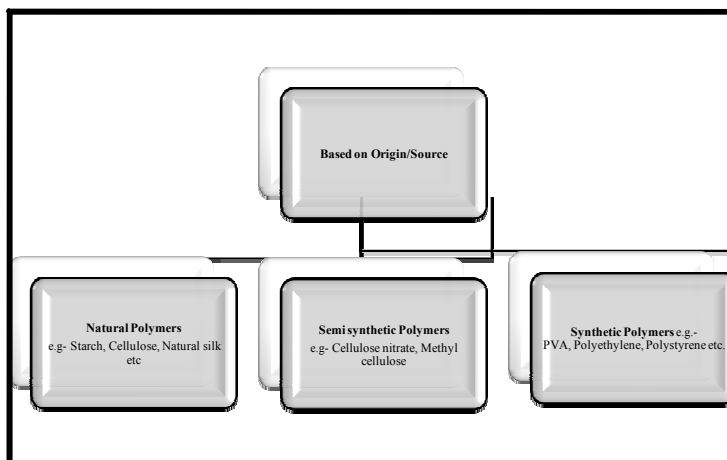


Figure 1: Classification of polymers based on origin

Natural polymer

Natural polymer occurs in nature also known as biopolymers. Polymers are natural rubber, natural silk, cellulose, starch, proteins, etc. as shown in the Figure 2.

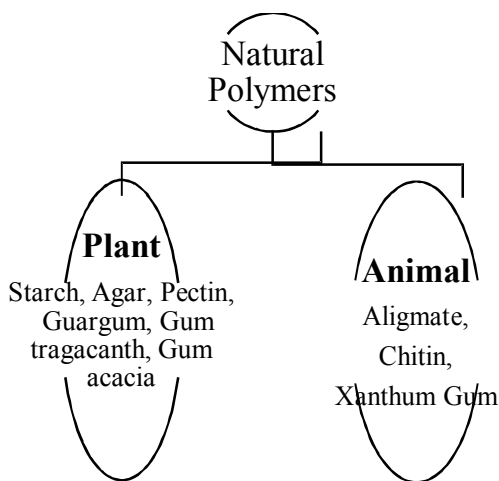


Figure 2: Classification of Natural Polymers

Semi synthetic polymer

Hydrogenated natural rubber,cellulosic, cellulose nitrate, methyl cellulose etc are chemically modified natural polymers.

Synthetic polymer

Synthetic polymers are synthesised in laboratory. These are man-made. Examples are polyvinyl alcohol, polyethylene, polystyrene, and polysulfide.

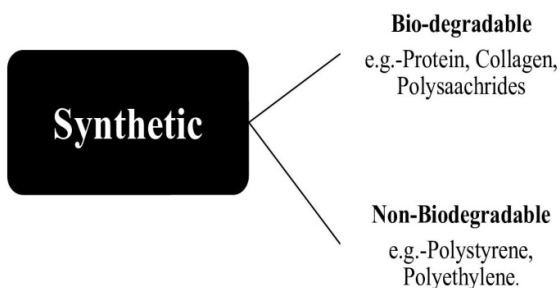


Figure 3: Classification of Synthetic Polymers

THERMAL RESPONSE

On the basis of thermal response, polymers can be classified into two groups as shown in figure 4.¹¹

Thermoplastic polymers

Polymers if treated with certain precautions it does not causes much change in property and they can be softened or plasticized repeatedly on application of thermal energy. Examples of such polymers are Polyolefin, nylons, linear polyesters and

polyether's, PVC, sealing wax etc.

Thermosetting polymers

Conversion of polymer into an infusible mass is because of chemical changes. Production of giant molecules and cross - linking of polymer chain molecules and the curing or setting process involves chemical reaction leading to further growth. For example, Phenolic, resins, urea, epoxy resins, diene rubbers, etc.

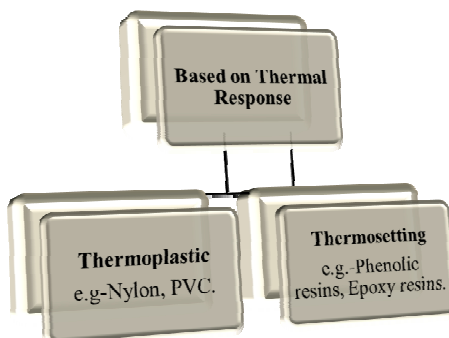


Figure 4: Classification of Polymers Based on Thermal Responses

MODE OF FORMATION

On the basis of mode of formation, polymers can be classified as shown in Figure 5.¹²

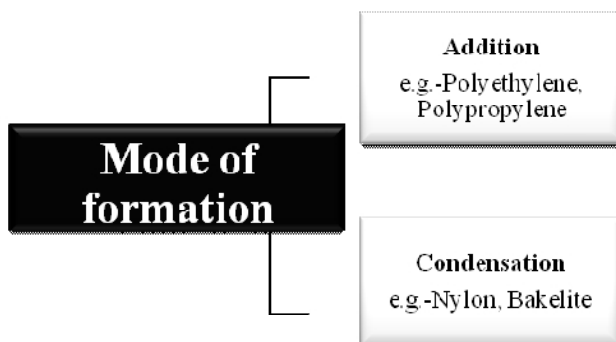


Figure 5: Classification of Polymers Based on Mode of Formation

Addition polymers

Addition polymerisation reaction is responsible for formation of polymer. Double and triple bonds are possessed by these monomer molecules. These are also known as chain growth polymer. Such as- polythene, polypropene, polystyrene, polyvinyl chloride etc.

water, alcohol, hydrogen chloride etc takes place by this polymerisation reaction. It possesses bifunctional or polyfunctional monomers. These are now also called as step growth polymers.

Such as- Nylon-6, 6 Nylon-6, Terylene, glyptal etc.

Condensation polymers

Condensation polymerisation reaction is responsible for the formation of polymer. Elimination of small molecule such as

LINE STRUCTURE

On the basis of structure, polymers are of three types. As shown in Figure 6.

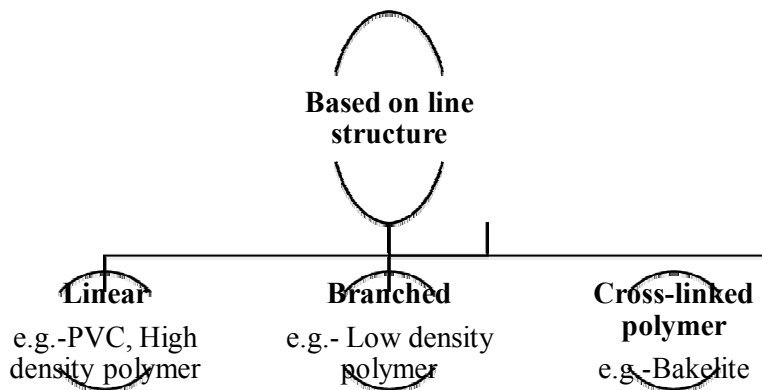
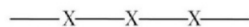


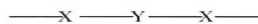
Figure 6: Classification of Polymers Based on Line Structure

Linear polymer

Linear polymer are those in which monomer units are joined in a linear fashion.

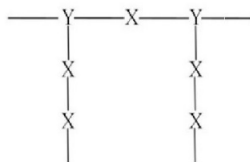


Linear Homopolymer

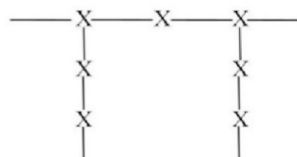


Linear Copolymer

Branched polymer:-Branched polymers are those in which monomer units are joined in branched manners.

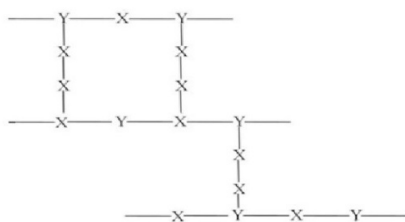


Branched Copolymer

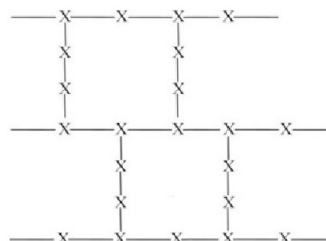


Branched Homopolymer

Cross linked polymer: - Cross linked polymer are those in which monomer units are joined in chain fashion.



Cross linked Homopolymer



Cross linked Copolymer

APPLICATION AND PHYSICAL PROPERTIES

Depending on its ultimate form and use a polymer can be classified as shown in figure 7.¹⁰

Rubber (Elastomers):- weak intermolecular forces, long flexible chains and high molecular weight are the characteristics of rubber. Elongation at break ranging between 300-1000% and it exhibit tensile strength in the range of 300-3000 psi.

Ex- Natural and synthetic rubber.

Plastics: - Relatively tough substance with high molecular weight are characteristics of plastic and it can be moulded (with or without) application of heat. This strength is ranging between 4000-15000 psi and elongation at break ranging from 20 – 200% or higher. The examples of plastics are, polyethylene, polypropylene, PVC, polystyrene, etc.

Fibres: - long chain polymers being characterised by high crystalline regions results to form secondary forces are called as fibres. Tensile strength ranging between 20,000-150,000psi. These are light weighted and have moisture absorption properties

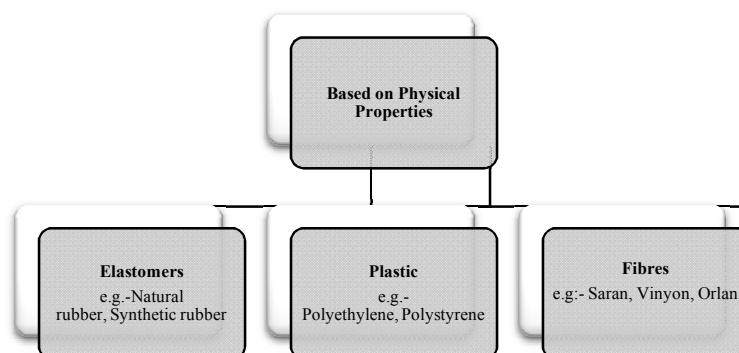


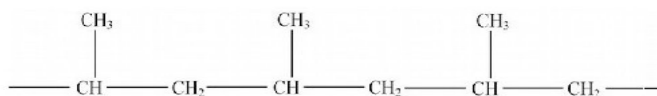
Figure 7: Classification of Polymers Based on Physical Properties.

TACTICITY

With respect to the main chain (backbone) of the polymer, the polymer posses geometric arrangement of the characteristic

group of monomer units which is called as tacticity. On the basis of structure, polymer may be classified into three groups:

Isotactic polymer:-In this polymer, the arrangement of the characteristic polymer on the same side of the main chain.



Isotactic Polypropene

Syndiotactic Polymer:-The polymers which have alternate arrangement of the side groups is called as syndiotactic polymer.

CRYSTALLINITY

Partial alignment of molecular chains is associated with the process of crystallization of polymers. Lamellae are those which are having chain fold together and form ordered regions, which compose spherulites.¹³ Dyeing of polymers get affected by crystallinity. Amorphous form is much more prone to dyeing as compared to crystalline form because the dye molecular penetrate much easier through amorphous regions.¹⁴ These are being classified as-

Crystalline Polymers: - Light scattering between crystalline and amorphous regions usually causes polymer to be opaque and called as crystalline polymers. Either for low (amorphous polymer) or high (crystalline) degree of crystallinity the transparency is higher as because density of such boundaries is lower.¹⁵ For example, atactic polypropylene is usually amorphous and transparent while syndiotactic polypropylene, which has crystallinity ~50%, is opaque.¹⁶

Semi crystalline Polymers

Highly ordered molecular structures with sharp melting point are possessed by semi crystalline materials. Semi crystalline material rapidly change to low viscosity fluid when given quantity of heat gets absorbed and they remain in solid form. Softens does not vary with temperature increases. Direction flow us transverse to flow causes less shrinking and thus material is anisotropic in flow. Chemical resistance is excellent. Beyond their glass transition temperature. Semi crystalline exhibit substantial improvement in HDT's which reinforced and retain useful levels of strength and stiffness.¹⁷

Amorphous Polymers: - During x-ray or electron scattering experiments polymer do not exhibit any crystalline structure and those polymers were called as amorphous polymers. E.g. - using straining-induced contrast enhancement in TEM. Formation of localised deformation zones, such as crazes, deformation bands, or shear bands, which are characterised by representative HVTEM micrographs, shows micromechanical behaviour of amorphous polymers.¹⁸

MECHANISM OF POLYMERIZATION

When the large number of small molecules link together is termed as monomers, with one another to form macromolecule or polymer molecule from chemical reaction is called polymerization. It can be termed as a process by which low molecular weight are converted into higher molecular compounds. Also the additional structural and compositional difference between polymers Flory stressed by which the mechanism of polymer molecule are build up. Also, Flory continued to use the term "addition polymerisation" (polymerization by repeated process) and "condensation processes" i.e., (with elimination of small molecules) in his discussion of polymerization mechanism. The basic terminology also classified that it is step growth polymerization and also chain growth polymerization.¹⁹

CONDENSATION OR STEP-GROWTH POLYMERIZATION

The chemical reaction in which polymer is termed and small molecule and by-product with the lower weight is released is known as condensation polymerisation. Condensate is also called as the by-product which was eliminated. When the reaction takes place in between two similar different monomer is called step-growth polymerization.²⁰⁻²¹

ADDITION POLYMERIZATION OR CHAIN POLYMERIZATION

When the two or more molecule of monomer attach together to form polymer is called additional polymerization. Basically in this polymerization no elimination of any molecule is done it is chain reaction and no product releases mainly it is obtained by linking together the monomer molecule weight is exactly an integral multiple of monomer as same as polythene obtained by ethylene. Mainly the single monomer is involved in addition polymerization and hence polymer is homopolymer and contain same monomer units. Additional polymer basically induced by light, heat or a catalyst for obtaining the double bond of monomer and thus creating the reactive sites for obtaining the double bond of monomer and thus creating the reactive sites.²¹

RHEOLOGICAL PROPERTIES OF POLYMERS

When the structure of polymer are considered by the size shape of molecule and also the distribution of these characteristic among the molecules, structure form and controlled assembly are the focus of joint stimulation and also various experiments investigated are the rheological features of vaginal hydrophilic polymer get and elucidated relationship between those characteristic gets composition and the general influence is therapeutic/ usage purpose.²²

Polymer melts

Also it has been observed that in last three decades considerable progress has been made in rheology in polymer solutions and polymer melts. In order to gain fundamental understanding of process ability of that material the rheological properties of polymeric material in the molten state is measured crucially. It is done because rheological behaviour are influenced by material structure and interfacial characteristics. The rheology of polymer is essential for two reasons. Firstly, it helped to solve out many polymer as such wide gauge variations in films poor quality of sheet and film, slow production rates and poor mechanical preparation. Secondly, it has been departed for the analysis of parameter such as: - molecular structure branching type and extent of branching, content entanglement and cross link density.²³ It is necessary to make measurement over a wide range of temperature and frequency (or shear rates) "Nichetti and Manas - zloczowen" has inculcated the ranges of relaxation time from largest molecule to smallest sub segments.²⁴

Polymer Blends and Melts

Polymer Blends

Different mixtures homopoly are mainly polymer blends-mers, copolymer, and terpolymer, whereas they can be homogeneous (miscible) or heterogeneous (multiphase). That can be crystalline and amorphous polymer. Whereas it is also said that when two chemically dissimilar polymer is miscible or not depends on the thermodynamics of mixing. It can also be understood clearly what governs polymer-polymer miscibility on molecular scale it can be referenced by polymer solution theory. It can be said that unique affecting polymer blends compressed with polymer solution is large in molecular weight of 60th component.²³ Polymer blending has been proven as most versatile and economic quote to produce new multiple phase polymeric material that satisfy the complex demands of performance.²⁵ Processing these polymer has a large effect on resulting mechanical and optical properties of end product. For instance dimensional stability is perused in injecting moulding or yield strength, also isoelastic polymer melt properties effect the young's modulus and even team strength. It is also said that

rheological behaviour is related to specific molecular structure and molecular weight distribution.²⁶

Vital Types of Multi-Phase Polymers: Compounds and Blends

Since year ago it has been the fact that polymer cannot mix with each other to form homogeneous mixture at segmental scale which has been driving force for a large number of studies on polymeric materials. It has been the main point to know that physical properties of these phase separated polymer such as toughness, flow ability, transparency and weather resistance to mention a few dictated by their morphology.²⁷ As a result of this a variety of chemical and physical method has been extensively exploited to control morphology of immiscible polymer mixture. Reaction polymer of various practical purpose such as modification of surface tension are widely utilized in between different phase which morphology and physical properties of multiphase polymeric material can be recommended and controlled. This is mainly known as reactive compatibility.²⁷

Immiscible Polymer Blends

The result in various phase of morphologies are mixing immiscible polymer in liquid state. They basically depend upon the nature and relative amounts of the polymer used and the flow history of the sample. The immiscible polymer behave as another material at different flow fields. It has been as concerned that phase morphology in the rheology of the polymer blends. Mainly polymer blends are immiscible. Mostly the polymer characteristics of these polymer are determined by the state of the interface primarily represented by a quality k called interfacial tension. Interfacial tension is excess free energy caused by existence of an interface arising from imbalance molecular forces.²⁸

Compatibilization

The process by which modifications of interfacial properties in immiscible polymer blend is known as compatibilization. This mainly causes the interfacial tension, stabilization of desired morphology and improved intervention between phases of solve state. In other words compatibilization results in formation of polymer alloys. Compatibilization is accomplished by physical or chemical masses. In the former case it has been observed that physically stabilishes polymer are desired level in which depression is generally by physical means (e.g., by quencher, retardation. Cross ionic or co cry stabilization). In the case the morphology does not only depend on the level of mechanical mixing but to great extent it was controlled by the compatibles was observed after years.²⁹

Importance of Rheological Properties in the Development of the Phase Structure

The two phase system depends, not only on rheological behaviour of the component, but with the size and distribution and the shape and discrete phase droplets dispersed in continuous matrix phase. These properties of multiphase system as strongly by morphology, which also depend on thermodynamics, which show the interaction between the constituent's polymers and flow history. Thereafter, it has been seen that rheological properties are essential in order to relate the morphology of phase separated state to processing multiphase system.³⁰ Mostly the prime models of morphological changes of polymer mainly tends to assume that an average response(e.g. an average size drop in being broken or site drop coalescence) gives better representation of the whole

system. This fact should be reasonably correct for blends with narrow distribution of drop size. Whereas there are various results for instance, that during initial stage may differ by three order of magnitudes. There the average size is not valid.²⁹ A recent kinetic theory of the structure development in the moderately concentrated polymer blends was proposed.

CONCLUSION

Polymers are the large size molecules which are formed from smaller units known as monomers. The process of formation of polymer is called as polymerization. In polymers, the monomer units are joined by covalent and thus they are more stable. Polymers are being broadly classified on different basis and they are being used in day to day life. Polymers at initial stage are used as solubilises, stabilizers and mechanical supporters. They are widely used in manufacturing of solid monolithic matrix systems, implants, films, beads, micro particles, Nanoparticles, inhalable and injectable system as well as viscous liquid formulations. Polymers are being collaborated for various applications in medical sciences, in various industrial preparations. Polymers are composed of numerous applications. Like as in biodegradable sutures. Researchers are working to reform the properties of the polymer and make them more compatible for use with lesser disadvantages. This review gives a brief description about the classification of polymers, their properties and many of its characteristics with its applications in day to day life.

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