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Application of Double Emulsion System in the Preparation of Microcapsules

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Abstract

Double emulsion is a kind of multiple emulsion system, which has the ability to protect substances and control the release of these substances from one phase to another. In recent years, the combination of this kind of emulsion system and traditional microcapsule preparation methods has been widely used in the preparation of microcapsules, which solves the problem that the traditional microcapsule preparation methods cannot effectively encapsulate highly water-soluble substances. In this paper, the common preparation methods of microcapsules based on W/O/W double emulsion system are discussed, and the main factors affecting the preparation of microcapsules are discussed, which are internal water phase volume, internal and external water phase osmotic pressure, stirring speed and the selection of emulsifier, in order to provide theoretical support for the application of double emulsion system in microcapsule preparation.

Keywords

Microcapsule; Double Emulsion System; Preparation Methods.

1. Introduction

According to their properties and the mechanism of capsule wall formation, the preparation methods of microcapsules can be divided into physical method, chemical method and physicochemical method. The most studied methods are in-situ polymerization, interfacial polymerization, complex coacervation, solvent volatilization, spray-drying and so on. In these methods, the embedding of lipophilic or insoluble substances is often realized by Ohammer W single emulsification technology, but this technology poses a severe challenge to the entrapment of highly water-soluble substances. The results show that the microcapsules of water-soluble substances can be prepared efficiently by constructing double emulsion system.

The double emulsion system obtained by double emulsification can be divided into two types according to the different media in the continuous phase, one is oil-in-water (O/W/O) type, which is suitable for water-soluble capsule materials to encapsulate oil-soluble substances, and the other is water-in-oil-in-water (W/O/W) type, which is suitable for the encapsulation of water-soluble substances and is the most widely studied double emulsion system at present. At present, many researchers at home and abroad have successfully prepared different types of microcapsules by combining W/O/W double emulsion with complex coacervation method, solvent volatilization method and membrane emulsification method. Food additives (xylitol,

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sucralose, antioxidants, etc.) generally choose double emulsion-complex coacervation method to prepare microcapsule products to achieve the purpose of prolonging the sweetness of food or masking its bitterness. Water-soluble drugs such as proteins and peptides (including interferon, vascular endothelial growth factor, etc.) can be encapsulated by double emulsion solvent volatilization to achieve the purpose of drug release. In addition, drug-loaded lysozyme and bovine serum albumin can also be used to obtain microcapsules with uniform particle size and high entrapment efficiency by membrane emulsification and double emulsion method. In this paper, the application of double emulsion system in the preparation of microcapsules and the factors affecting the preparation of microcapsules were discussed in detail, in order to provide theoretical support for the application of double emulsion system in the preparation of microcapsules.

2. Preparation of Microcapsules based on W/O/W Double Emulsion System.

2.1. Preparation of Double Emulsion System.

Taking the preparation of W/O/W double emulsion as an example, there are two preparation methods of the emulsion system, which are one-step emulsification and two-step emulsification. Because the two-step emulsification method is easier to operate and control than the one-step emulsification method, and the stability of the emulsion is higher, the W/O/W double emulsion is often prepared by the two-step emulsification method. The steps of preparing double emulsion system by two-step emulsification method are as follows: (1) the water-soluble substance is dissolved in the aqueous phase, and the lipophilic emulsifier is dissolved in the oil phase, and the two are mixed uniformly, and theW/O emulsion is obtained by high-speed shearing. (2) the W/O emulsion is added to the outer aqueous phase containing hydrophilic emulsifier, and the Wcord O/W emulsion is prepared by low speed and emulsification.

2.2. Preparation of Microcapsules based on W/O/W Double Emulsion System.

At present, the preparation of microcapsules based on W/O/W double emulsion system is mainly the combination of double emulsion system and traditional microcapsule preparation methods to prepare microcapsule products. The purpose is to solve the main problem that the traditional microcapsule preparation methods can not efficiently encapsulate highly water-soluble substances, but also can better protect the biological activity of substances, and obtain microcapsules with smaller particle size, higher entrapment efficiency and controlled release.

2.2.1. Double Emulsification-complex Coacervation Method.

The complex coacervation method takes two kinds of substances with opposite charge as capsule materials, and makes the two substances with opposite charge agglomerate due to electrostatic action by changing the pH value, temperature or concentration of the solution, thus preparing microcapsules. This method is only suitable for microencapsulation of insoluble solid powder or liquid.

2.2.2. Double Emulsion Solvent Volatilization.

The basic principle of solvent volatilization method is to dissolve the core and wall materials in a certain organic solvent, then disperse into the medium in the state of droplets, and then heat to remove the volatile solvent to prepare microcapsules. The main defect of this method is that the encapsulation efficiency of water-soluble substances is low, which affects the accumulation of core materials on the surface of microcapsules, which is prone to sudden release, resulting in the release of a large number of drugs in a short time and a sudden increase in the level of blood drugs in the body. thus affecting the role of drugs.

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2.2.3. Membrane Emulsification Double Emulsion Method.

Membrane emulsification double emulsion method is an improved method to prepare microcapsules by combining rapid membrane emulsification method with double emulsion solvent volatilization method. the most important feature of this method is that the drug-loaded microcapsules with uniform particle size can be prepared simply and rapidly. it can also improve the performance of sustained and stable drug release. The operation steps are divided into three steps: (1) the preparation of the pre-coated emulsion; (2) the preparation of the composite emulsion by pressing the pre-coated emulsion through the SPF (Shirasu Porous Glass) membrane under a certain pressure; and (3) stirring the compound emulsion at room temperature until the solvent volatilizes completely, and the microcapsules are obtained by curing, centrifugation, washing and drying.

3. Main Factors Affecting the Preparation of Microcapsules by Double Emulsion System

3.1. Internal Aqueous Phase Volume

Only the inner aqueous phase within a certain range of volume can form uniform pores on the surface of the microcapsules and provide a channel for the release of the contents. The pore structure can not be formed when the volume of the inner water phase is too small, and when the volume of the inner water phase gradually increases to a certain value, it can ensure that the inner water phase escapes to form a pore. If the volume of the inner water phase further increases, although the inner water phase can escape to form a pore structure, due to the relatively slow curing rate, the oil phase will merge and eliminate the pores.

3.2. Internal and External Aqueous Phase Osmotic Pressure.

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3.3. Emulsion Stirring Speed.

The emulsifying and stirring methods of double emulsion system mainly include ultrasonic emulsification and high-speed shearing. The stirring speed of emulsification directly affects the particle size of microcapsules. It was found that with the increase of ultrasonic power and ultrasonic time, the more sufficient the emulsification was, the smaller the particle size of the emulsion droplets was and the smaller the particle size of the microcapsules was. However, if the ultrasonic power is too low, it is easy to produce solid polylactic acid microcapsules, resulting in low entrapment efficiency.

3.4. Emulsifier.

Emulsifiers are needed to control the size of emulsion droplets in the preparation of double emulsion system. Hydrophobic emulsifiers are generally used in the inner water phase, and Span series are commonly used in the inner water phase, while hydrophilic emulsifiers are used in the outer water phase, such as Tween series with higher HLB value. Different emulsifiers and concentrations will affect the stability of the emulsion. Through the study on the effect of the amount of different emulsifiers in colostrum on the particle size of microcapsules, it is shown that when the volume fraction of emulsifier is 6%, the particle size of microcapsules is the smallest, and when the volume fraction of emulsifier is more than 6%, the average particle size of microcapsules increases gradually, which may be due to the increase of emulsifier dosage. The decrease of the interfacial tension of the dispersed phase reduces the agglutination

between the droplets and ensures the stability of the emulsion. when the concentration of emulsifier is too high, the viscosity of the emulsion system increases, so it is difficult to cut into small droplets. Therefore, in order to prepare microcapsules with uniform particle size and suitable size, it is necessary to choose suitable emulsifier.

4. Summary

The combination of double emulsion system and traditional preparation methods of microcapsules can achieve the entrapment of proteins, peptides and other water-soluble substances, and well protect the biological activity of these substances. The key step of this method is the construction of double emulsion system, so the microcapsules with high entrapment efficiency and uniform particle size can be obtained by selecting appropriate internal water phase volume ratio, internal and external water phase osmotic pressure, emulsion stirring speed, emulsifier and so on.

The double emulsion system can not only be combined with complex coacervation method, solvent volatilization method and membrane emulsification method, but also can be combined with spray drying method to prepare microcapsules to protect the core material from the influence of high temperature airflow during spray drying. improve the activity of the material.

The preparation of microcapsules based on double emulsion system not only has a broad application prospect in food and medicine, but also has great potential in the field of agriculture. Especially biological control, it is a research hotspot in the field of crop protection, and the antimicrobial peptides which have highly selective control effect on specific diseases are also a kind of substances with high water solubility. it is difficult to obtain high drug-loaded microcapsules by traditional microcapsule preparation methods such as in situ or interfacial polymerization. If the microencapsulated preparation is prepared by double emulsion liquid system, it can not only achieve the effect of prevention and control, but also protect the activity of antimicrobial peptides, and the protection of two layers of aqueous phase can also prevent the rapid spillover of antimicrobial peptides and achieve the purpose of slow release. Compared with the simple antimicrobial peptide solution, the microencapsulated preparation is more stable and the stress resistance is greatly improved.

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