Review Article *ISSN: 2277-8713*
Margaret Mercy, IJPRBS, 2013; Volume 2(3): 215-224 *IJPRBS*

INTERPENETRATING POLYMER NETWORK (IPN) MICROPARTICLES AN ADVANCEMENT IN NOVEL DRUGDELIVERY SYSTEM: A REVIEW

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IJPRBS-QR CODE *PAPER-QR CODE*

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Accepted Date:
16/05/2013
Publish Date:
27/06/2013
Keywords
Interpenetrating polymer network (**IPN**),
Micro particles,
Hydro gels

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Abstract

An interpenetrating polymer network (IPN) is any material containing two polymers, each in network form. An IPN is a combination of at least two polymers, and IPN can produce synergistic effect by sharing the properties of both the polymers consequently avoiding the limitations of natural as well as synthetic polymers. The present review discusses various types of IPN. Various methods of preparation and advantages on IPN are elaborated. The concepts of high swelling capacity, specificity and sensitivity of IPN play an important role in targeting delivery of drugs. IPN has various advantages as a biomaterial and is widely used as carrier systems for delivery of the short biological half life drugs.

INTRODUCTION:

During the past decades, a diversity of polymer-based pharmaceutical carrier systems have been developed as a new means of the controlling temporal or distributional drug delivery [1]. These controlled drug release systems offer numerous advantages in comparison with conventionally administered drugs in dosage forms, such as improved efficiency and reduced toxicity. Polymeric cross-linked carrier matrices, such as micro particles, hydro gels and supra molecular polymer aggregates are typical examples of common drug delivery devices.

INTERPENETRATING POLYMER NETWORK (IPN):

An interpenetrating polymer network (IPN) is any material containing two polymers, each in network form. An IPN is a composite of at least two polymers, exhibiting varied characteristics, which is obtained when at least one polymer network is synthesized or cross linked independently in the immediate presence of the other or in other words [2]. An IPN is a combination of at least two polymers chains each in network form, of which at least one is synthesized. The three conditions for eligibility as an IPN are as follows:

1. The two polymers are synthesized or cross linked in the presence of the other.

2. The two polymers have similar kinetics.

3. The two polymers are not dramatically phase separated.

STRUCTURE OF IPN:

An IPN is a combination of at least two polymers, exhibiting different characteristics, it is prepared when at least one polymer network is synthesized or cross linked independently in the presence of the other without any covalent bonds between them.

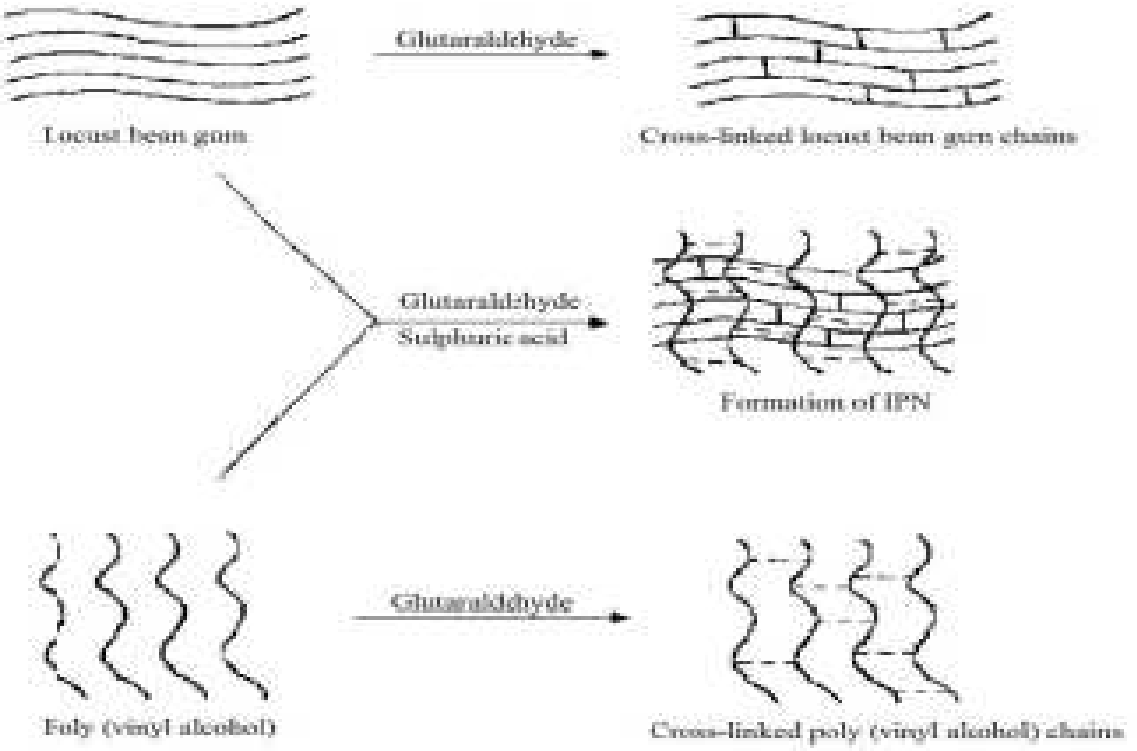


Figure-1: Structure of IPN

EFFECTS OF IPN:

IPN can produce synergistic effect by sharing the properties of both the polymers consequently avoiding the limitations of natural as well as synthetic Polymers [3]. Interpenetrating polymer network (IPN) is not formed from normally mixing of two or more polymers and also does not produce from copolymers.

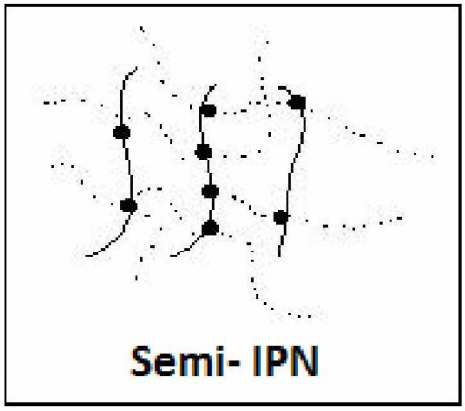
CLASSIFICATION OF IPN:

BASED ON CHEMICAL BONDING

Covalent Semi IPN: It contains two separate polymer systems that are cross linked to form a single polymer network.

Non Covalent Semi IPN: In this only one of the polymer systems is cross linked.

Non Covalent Full IPN: In which the two separate polymers are independently cross linked.



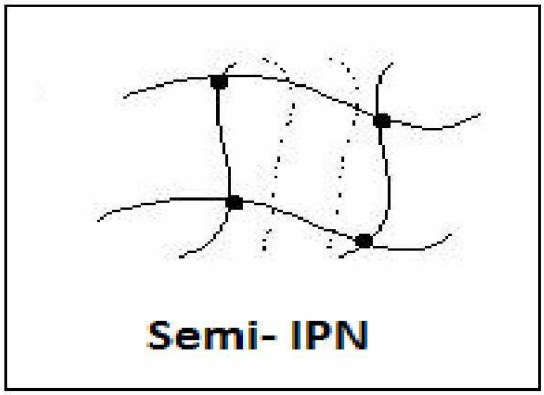


Figure-2: Covalent semi IPN **Figure-3**: **Non covalent semi IPN**

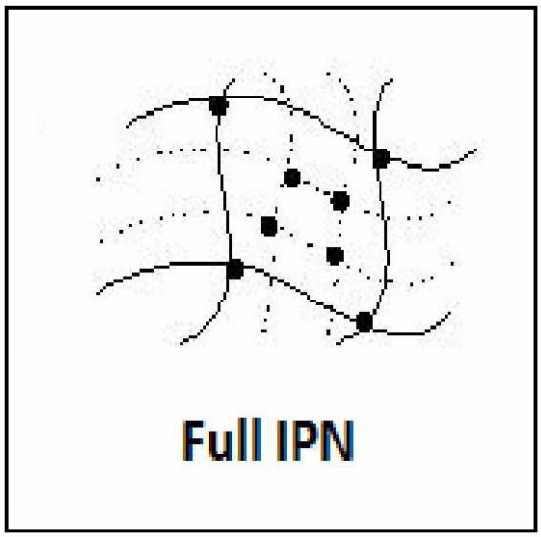


Figure-4: Full IPN

BASED ON ARRANGEMENT PATTERN NOVEL IPN:

Polymer comprising two or more polymer networks which are at least partially

Inter-locked on a molecular scale but not co-valently bonded to each other and cannot be separated unless chemical bonds are broken [4].

Sequential IPN: In sequential IPN the second polymeric component network is polymerized network.

Simultaneous IPN: Simultaneous IPN is prepared by a process in which both component networks are polymerized.

Semi IPN: If only one component of the assembly is cross linked leaving the other in a linear form, the system is termed as semi IPN.

GENERAL CLASSIFICATION OF IPN:

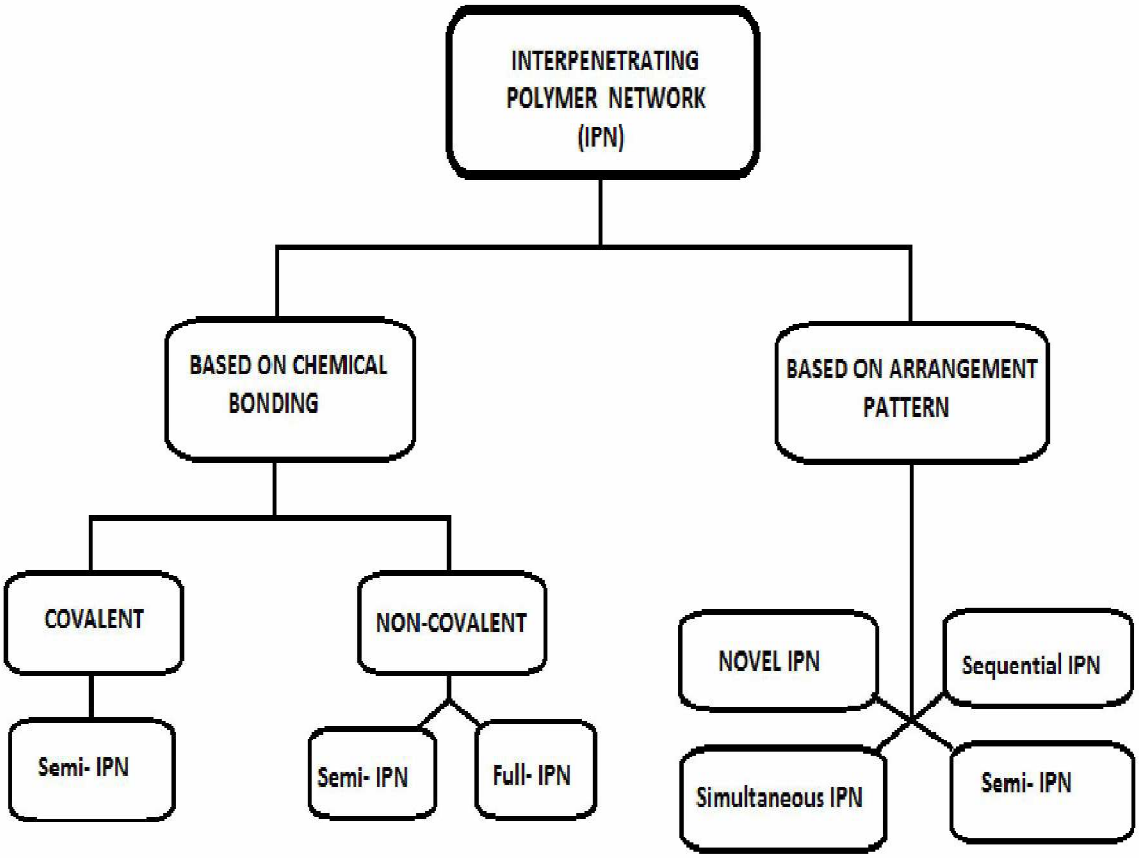
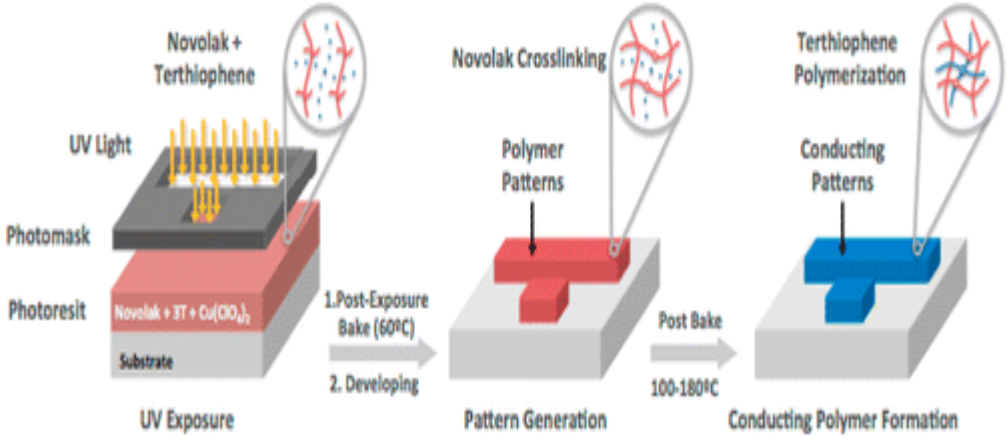
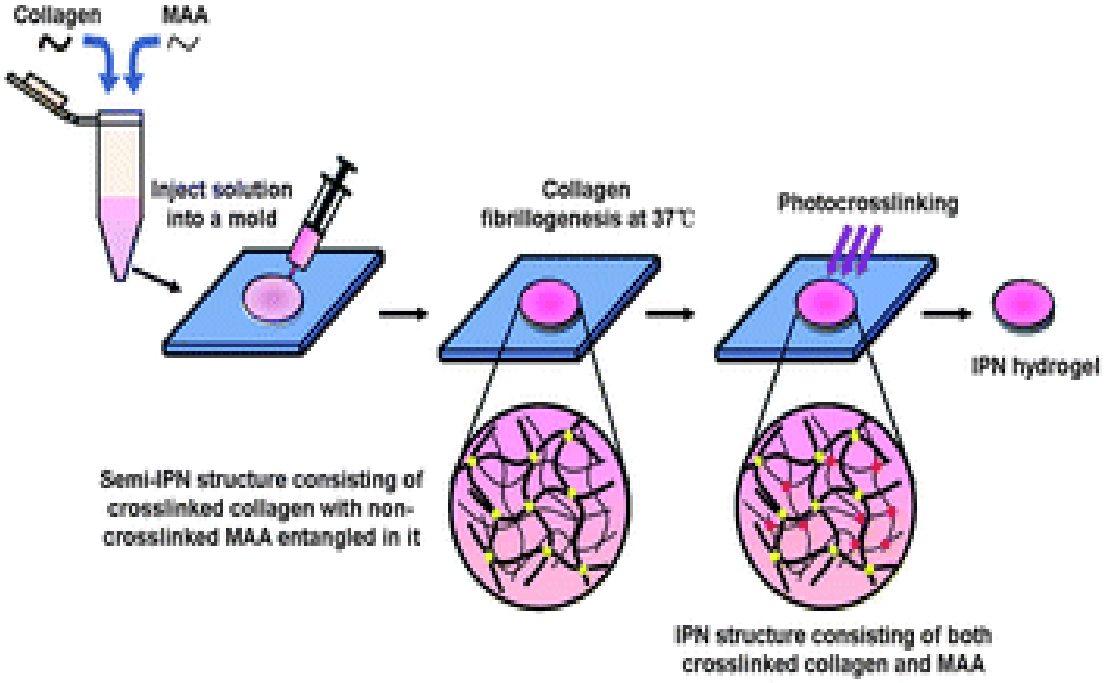


FIG-5: General Classification of IPN

FIG-6: INSITU PREPARATION OF IPN

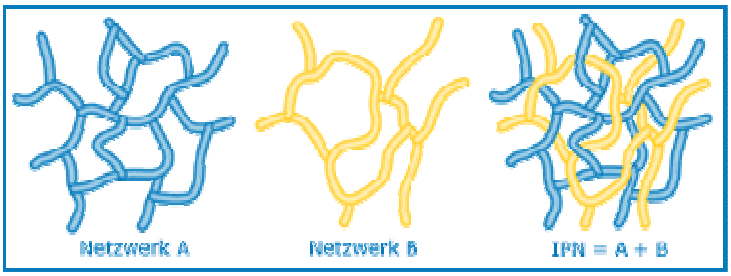


INSITU METHOD OF PREPARATION OF IPN: The in-situ polymerization inside several host polymers such as Novolak-based negative-tone photo resist, polystyrene (PS), poly(4-vinylphenol) (P4VP), poly(methyl methacrylate) (PMMA), and poly(4-vinylphenol)-co-(methyl methacrylate) (P4VP-co-MMA) to form an interpenetrating polymer network (IPN). The in situ synthesized into the NovolaK matrix by a post bake after the lithography process (exposure + development)[2]. The electrical conductivity of the patterned film is 10^{-2} S/cm. this synthetic approach is of potential application to modify the conductivity of numerous insulating polymers while preserving their physical and chemical properties.



Hydro gels hold great promise for bone tissue engineering but their application is greatly limited by their low cell affinity and poor mechanical properties, as well as limited cell spreading ability for anchorage dependent cells such as osteoblasts. In this study, a series of hydro gels based on an interpenetrating polymer network (IPN) of methacrylated alginate (MAA) and collagen were developed to support pre-osteoblast spreading and proliferation as well as estrogenic differentiation.

Figure-7: Characteristic features of IPN



The ideal characteristics of an IPN are as follows [3, 4]:

a) An ideal IPN can suppress creep and flow.

b) IPN can swells in solvents without dissolving.

c) IPNs are distinguishable from blends, block copolymers, and graft copolymers.

d) To keep the Separate phases together when the blends are subjected to stress.

e) These systems differ mainly because of the number and types of crosslink's that exist in the system.

STEPS INVOLVED IN THE PREPARATION OF IPN BY DIFFERENT METHODS

1) Formation of three immiscible chemical phases.

2) Deposition of coating material

3) Rigidization of the coating material.

METHODS OF PREPARATION OF IPN:

1. Coacervation Phase Separation:

a) Incompatible polymer addition:

b) Non-solvent addition:

c) Salt addition:

d) Polymer-polymer interaction:

e) Solvent evaporation:

2. Multiorifice-Centrifugal Process:

3. Pan Coatings:

4. Air Suspension Coating:

5. Spray Drying and Spray Congealing:

6. Polymerization:

7. Melt-dispersion technique:

8. Emulsion-cross-linking method

MECHANISM OF DRUG RELEASE:

The release of drugs from biodegradable microspheres can be classified broadly into four different categories.

1) Degradation controlled monolithic system

2) Diffusion controlled monolithic system

3) Erodible poly-agent system

ADVANTAGES OF IPN:

In modern era polymer IPN systems gaining huge popularity due to its following inherent advantages [2, 3]:

a) IPN is also attractive in producing synergistic properties from the component

Polymers. For example, when a hydrophilic gelling polymer is interpenetrated with a relatively hydrophobic gelling polymer [3] the resultant IPN hydro gel is expected to have an improved capability of immobilizing a drug.

b) IPN systems are known to increase the phase stability of the final product.

c) IPN enhances the mechanical properties of the final product.

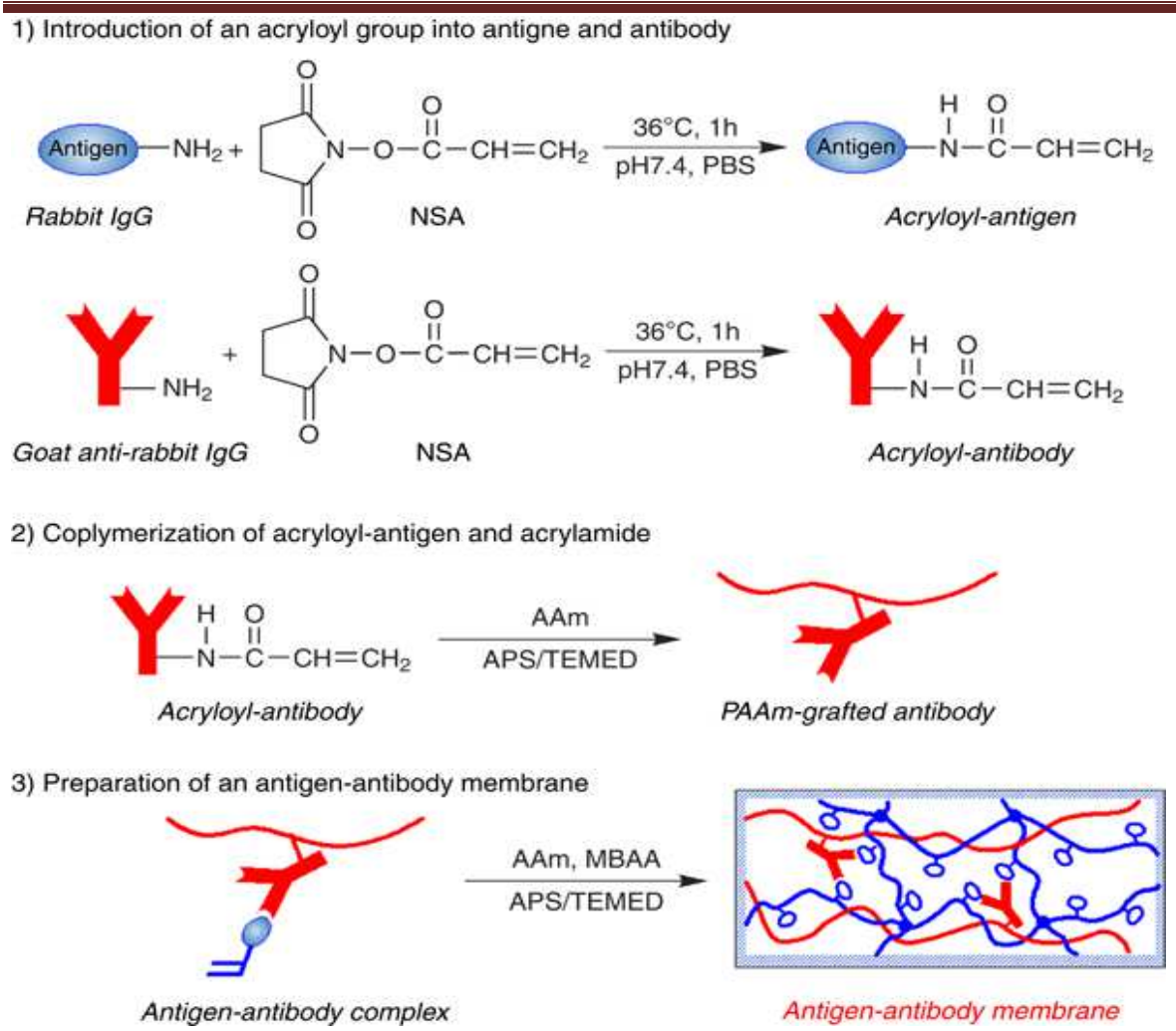
d) As long as the reacting ingredients are blended thoroughly during the synthesis, thermodynamic incompatibility can be made to overcome due to the permanent interlocking of the network segments.

e) Polymer comprising two or more polymer networks which are at least partially interlaced on a molecular scale but not covalently bonded to each other and cannot be separated unless chemical bonds are broken.

Bioengineered Tissue:

Tissue engineering is a promising field with the view to provide functional replacement of impaired tissues or organs to patients [4]. Tissue engineering requires a mechanically stable, biocompatible and biodegradable scaffold that permits cell adherence and proliferation and allows protection of cell specific properties.

FIGURE-8: Introduction of Acryloyl group in to antigen and antibody



PROBLEMS OCCURING WITH IPN MICROSPHERES OF NON-COVALENT IPN:

1) The problem with the non-covalent systems, which can also be a problem with the covalent systems, is the lack of an effective interface.

2) This problem could stem from several factors including surface energy phenomena and lack of molecular interactions between phases. Organic-Inorganic associations show several polymers that can interact with the inorganic phase.

3) These polymers are proposed to hydrogen bond with the inorganic phase, creating an interface between the two materials.

4) the key to having non-covalent organic-inorganic materials is not only utilizing a polymer that can have hydrogen bonding between the two phases but also to have low loading of the inorganic phase.

CONCLUSION:

The concepts of high swelling capacity, specificity and sensitivity of IPN play an

important role in targeting delivery of drugs. By understanding the nature of drug delivery systems and their durability in the body, which can interact with the systems, can be identified. IPN has various advantages as a biomaterial and is widely used as carrier systems for delivery of the short biological half life drugs.

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