Preparation and characterization of medical gelatin matrix composites

Yao Zhang
Zhuhai College of Jilin University, China
403208788@qq.com

Abstract. Gelatin is a kind of macromolecule hydrophilic colloid which is processed by collagen. It exists widely in nature and belongs to renewable green resources. A new composite material can be obtained by combining gelatin as raw material and other substances. New gelatin composites exhibit superior properties and are widely used in medicine, food, cosmetics and other fields. Based on the structural properties of collagen materials, the preparation of medical gelatin-based composites was studied according to the composite principle and method in materials science. The characteristics of medical gelatin-based composites and their applications in medicine were also described.

Key words. Collagen, gelatin, composite, preparation, characteristics

1. Introduction
Gelatin belongs to macromolecular hydrocolloid, which is obtained by collagen degradation. Collagen is a kind of green resource widely existing in nature. It belongs to a kind of biopolymer and fibrin with biological function. Collagen is synthesized from animal cells. As far as the structure of collagen is concerned, its molecular chain is composed of amino acids. The peptide chain formed by the combination of amino acids has a left-handed structure. Each of the three left-handed peptide chains forms a right-handed large helix structure (also known as the triple helix structure). Unique molecular structure makes collagen have good biological properties, and it often exists as a support for living tissue. With the development of material chemistry, collagen has been found to promote blood coagulation and endow connective tissue with certain mechanical strength. Therefore, in the course of more than 20 years of research, people began to try to use collagen as raw material to develop collagen products for biomedical, food, cosmetics.

Gelatin is a macromolecular hydrocolloid obtained from collagen degradation. In general, collagen has two ways to degrade into gelatin. Collagen can be deformed into gelatin by physical action (such as light, heat, ultraviolet light, etc.), and can be degraded into gelatin by chemical conditions (such as acid, alkali, enzyme catalysis, etc.). Gelatin is still composed of amino acids, but it has lost its biological activity because of the destruction of the three helical structures in collagen molecules by physical or chemical processes. Biologically inactive gelatin has many excellent properties, such as film forming, surface activity and colloid protection, so it was developed into a "commercial protein" in the early days. However, gelatin also has some limitations, such as moisture resistance and poor mechanical properties. It is a hotspot for domestic and foreign scholars to reconstruct gelatin by means of materials science and
endow it with superior properties. In this paper, the composite reaction of gelatin and natural polymer materials was studied, and the properties of gelatin composite materials and their applications in medicine were explained.

2. Preparation, characteristics and application of medical gelatin matrix composites

2.1. Preparation of gelatin matrix composites as medical carrier materials

A kind of gelatin matrix composites for enzyme immobilization and drug release were prepared by the compound reaction of alginate and gelatin. Sodium alginate is a kind of alginate which is widely used. It is a by-product of deiodination and demanitol of kelp. Sodium alginate belongs to a kind of natural polysaccharide by structure analysis. Because of its good fluidity and certain stability, it has broad application space in medicine and food industry. Sodium alginate reacts with calcium ions to form a molecular structure similar to an elliptical spherical egg box (see Fig. 1); gelatin produces a fixed spatial structure due to temperature-induced changes in the molecular spatial structure. Because the mechanism of alginate formation is different from gelatin, the reaction mechanism of the two compounds is more complex in the process of composite reaction. Wang Ailing, a scholar, obtained a kind of gelatin composite material based on sodium alginate through investigation and experiment, and then immobilized Aspergillus niger lipase with the gelatin composite material as the carrier. After considering the influence factors of gelatin, sodium alginate concentration, temperature and calcium ion concentration, the optimum material control conditions for preparing gelatin-based carrier of immobilized Aspergillus Niger lipase were obtained (see Table 1).

![Fig 1. Structure of calcium alginate gel egg box](image)

| Table 1. The best material control conditions for preparing gelatin base of immobilized enzyme sodium alginate |
|-------------------------------------|----------------------------------|
| Influence factor                   | Optimal control condition        |
| Sodium alginate concentration     | 1.25%                            |
| Gelatin concentration             | 0.5%                             |
| Calcium concentration             | 10%                              |
| Fixed enzyme quantity             | 450IU/g                          |
| temperature                       | 35°C                             |
| PH                                | 9.0                              |
| Categories of organic solvents and metal ions | common |
The results showed that the gelatin-based carrier of immobilized Aspergillus Niger lipase significantly improved the thermal stability of the enzyme and expanded the application space of the enzyme. Foreign scholars have tried to prepare a blend membrane based on sodium alginate and gelatin. The blend membranes were prepared by evaporative solvent. The researchers added ciprofloxacin to the membranes and crosslinked it with calcium ion solution (5%). After drying, the membranes with a thickness of about 40 microns were obtained. The experimental results show that when the gelatin content is controlled to 50%, the mechanical properties of the film are the best, and the elongation at break is close to 20%. X-ray diffraction experiments showed that the diffraction peaks of sodium alginate shifted obviously with the addition of gelatin, which indicated that a compound reaction took place between the two. However, under the scanning electron microscope observation, the longitudinal section of the film was smooth and uniform, which indicated that there was a good relationship between sodium alginate and gelatin. Fusion. Fig. 2 is a cross-sectional view of sodium alginate and gelatin film formed under scanning electron microscopy. Fig. 3 is a cross-sectional view of the film formed after adding ciprofloxacin. It can be seen that the longitudinal section of the film in Figure 2 is more uniform and flat, and there are many "voids" in the longitudinal section of the film in Figure 3, which is formed after the dissolution of gelatin. The results showed that the longer the crosslinking reaction time, the slower the drug release rate, and the gelatin content was proportional to the drug release rate.
2.2. *Gelatin based composites for skin tissue*

The composite materials with biodegradability and mechanical properties can be obtained by the composite reaction of chitosan and gelatin, which is expected to be used in artificial skin grafting. Chitosan belongs to a class of natural organic compounds. It mainly exists in the outer wall of algae and in the shell of arthropods. It has good film-forming and adsorption properties, and is widely used in the field of medicine. Using chitosan and gelatin to blend can achieve a “complementary” effect, chitosan can significantly improve the water resistance and mechanical properties of gelatin, while gelatin can be more regular distribution of chitosan chain. Yu Zuyu, a scholar, used chitosan and gelatin as the main raw materials and prepared a kind of blend membrane with different structure by dry-wet separation method. The gelatin/chitosan blend film was prepared according to the ratio of gelatin to chitosan about 2:7.8. The obtained film was vacuum defoamed and dried. Then the film was set in the mixed solution of sodium hydroxide and sodium carbonate (2.0% sodium hydroxide and 0.5% sodium carbonate) for about 20 hours. The chitosan / gelatin blend membrane can be obtained by washing and drying. Chitosan/gelatin blend membranes have two different layers inside and outside, with a spongy layer inside (see Figure 3) and a dense layer outside (see Figure 4). The longer the drying time, the higher the density and smoothness of the film, and the lower the mechanical hardness of the film. Since the properties of the membrane are more suitable for artificial skin, people began to try to apply it to artificial skin grafting.

![Fig 4. outer structure of chitosan / Gelatin Blend Membrane](image1)

![Fig 5. inner structure of chitosan / Gelatin Blend Membrane](image2)
3. Summary

In summary, this paper mainly explores two kinds of medical gelatin composite materials, including drug carrier and artificial skin, and their preparation, characteristics and applications. Today, with the gradual depletion of natural resources, it is very important to develop new artificial materials. Gelatin, as a kind of abundant natural resources, will be combined with other polymer compounds to obtain a series of high-performance compounds which can be used in many fields, which is of great significance for saving limited natural resources and promoting social development.

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