IJPSR (2012), Vol. 3, Issue 12 **(Research Article)**

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 11 June, 2012; received in revised form 21 November, 2012; accepted 29 November, 2012

PLGA: A POLYMER OF CHOICE AS NANOCARRIER'S TO ACHIEVE EFFECTIVE DELIVERY OF MEDICINAL SUBSTANCES

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Keywords:
PLGA polymer, Biodegradation, Nanoparticles, Double emulsion solvent evaporation method, Immunogenicity, Gene delivery

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ABSTRACT

Poly (D,L-lactide-co-glycolic acid) the first synthetic biodegradable polymer used in surgery as resorbabe material, is also approved by USFDA for use in drug delivery. The nanoparticle composed of PLGA can be used for both controlled and targeted drug delivery. There are various grades of PLGA which are having different biodegradation characteristics such as degradation takes place in several days to years. Thus one can develop a nanoparticulate delivery system with desired characteristics like Biodegradation, Biocompatibility, Particle size, Surface property, Drug release, Targetability and Immunogenicity. This review focus on the PLGA, its characteristics, Method of preparation of nanoparticles for lipophillic and hydrophilic drugs and the use of nanoparticles via different routes to target various disease conditions.

INTRODUCTION: Biomaterials mainly biopolymers play an important role in human health. According to their degradation properties, biopolymers can be further classified into biodegradable and non-biodegradable biopolymers. Many implants, such as bone substitution materials, some bone fixing materials, and dental materials, should possess long term stable performance in the body. In recent years, developments in tissue engineering, regenerative medicine, gene therapy, and controlled drug delivery have promoted the need of new properties of biomaterials with biodegradability.

Biologically derived and synthetic biodegradable biopolymers have attracted considerable attention. Biopolymers with diverse specific properties are needed for in vivo applications because of the diversity and complexity of in vivo environments. Nowadays, synthetic biopolymers have become attractive alternatives for biomedical applications for the following reasons:

1. Most biologically derived biodegradable polymers possess good biocompatibility.
2. Chemical modifications to biologically derived biodegradable polymers are difficult.
3. Chemical modifications may cause the alteration of the bulk properties of biologically derived biodegradable polymers.
4. A variety of properties can be obtained and further modifications are possible with properly designed synthetic biopolymers without altering the bulk properties [1].

The first synthetic polymers designed specifically for use in the body as resorbable materials were the polyglycolides, also known as poly (glycolic acid)s, which were used to make the Dexon sutures in 1970. In parallel, research on aliphatic polyesters derived from lactic acid was initiated and led to the first lactic/glycolic copolymer (PLAGA) exploited as the Vicryl suture. The PLAGA-based sutures, which did not require surgical removal after healing, paved the way for many other applications known as temporary therapeutic applications.

Research on PLAGA polymers, copolymers, and stereocopolymers has been extensive, resulting in many preparation, formulation and characterization techniques for both implantable and injectable controlled delivery systems. A 1974 patent, filed in 1971, by American Cyanamid describes resins containing polyglycolic acid units for water-degradable packaging and slow release materials. By the late 1980s, the number of patents for lactide- and glycolide-based implants and other devices had escalated significantly. Currently, both implantable and injectable controlled delivery systems are largely dependent on degradation and removal of the delivery device with few to no adverse biological reactions. Both academic and industrial researchers have focused on understanding the biodegradation mechanisms of these polymers and the effect on their performance of preparation, processing, and sterilization procedures [2].

Lactide/glycolide copolymers have had such strong success in drug delivery formulations because their degradation can range from 3 weeks to over a year, depending on the composition of the copolymer as well as the method of preparation and formulation. The fastest degradation is seen for copolymers with 50:50 ratio of lactide to glycolide and with low molecular weights.

Decreasing the degree of crystallinity will also increase the degradation rate of the resulting polymer. The ability of PLAGA polymers to dissolve in a variety of organic solvents as well as to be extruded into a number of shapes has been instrumental in exploring their use from biodegradable sutures into implants, microparticles, nanoparticles, and fibers for an ever-increasing number of controlled release formulations and devices [3].

One particular advantage is that because PLA and PGA have significantly different properties, careful choice of copolymer composition allows for the optimization of PLGA for intended applications. Property modulation is even more significant for PLGA copolymers because with 25–75% lactide composition, PLGA forms amorphous polymers, which are very hydrolytically unstable compared with the more stable homopolymers. This is evident in the degradation times of 50:50 PLGA, 75:25 PLGA, and 85:15 PLGA being 1-2 months, 4-5 months, and 5-6 months, respectively.[1]

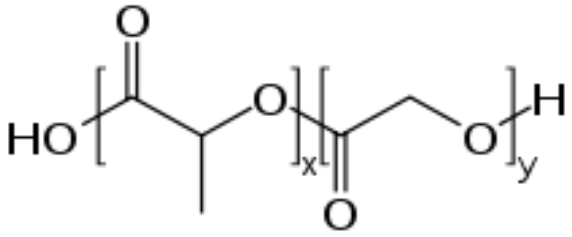

FIG. 1 : STRUCTURE OF POLY(D,L-LACTIDE-CO-GLYCOLIC ACID)

Synthesis of PLGA: PLGA or poly (lactic-co-glycolic acid) is a co-polymer which is synthesized by means of random ring-opening co-polymerization of two monomers, the cyclic dimers (1, 4-dioxane-2,5-diones) of glycolic acid and lactic acid. During polymerization, successive monomeric units (glycolic or lactic acid) are linked together in PLGA by ester linkages, thus yielding linear, aliphatic polyester as a product [4, 5, 6, 7].

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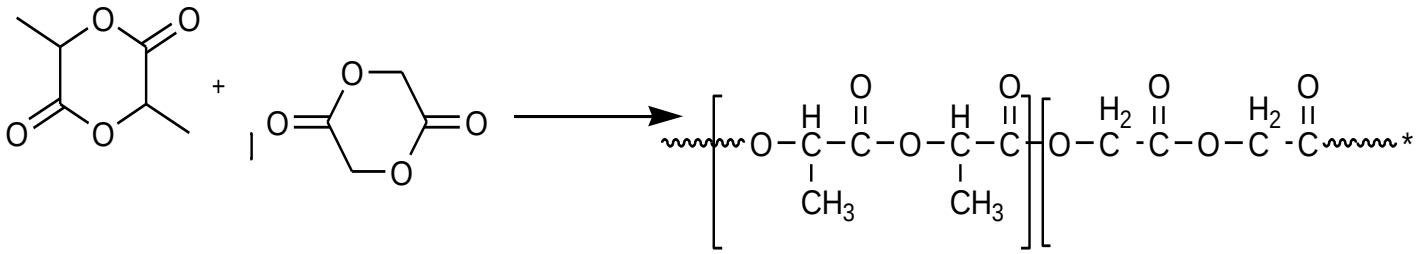

FIG. 2 : SYNTHESIS OF PLGA

Owing to their excellent biocompatibility, the biodegradable polyester called poly (D, L-lactide-co-glycolide) (PLGA) is the most frequently used biomaterial and is already commercialized for a variety of drug delivery systems (blends, films, matrices, microspheres, nanoparticles, pellets, etc.). Polymeric nanoparticles of this polymer are used for the delivery of various drugs (antipsychotic, anesthetics, antibiotics, antiparasites, antitumorals, hormones, proteins, etc.).

PLGA has been successful as a biodegradable polymer because it undergoes hydrolysis in the body to produce the original monomers, lactic acid and glycolic acid. These two monomers under normal physiological conditions, are by-products of various metabolic pathways in the body. Since the body effectively deals with the two monomers, there is very minimal systemic toxicity associated with using PLGA for drug delivery or biomaterial applications.[4, 5]

Physicochemical Properties of PLGA: PLGA prepared from L-poly lactide (L-PLA) and poly glycolide (PGA) are crystalline co-polymers while those from D,L-PLA and PGA are amorphous in nature It has been found that PLGAs containing >70% glycolide are amorphous in nature. Physical properties such as the M.W. affect the mechanical strength of the polymer and its ability to be formulated as a drug delivery device. Also, these properties may control the polymer biodegradation rate and hydrolysis. Commercially available PLGA polymers are usually characterized in terms of intrinsic viscosity, which is directly related to their M.W.

The mechanical strength, swelling behavior, capacity to undergo hydrolysis and, subsequently, the biodegradation rate are directly influenced by the crystallinity of the PLGA polymer. The resultant crystallinity of the PLGA co-polymer is dependent on the type and the molar ratio of the individual monomer components (lactide and glycolide) in the copolymer chain. PLGA polymers containing a 50:50 ratio of lactic and glycolic acids are hydrolyzed much faster than those containing a higher proportion of either of the two monomers. PGA is highly crystalline because it lacks the methyl side groups of the PLA. Lactic acid is more hydrophobic than glycolic acid and, therefore, lactide-rich PLGA co-polymers are less hydrophilic, absorb less water and subsequently degrade more slowly.

It has a glass transition temperature (Tg) of 45°C and an inherent viscosity of 0.5-0.8 mPa. The Tgs of the PLGA co-polymers are above the physiological temperature of 37°C and hence they are normally glassy in nature. Thus, they have a fairly rigid chain structure, which gives them significant mechanical strength to be formulated as a degradable device. It has been reported that the Tgs of PLGA decrease with the decrease of lactide content in the co-polymer composition with decreasing M.W. [8, 9].

Biodegradation of PLGA: In both *in vitro* and *in vivo*, the PLGA co-polymer undergoes degradation in an aqueous environment (hydrolytic degradation or biodegradation) through cleavage of its backbone ester linkages. The polymer chains undergo bulk degradation and the degradation generally occurs at a uniform rate throughout the PLGA matrix. It has been recorded that the PLGA biodegradation occurs through random hydrolytic chain scissions of the swollen polymer.

The carboxylic end groups present in the PLGA chains increase in number during the biodegradation process as the individual polymer chains are cleaved. These are known to catalyze the biodegradation process. It has also been reported that large fragments are degraded faster internally and amorphous regions degrade faster than crystalline regions. The biodegradation rates of the PLGA co-polymers are dependent on the molar ratio of the lactic and glycolic acids in the polymer chain, M.W. of the polymer, the degree of crystallinity and the Tg of the polymer.

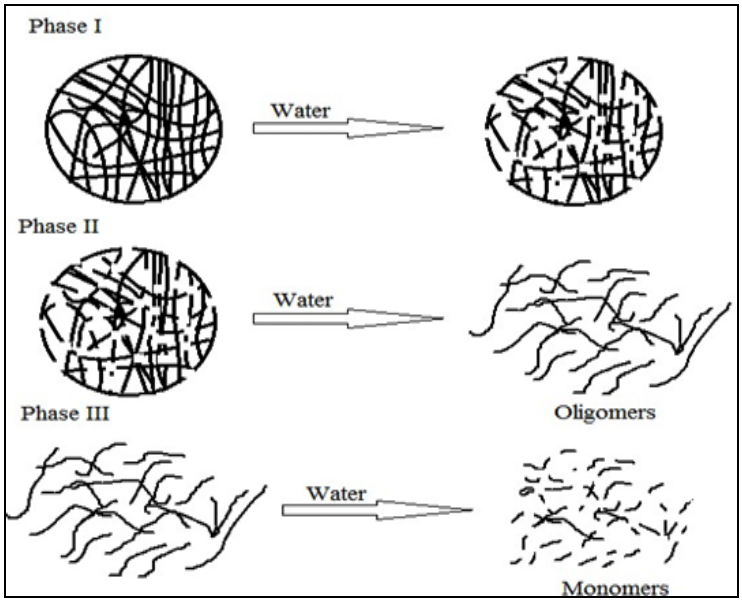

FIG. 3 : DEGRADATION OF PLGA BASED DELIVERY SYSTEM

A three-phase mechanism for PLGA biodegradation has been proposed:

1. Random chain scission process. The M.W. of the polymer decreases significantly, but no appreciable weight loss and no soluble monomer products are formed.
2. In the middle phase, a decrease in M.W. accompanied by a rapid loss of mass and soluble oligomeric and monomer products are formed.
3. Soluble monomer products formed from soluble oligomeric fragments. This phase is that of complete polymer solubilization.

The role of enzymes in any PLGA biodegradation is unclear. Most of the literature indicates that the PLGA biodegradation does not involve any enzymatic activity and is purely through hydrolysis. However, some findings have suggested an enzymatic role in PLGA breakdown based on the difference in the in vitro and in vivo degradation rates. It has also been found that motion and buffers may affect their rate differences. However, it is known that PLGA biodegrades into lactic and glycolic acids. Lactic acid enters the tricarboxylic acid cycle and is metabolized and subsequently eliminated from the body as carbon dioxide and water. Glycolic acid is either excreted unchanged in the kidney or it enters the tricarboxylic acid cycle and is eliminated as carbon dioxide and water [10].

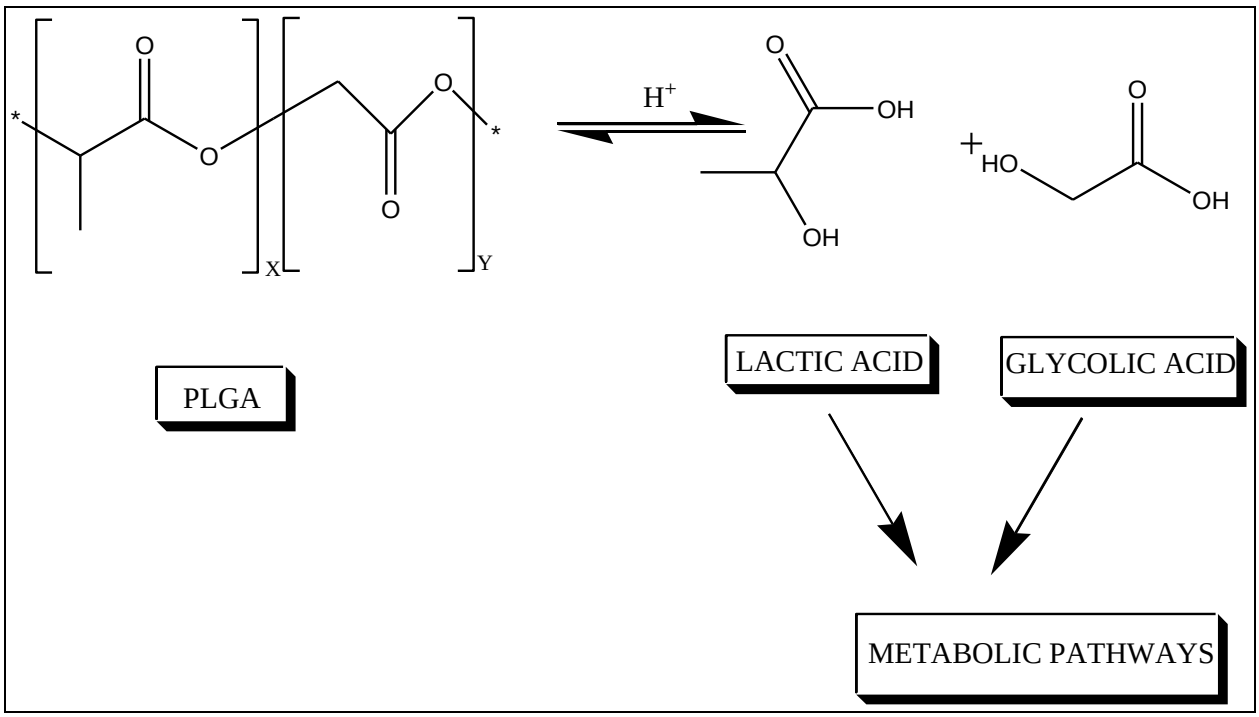

FIG. 4 : BIODEGRADATION OF PLGA

Biocompatibility of PLGA: The PLGA polymer had several advantages like good mechanical properties, low immunogenicity and toxicity, excellent biocompatibility and predictable biodegradation kinetics.

The wide acceptance of the lactide/glycolide polymers as suture materials made them attractive candidates for biomedical applications like ligament reconstruction, tracheal replacement, surgical dressings, vascular grafts and nerve, dental and

fracture repairs. PLGA microspheres (average size 30 µm) induced a mild foreign body reaction and were reported to be biocompatible. The volume of microspheres injected into the tissue may be considered as an open porous implant, which induces an inflammatory response characterized by the infiltration of macrophages, neutrophils, fibroblasts and some lymphocytes and by the formation of fibrin, giant cells and new blood vessels. Tissue reaction to the PLGA microsphere injection site after Week 1 showed heavy macrophage infiltration around the muscle due to a systemic rise in the level of activated macrophages, which release cytokines, growth factors and other bioactive agents to modulate the function of other cell types in the inflammatory milieu.

The release of octreotide acetate from PLGA microspheres has been tested in rabbits and humans. Similar release patterns from rabbits and humans were observed [8, 9].

Different compositions of PLGA:

Composition rate		weight-average molecular weight	inherent viscosity (dl/g)
DL-lactic acid	glycollic acid		
100	0	5,000	0.085-0.099
100	0	10,000	0.118-0.137
100	0	15,000	0.147-0.177
100	0	20,000	0.177-0.216
75	25	5,000	0.082-0.098
75	25	10,000	0.119-0.140
75	25	15,000	0.152-0.185
75	25	20,000	0.186-0.230
50	50	5,000	0.088-0.102
50	50	10,000	0.122-0.143
50	50	15,000	0.154-0.186
50	50	20,000	0.187-0.229

Nanoparticles: Nanoparticles are defined as particulate dispersions or solid particles with a size in the range of 10-1000nm. The drug is dissolved,entrapped, encapsulated or attached to a nanoparticle matrix. Depending upon the method of preparation, nanoparticles, nanospheres or nanocapsules can be obtained. Nanospheres are matrix systems in which the drug is physically and uniformly dispersed. In recent years, biodegradable polymeric nanoparticles, particularly those coated with hydrophilic polymer such as poly(ethylene glycol) (PEG) known as long-circulating particles, have been used as potential drug delivery devices because of their ability to circulate for a prolonged period of time, target a particular organ, a carriers of DNA in gene therapy, and their ability to deliver proteins, peptides and genes.[11, 12]

Nanoparticles are defined as solid, submicron-sized drug carriers that may or may not be biodegradable. The term nanoparticle is a collective name for both nanospheres and nanocapsules. Nanospheres have a matrix type of structure. Drugs may be absorbed at the sphere surface or encapsulated within the particle. Nanocapsules are vesicular systems in which the drug is confined to a cavity consisting of an inner liquid core surrounded by a polymeric membrane. In this case the active substances are usually dissolved in the inner core but may also be adsorbed to the capsule surface.

Nanoparticles are receiving considerable attention for the delivery of therapeutic drugs [13, 9].

Particle size is one of the key features in determining performance because it influences circulating half-life, cellular uptake and biodistribution. The kinetic aspects of drug release are also strongly influenced by particle size. Early interest in drug-loaded particles centered on their application as vehicles for sustained drug release, but now there is great interest in using similar particles for targeting the delivery of drugs to specific tissues, vascular beds, and cells. For the latter application smaller particles, particularly those in the range of ~100 nm, are likely to be advantageous because they are taken up by cells at rates 15 to 250 fold greater than micron size particles. This difference in the rate of uptake can be the distinction between specific and non-specific uptake.

The uniformity of the particle population is also a significant factor in performance. Preparations of particles that are highly uniform will exhibit more consistent biodistribution, cellular uptake, and drug release. Preparations of particles lacking uniformity will exhibit variance in all of these parameters, making it difficult to draw conclusions about which subset of the particle population is responsible for biological effect [14].

The major goals in designing nanoparticles as a delivery system are to control particle size, surface properties and release of pharmacologically active agents in order to achieve the site-specific action of the drug at the therapeutically optimal rate and dose regimen.

The advantages of using nanoparticles as a drug delivery system include the following:

- Particle size and surface characteristics of nanoparticles can be easily manipulated to achieve both passive and active drug targeting after parenteral administration.
- They control and sustain the release of drug during the transportation and at the site of localization, altering organ distribution of the drug and subsequent clearance of the drug so as to achieve increase in drug therapeutic efficacy and reduction in side effects.
- Controlled release and particle degradation characteristics can be readily modulated by the choice of matrix constituents.
- Drug loading is relatively high and drugs can be incorporated into the systems without any chemical reaction.
- Site-specific targeting can be achieved by attaching targeting ligands to surface of particles or use of magnetic guidance.
- The system can be used for various routes of administration including oral, nasal, parenteral, intra-ocular etc.[8, 15, 16, 14, 7]

Methods for preparation of PLGA Nanoparticles: Several methods for polymeric nanoparticle production have been developed by researchers. These methods generally include two main steps. The first step is to prepare an emulsified system, and this is common to all the methods used. The nanoparticles are formed during the second step, which varies according to the method used. In general, the principle of this second step gives its name to the method. Some methods do not require the preparation of an emulsion prior to obtaining the nanoparticles, and are based on spontaneous Precipitation of a polymer or through self assembly of macromolecules. The commonly used methods for preparation of PLGA nanoparticles are briefly described [10].

1. **Emulsification Solvent Evaporation:** Emulsification solvent evaporation is one of the most frequently used methods. The polymer and the drug are first dissolved in a water-immiscible volatile solvent, such as dichloromethane or chloroform, which is then emulsified in an aqueous solution containing a stabilizer. The emulsification is brought about by subsequent exposure to a high-energy shearing source, such as an ultrasonic device or homogenizer.

   The organic phase is evaporated under reduced pressure or vacuum, resulting in a fine aqueous dispersion of nanoparticles. The nanoparticles are collected by ultracentrifugation and washed with distilled water to remove stabilizer residues or any free drug, and then lyophilized for storage.

   The emulsion evaporation method can be used for the preparation of particles with sizes varying from a few nanometers to micrometers by controlling the stirring rates and conditions, and shows high efficiency for the incorporation of lipophilic drugs. To entrap hydrophilic drugs, the double-emulsion technique is employed, which involves the addition of aqueous drug solution to organic polymer solution under vigorous stirring to form a water-in-oil emulsion. This water-in-oil emulsion is added into a second aqueous phase containing a stabilizer with stirring to form the water-in-oil-in-water emulsion. The emulsion is then subjected to solvent removal by evaporation [17].

2. **Emulsification solvent diffusion:** This method is also known as emulsification and solvent displacement. The solvent used to prepare the emulsion needs to be partly soluble in water. The polymeric solution is added to an aqueous solution, containing stabilizer under vigorous stirring. Once the oil-in-water emulsion is obtained, it is diluted with a large quantity of pure water. As a result of this dilution, additional organic solvent from the organic phase contained in the dispersed droplets can diffuse out of the droplets, leading to precipitation of the polymer.

   Suitable solvents include benzyl alcohol, propylene carbonate, ethyl acetate, isopropyl acetate, methyl acetate, methyl ethyl ketone, benzyl alcohol, butyl lactate, and isovaleric acid. This method has been used for PLGA nanoparticle preparation in many studies. It should be noted that the solvent

evaporation process is similar to this method, in the sense that the solvent must first diffuse out into the external aqueous dispersion medium before it can be removed from the system by evaporation [10].

3. **Emulsification reverse salting-out:** The emulsification reverse salting-out technique involves the addition of polymer and drug solution to a water-miscible solvent, such as acetone, and to an aqueous solution containing the salting-out agent, such as magnesium chloride, calcium chloride, and a colloidal stabilizer, such as polyvinyl pyrrolidone under vigorous mechanical stirring.

   When this oil-in-water emulsion is diluted with a sufficient volume of water, it induces the formation of nanoparticles by enhancing the diffusion of acetone into the aqueous phase. The dilution produces a sudden decrease in the salt concentration in the continuous phase of the emulsion inducing the polymer solvent to migrate out of the emulsion droplets. The remaining solvent and salting-outagent are eliminated by cross-flow filtration. Although the emulsification-diffusion method is a modification of the salting-out procedure, it has the advantage of avoiding the use of salts and thus eliminates the need for intensive purification steps.[16]

4. **Nanoprecipitation:** The nanoprecipitation method is a one-step procedure, also known as the solvent displacement method. It is usually employed to incorporate lipophilic drugs into the carriers based on the interfacial deposition of a polymer.Nanoprecipitationis performed using systems containing three basic ingredients, i.e, the polymer, the polymer solvent,and the nonsolvent of the polymer. The solvent should be organic, miscible in water, and easily removed by evaporation.

   For this reason, acetone is the most frequently used solvent with this method. Sometimes it exists as a binary blend of solvents, as acetone with a small amount of water, or as a blend of ethanol and acetone. Polymer, drug, and lipophilic surfactant (eg, phospholipids) are dissolved in a semipolar water miscible solvent, such as acetone or ethanol. The solution is then poured or injected into an aqueous solution containing stabilizer under magnetic stirring. Nanoparticles are formed immediately by rapid solvent diffusion. The solvent is then removed from the suspension under reduced pressure [10].

PLGA in Drug Delivery Systems: Devices based on polymers of lactic and glycolic acids are widely used in a number of biomedical and pharmaceutical applications. Co-polymers of lactide and glycolide, referred to as PLGA, have generated tremendous interest because of their excellent biocompatibility, biodegradability and mechanical strength.

The discovery and the synthetic work on low molecular weight (M.W.) oligomeric forms of lactide and/or glycolide polymers was first carried out several decades ago. The methods to synthesize high M.W.s of these polymers were first reported during the late 1960s and early 1970s. A number of groups have published pioneering work on the utility of these polymers to make sutures/fibers.

Various polymeric devices like microspheres, microcapsules, nanoparticles, pellets, implants and films have been fabricated using these polymers. They are also easy to formulate into various delivery systems for carrying a variety of drug classes, such as vaccines, peptides, proteins and micromolecules, which have been approved by the Food and Drug Administration for drug delivery use.

- **PLGA Nanoparticles in cancer therapy:** Because of their versatility and wide range of properties, biodegradable PLGA nanoparticles are being used as novel drug delivery systems. In particular, this class of carrier holds tremendous promise in the area of cancer therapy [4, 18, 19, 2]. Cancer is a worldwide public health problem and millions of people presently suffer from this deadly disease. Cancer research involves intensive scientific efforts to identify the causes of cancer and to develop specific strategies for its prevention, diagnosis, treatment and cure. In current anticancer therapy drugs are administered via the intravenous and/or oral route using conventional formulations, including injections, tablets, and capsules.

Controlled and targeted delivery of an anticancer agent at the site of action is necessary to maximize the killing effect during the tumor growth phase and to avoid drug exposure to healthy adjacent cells, thereby reducing drug toxicity. Nanoparticle-based drug delivery systems have many advantages for anticancer drug delivery, including an ability to pass through the smallest capillary vessels, because of their very small volume and being able to avoid rapid clearance by phagocytes, so that their presence in the blood stream is greatly prolonged. Nanoparticles can also penetrate cells and gaps in tissue to arrive at target organs including Liver, Spleen, Lung, Spinal cord and Lymph.

They may have controlled-release properties due to their biodegradability, pH, ions and/or temperature sensitivity. All these properties can improve the utility of anticancer drugs and reduce their toxic side effects. PLGA nanoparticles linked to targeting ligands are used to target malignant tumors with high affinity. PLGA nanoparticles also have large surface areas and functional groups for conjugating to multiple diagnostic (e.g., optical, radio isotopic, or magnetic) agents. Nanoparticle carriers have high stability in biological fluids, and are more able to avoid enzymatic metabolism than other colloidal carriers, such as liposomes or lipid vesicles [4, 18, 20].

- **PLGA Nanoparticles in targeted gene delivery:** Gene therapy involves the delivery of one or more genes and the sequences controlling their expression into the target cell or tissue. These newly delivered genes can then replace a defective gene or add genes, which "rewrite" certain aspects of the cell's functions, thus producing new proteins. The delivery of genes to the cell or tissue needs to be carried out using a vehicle, approved for clinical applications, which facilitates the gene's entrance into the cell. We have developed two new vehicles for gene delivery: Nanoparticles and ultrasound waves.

  The nanoparticles containing the new gene are injected into the site of interest where they are taken up by the cells and release their gene contents in the cells. The ultrasound energy, which is given from outside the body, forces the entrance of genes into the organ without the need of invasive surgery. Both technologies are used to deliver genes, which encode for the anticancer drugs [21, 7].

  Biodegradable nanoparticles have been used frequently as gene delivery vehicles due to their extensive bioavailability better encapsulation, high stability, and minimal toxicity. They can be tailor made to achieve both controlled drug release and tumor targeting by tuning the polymer characteristics and shaping the surface through nanoengineering. A number of different polymers, both synthetic and natural, have been utilized in formulating biodegradable nanoparticles.

  One of the most extensively investigated polymers for nanoparticles is the biodegradable and biocompatible poly(D,L-lactide-co-glycolide) (PLGA), which has been approved by the FDA for certain human clinical uses [21].

- **PLGA nanoparticles in delivery of proteins and peptides:** Significant advances in biotechnology and biochemistry have led to the discovery of a large number of bioactive molecules and vaccines based on peptides and proteins. Development of suitable carriers remains a challenge due to the fact that bioavailability of these molecules is limited by the epithelial barriers of the gastrointestinal tract and their susceptibility to gastrointestinal degradation by digestive enzymes.

  Polymeric nanoparticles allow encapsulation of bioactive molecules and protect them against enzymatic and hydrolytic degradation. For instance, it has been found that insulin-loaded nanoparticles have preserved insulin activity and produced blood glucose reduction in diabetic rats for up to 14 days following the oral administration. The surface area of human mucosa extends to 200 times that of skin48. The gastrointestinal tract provides a variety of physiological and morphological barriers against protein or peptide delivery, e.g.,

  a) Proteolytic enzymes in the gut lumen like pepsin, trypsin and chymotrypsin;

b) Proteolytic enzymes at the brush border membrane (endopeptidases);

c) Bacterial gut flora

d) Mucus layer and epithelial cell lining itself.

The histological architecture of the mucosa is designed to efficiently prevent uptake of particulate matter from the environment. One important strategy to overcome the gastrointestinal barrier is to deliver the drug in a colloidal carrier system, such as nanoparticles, which is capable of enhancing the interaction mechanisms of the drug delivery system and the epithelia cells in the GI tract [19, 22, 23].

- **PLGA Nanoparticles for Drug Delivery Into The Brain:** The blood-brain barrier (BBB) is the most important factor limiting the development of new drugs for the central nervous system. The BBB is characterized by relatively impermeable endothelial cells with tight junctions, enzymatic activity and active efflux transport systems. It effectively prevents the passage of water soluble molecules from the blood circulation into the CNS, and can also reduce the brain concentration of lipid-soluble molecules by the function of enzymes or efflux pumps.

  Consequently, the BBB only permits selective transport of molecules that are essential for brain function. Strategies for nanoparticle targeting to the brain rely on the presence of and nanoparticle interaction with specific receptor-mediated transport systems in the BBB. For example polysorbate 80/LDL, transferring receptor binding antibody (such as OX26), lactoferrin, cell penetrating peptides and melanotransferrin [23, 24].

CONCLUSION: Nanotechnology offers new ways to address these drug delivery challenges and are being applied in a wide range of healthcare settings. Given a responsible Research & Development strategy, including the early consideration of public safety concerns, significant therapeutic advances are to be expected from this growing field within the next few years.

Looking further into the future, nanomedical concepts such as dissolving 'smart' applications, ticking tablets, and implantable systems able to monitor disease biomarkers and deliver the appropriate therapeutics are transforming science fiction into fact as the supporting technologies advance.

PLGA is a suitable biomaterial or polymer for the preparation of novel drug delivery systems due to its biodegradability and biocompatibility. The present review summarized the recent studies on PLGA based polymeric nanoparticles. PLGA-based polymeric nanoparticles loaded with different drugs showed effectiveness in their respective therapies.

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How to cite this article:
Verma A, Ratnawat S, Sharma G, Gupta AK and Jain S: PLGA: A Polymer of Choice as Nanocarrier's to achieve effective delivery of Medicinal Substances. *Int J Pharm Sci Res*. 3(12); 5087-5096.