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Biodegradable Polymers: An Important Polymer in Drug Delivery System: A Short Review

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Abstract: Biodegradable polymers are designed to degrade upon disposal by the action of living organisms. The biodegradability of a given polymeric material is defined by the chemical structure of the polymer. The following review presents an overview on Biodegradable polymers in pharmaceutical drug delivery of therapeutic agents. In recent years significant advances have been made in the development of biodegradable polymeric materials for biomedical applications. There are mainly two classes of Biodegradable polymers that can be distinguished into synthetic and natural polymers. Biodegradable polymers have been mainly used as Compostable plastics, Bio-erodable, Bioplastics in packaging, agriculture, medicine and other areas. In the biomedical area they are generally used as implants because of their biocompatibility and biodegradability and are supposed to give long term service. This review article focuses on the different biodegradable polymers that are currently being used, their properties as well as various developments in their applications.
Keyword: Biodegradable polymers, Medicine, Synthetic Polymers, Natural Polymers, Biocompatibility.

I. INTRODUCTION

Biodegradable polymers are the polymers that are degradable *in vivo*, either enzymatically or nonenzymatically, to produce biocompatible or non toxic by-products. Now they are becoming very demanding in pharmaceutical applications especially in the field of drug delivery. The word biodegradation is a natural process in the environment by which complex organic chemicals are converted into simpler compounds, mineralized and redistributed in the environment through material cycles such as the Carbon, nitrogen and Sulphur cycles. Biodegradation takes place by two processes, either by the action of enzymes and/or chemical deterioration associated with living organisms. For the past few decades, biodegradable polymers (either synthetic or natural) are capable of being cleaved into biocompatible by-products through chemical or enzyme-catalyzed hydrolysis. This property makes it possible to implant them into the body without any subsequent removal by the surgical operation.

Polymers are also range from their use as binders in tablets to viscosity and flow controlling agents in liquids, emulsions and suspensions; also can be used as film coatings for the following reasons-

A. To enhance drug stability.
B. To camouflage the unpleasant taste of a drug and
C. To modify the release characteristics.

II. REVIEW

A. Drug Delivery system

Drug delivery refers to approaches, formulations, technologies and systems for transporting a pharmaceutical compound in the body as needed to safely achieve its therapeutic effect. It might involve facilitating systemic pharmacokinetics, or may involve scientific site targeting within the body, or may also involve medical devices or drug device combination products. Drug delivery technologies modify release profile, absorption, distribution and elimination for the benefit of improving product efficacy and compliance.

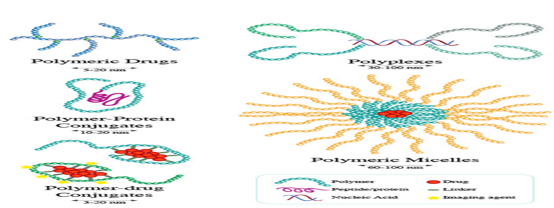

Figure 1. Polymer based Drug Delivery System

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B. Targeted Drug Delivery System

Sometimes called Smart drug delivery. It is method of delivering medication in a manner that increases the concentration of the medication in some parts of the body relative to others. The advantages to the targeted release system,

1) The reduction in the frequency of the dosages taken by the patient,
2) Having a more uniform effect of the drug,
3) Reduction of drug side-effects and
4) Reduce fluctuation in circulating drug delivery systems.

C. Self-microemulsifying Drug delivery system

SMEDDS is that uses a microemulsion achieved by chemical rather than mechanical means. It employs the familiar ouzo effect displayed by anethole In many anise-flavored liquors. Microemulsions have significant potential for use in drug delivery. SMEDDS in research or development include formulations of the drugs-

1) Anethole trithione
2) Curcumin
3) Vinpocetine
4) Tacrolimus
5) Nobilitin

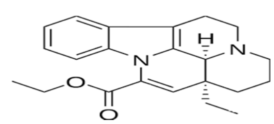

Figure 2. Vinpocetine

D. Drug Carrier

Drug carriers are substances that serve as mechanisms to improve the delivery and the effectiveness of drugs. They are used in sundry drug delivery systems such as:

1) Decrease drug metabolism,
2) Controlled-release technology to prolong *in vivo* drug actions,
3) Reduce drug toxicity and
4) To increase the effectiveness of drug delivery to the target sites of pharmacological actions.

E. Biomaterials for delivery systems

In the earlier stage the polymers were mainly used for non-biological uses, and now selected for drug delivery system due to their desirable physical properties, for example:

1) Poly (ethylene) for toughness and lack of swelling.
2) Poly (siloxanes)or silicones for insulating ability.
3) Poly (urethanes) for elasticity.

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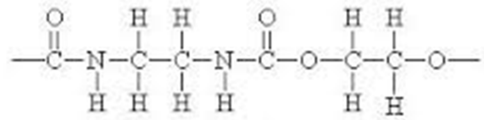
Polyurethane

4) Poly (methyl methacrylate) (PMMA) for physical strength and transparency.

F. *Biodegradable Drug Delivery System*

In recent years the use of polymers have been extended towards medical applications and drug targeting. For example;

1) Poly (lactic acid)
2) Poly (lactic-co-glycolic acid)
3) Polyanhydrides
4) Poly(ortho esters)
5) Poly(phosphoesters)

G. *Polymer Degradation*

Polymer degradation is a change in the properties like- tensile strength, color, shapes etc of a polymer under the influence of one or more environmental factors such as heat, light or chemicals like acids, alkalis and some salts. Degradation may also be induced by high energy radiation, ozone, atmospheric pollutants, mechanical stress, hydrolysis and other factors. Degradation can be useful for recycling/reusing the polymer waste to prevent or reduce environmental pollution. It can also be induced deliberately to assist structure determination. Following table shows the degradation time and months for polymers:

Polymer	Degradation Time, Months
Polycaprolactone	24-36
Poly(L-lactide)	24
Poly(DL-lactide)	12-18
Polyglycolide	3-4
95:5 Poly(DL-lactide-co-glycolide)	12
90:10 Poly(DL-lactide-co-glycolide)	10
85:15 Poly(DL-lactide-co-glycolide)	9
75:25 Poly(DL-lactide-co-glycolide)	5
50:50 Poly(DL-lactide-co-glycolide)	2
90:10 Poly(DL-lactide-co-caprolactone)	9
75:25 Poly(DL-lactide-co-caprolactone)	6
50:50 Poly(DL-lactide-co-caprolactone)	2
Polydioxanone	12
Polyesteramides	4-12
Copolyoxalates	4-12
Polycarbonates	2-12
Poly(glutamic-co-leucine)	24-48

Table 1. Degradation time of Polymers.

H. *Need for Biodegradable Polymers-*[2]

1) Leaving non-biodegradable foreign materials in the body for an indefinite time period caused toxicity problem that's why surgical removal of a drug depleted delivery system was difficult.
2) Avoid reduction in bone density.
3) No need for a second surgery for removal of polymers.
4) Give excellent potential as the basis for controlled drug delivery.

I. *Advantage of Biodegradable polymers-*[2]

1) Biodegradable polymers play the role of a drug depot providing a more or less long-term supply of drug to the blood at a constant rate.
2) As biocompatible materials as a rule
3) The polymer carrier would degrade into non toxic, absorbable subunits which would be subsequently metabolized.
4) Degradable system eliminates the necessity for surgical removal of implanted device following depletion of a drug.

J. *Disadvantage of Biodegradable polymers-*[2]

1) Degradable systems which are administered by injection of a particulate form are non-retrievable.
2) Sometimes degradable polymers exhibit substantial dose dumping at some point.

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3) A "burst effect" or high initial drug release soon after administration is typical of most system.

K. Factors Affecting Biodegradation Of Polymers[9-13]

1) Chemical structure.
2) Chemical composition.
3) Presence of ionic groups.
4) Distribution of repeat units in multimeters.
5) Molecular weight.
6) Configuration structure.
7) Presence of unexpected units or chain defects.
8) Molecular weight distribution.
9) Morphology (amorphous/semicrystalline, microstructures, residual stresses).
10) Presence of low-molecular-weight compounds.
11) Processing conditions.
12) Annealing.
13) Sterilization process.
14) Storage history.
15) Shape
16) Site of implantation.
17) Adsorbed and absorbedcompounds(water,lipids,ions etc).
18) Physiochemical factors (shape and size changes, m,echanical stresses, stress and solvent-induced cracking etc).
19) Mechanism of hydrolysis (enzymes versus water).

III. CONCLUSION

It can be concluded from the whole discussion that Biodegradable polymers have potential for the development of new, advanced and capable of delivering a wide range of bioactive materials. There are numerous synthetic biodegradable polymers which are available and targeted drug delivery applications. However, only few have entered the market since many drugs faces the problem of sensitivity to heat, shear forces and interaction between polymers. These problems can be overcome by fully understanding the degradation mechanism to adjust the release profile.

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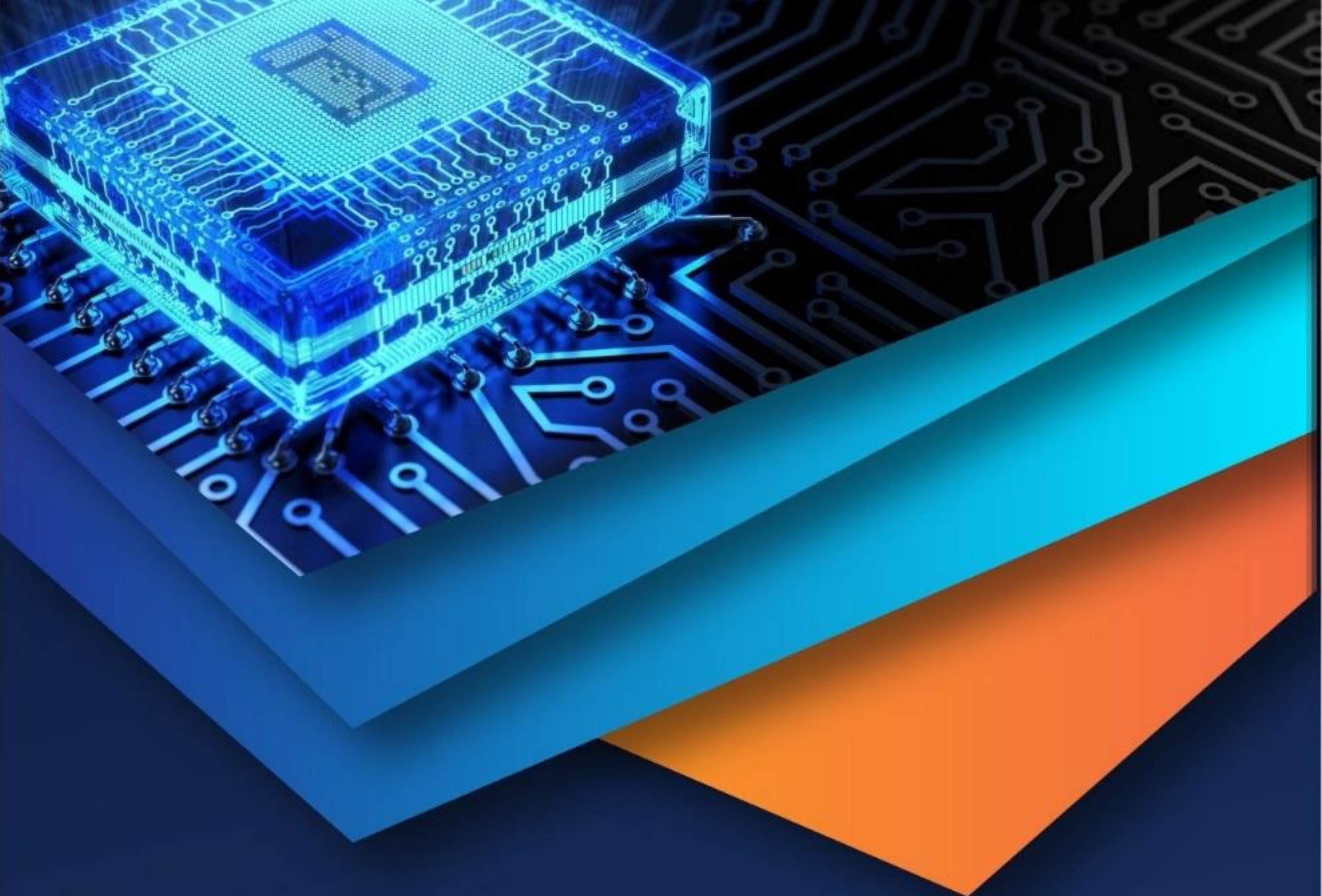

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