Short Communication

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Research and Comparison on Modification of Medical Polylactic Acid

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ABSTRACT

Due to its good biocompatibility, polylactic acid (PLA) has always been a research hotspot in the field of biomedical materials. This paper introduces and exemplifies the methods of PLA modification in detail and compares them. Different methods have advantages and disadvantages. In terms of medical materials, it can be selected according to different application requirements.

Keywords: Medical PLA; PLA Monomer; Toughening Modification

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PLA which is widely used in orthopedic implants, drug carriers, and medical films, can be degraded into harmless lactic acid. There are two main methods for the synthesis of PLA: direct polycondensation of lactic acid and ring-opening polymerization of lactide [1]. When lactic acid is directly polycondensed, high molecular weight PLA cannot be obtained due to the production of water. High molecular weight PLA is usually prepared by the ring-opening polymerization process of lactide. There are two main ways of PLA *in vivo*: hydrolysis and enzymatic degradation [2]. In the actual process, the two degradation modes work together, and which mode is dominant is closely related to the internal structure of the material, hydrophilicity, and molecular weight.

PLA Synthesis Method

There are three ways to synthesize PLA, direct polycondensation of lactic acid monomer, ring-opening polymerization of propylene glycol ester and further polymerization of lactic acid prepolymer. The first method is to directly obtain the polymer by the bulk condensation polymerization of lactic acid monomer. This method is simple to operate, low in cost and high in purity, but it is not easy to obtain high molecular weight PLA. The second method which most literatures use to prepare PLA [3], can obtain high molecular weight PLA. Depending on the catalyst, it can usually be divided into anionic ring-opening polymerization, cationic ring-opening polymerization and coordination. Ring-opening polymerization. The third method is to first heat the lactic acid monomer to prepare a prepolymer, then add a catalyst to the system and remove the water generated by the reaction.

Toughening and Modification of PLA

Block Toughening

Block copolymers are generally soft and hard segments connected polymers with good toughness and elasticity. The introduction of polymer segments with low glass transition temperature into the main chain of PLA has obvious toughening effect. Polytrimethylene carbonate and polycaprolactone have good

biological activity, can be degraded non-toxic *in vivo*. At the same time, the monomer can be directly ring-opening polymerization with lactide, which is a biodegradable product. Excellent choice for polymer materials.

Graft Toughening

Graft toughening is generally based on rubber as the main chain, PLA segment as the side chain or direct synthesis of branched PLA. Inside the polymer, the PLA side chains are entangled with each other, which increases the stress transfer and realizes the toughening of the material. The PLA grafting reaction can initiate the polymerization of lactide through macroinitiators to form dendritic polymers to increase the toughness of PLA [4], such as polyisoprene.

Co-Blended Toughening

Co-blended is a method in which two or more polymers are uniformly mixed in a certain way (solution, melt or mixing) to improve material properties. Compared with the copolymerization method, the Co-blended method is simple, low in cost and widely used in industry. Polycaprolactone degradation products are nontoxic, have good biocompatibility, and have high elongation at break, making it the best choice for the toughening phase of biomedical PLA [5].

Plasticizing and Toughening

Plasticizers have good compatibility and can reduce the glass transition temperature of materials, improve the flexibility of glassy polymers, and play a role in toughening and plasticizing [6]. Polyethylene glycol has good biocompatibility, is degradable *in vivo* and the degradation products are non-toxic. Adding it to PLA can improve the crystallization speed of PLA.

Composite Toughening

In order to improve the mechanical properties of PLA and obtain strong PLA, inorganic nanoparticles can be introduced into the system to form a ternary composite toughened system. Montmorillonite, tricalcium phosphate and hydroxyapatite have been used [7]. It is proved that it can promote the mechanical properties of the material.

Comparison of Different Toughening Methods

The Co-blended toughening is simpler than block toughening and graft toughening, and is easier to use in industry, but it does not significantly improve the thermomechanical properties of PLA. The block toughening has obvious toughening effect on the material, and due to the chemical bonding between the molecular chains, the thermomechanical properties of the polymer change significantly. The above toughening methods are often accompanied by a decrease in mechanical strength. The introduction of nanoparticles can alleviate this situation, but some nanoparticles have poor dispersion, which has a negative impact on the mechanical properties of the material. The above-mentioned toughening methods have advantages and disadvantages and can be selected according to the application requirements. Biomedical materials have high requirements on the controllability of their components, structures, and properties. To achieve the controllable construction of biomedical PLA systems, it is necessary to select appropriate methods for different application scenarios.

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