Application research progress of cyclodextrin and its derivatives

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Abstract. The emergence of supramolecular chemistry is a new era of chemical development. It is a rapidly developing new interdisciplinary subject. Many major achievements have been made. Supramolecular chemistry refers to two molecules (host and guest) or multiple molecules. Under the action of the non-covalent bond between molecules, a highly complex multi-molecular polymer with specific functions and special properties is formed. After literature search, the cyclodextrin and its derivatives are briefly introduced based on references, and the pharmaceutical aspects of cyclodextrin and its derivatives are reviewed in terms of sources, preparation methods, properties, and applications.

Keywords: cyclodextrin; cyclodextrin derivatives, research progress.

1. Basic overview

1.1. Cyclodextrin overview

Cyclodextrin is a kind of oligosaccharide with cyclic structure.Cyclodextrin(CD)is a series of cyclic oligosaccharides produced by amylose under the action of cyclodextrin glucosyltransferase produced by Bacillus[1-3].The general term for glycans,belongs to the second-generation supramolecular macrocyclic host compound.Cyclodextrin usually contains 6-12 D-glucopyranose units,all of which are connected end to end in the form of 1,4-glycosidic bonds,and its structure resembles a conical barrel without a bottom.According to the different binding modes of glycoside bonds,cyclodextrins can be divided intoα-cyclodextrin,β-cyclodextrin andγ-cyclodextrin.Cyclodextrins were first discovered by Villies in 1891,and their research developed rapidly in the 1960s.The existence of free hydroxyl groups at the small open end of cyclodextrin makes it hydrophilic,and the cavity forms a hydrophobic zone due to the shielding effect of the C-H bond.Because the cavities of different sizes can selectively complex metal ions of different sizes,inorganic and organic molecules,and substances that are difficult to dissolve in water,they are used in catalysis science,analytical separation science,dye science,daily chemical industry,petrochemical industry,and geochemical industry[4,5].Many fields such as mineral science,cosmetic science,flavor science,food science and medicine have been widely used,and in the 21st century hot subjects such as life science,environmental science,information science,material science,nano science,aerospace and other fields Both show broad application prospects.At the same time,it also highlights a wide range of application values in various fields of industry,agriculture,national defense construction and modernization in the new era.At present,it has become a new and popular edge subject—cyclodextrin chemistry[6,7,11].

2. Introduction

2.1. Synthesis of new cyclodextrin derivatives and application in materials science

Studies have shown that the use of host-guest interactions to construct supramolecular polymers is one of the hot topics in the study of supramolecular assembly.As a kind of inorganic nano-molecules,the polymerization reaction of polymetallic oxygen clusters is also its difficulty[8-9].Some scholars believe that when the anthracene molecule is combined withγ-cyclodextrin in a ratio of 1:2,it has the effect of accelerating the photocyclization reaction.To this end,they designed and synthesized an Anderson-type polymetallic oxygen cluster material modified on both sides of anthracene and made it water-soluble through ion replacement[10].After addingγ-cyclodextrin in water,they successfully constructed a new type of linear supramolecular polymer using host-guest interactions,and formed a fibrous structure through further self-assembly.

Self-assembly in solution to form a two-dimensional supramolecular organic framework with a definite structure is a hot topic in supramolecular chemistry[12,17,22].For this reason,Jiang Fengrui of Jilin University and others have designed and synthesized a new type of three-bridged cyclodextrin and dimerized boola-type azobenzene surfactant.Through the host-guest interaction between the two in aqueous solution,the first For example,a two-dimensional supramolecular organic framework with cyclodextrin as the main body,the chirality of the cyclodextrin can be transferred to the azobenzene molecule through the host-guest interaction.They also dynamically controlled the assembly and disassembly behavior of organic frameworks through ultraviolet light and visible light.This research has enriched the building blocks of supramolecular organic frameworks and opened up a new way for the synthesis and application of two-dimensional framework materials in the future.The research will be in the material[13-15].

It has been applied in the fields of material science,organic synthesis,supramolecular synthesis and host-guest chemistry[16].

Studies have shown that bridged cyclodextrin has the advantages of good water solubility,excellent biocompatibility,and can bind and solubilize organic guest molecules,so it is an excellent structural building element.Because Anderson-type polymetallic oxygen clusters have the characteristics of easy modification,stable structure,good water solubility and inhibition of the aggregation of guest groups,for this reason,Gao Bo of Jilin University and others designed and synthesized triphenylbenzene as the center,and clicked on CuAAC.It reacts with three-bridged cyclodextrin linked to cyclodextrin[18-20].Combining bridged cyclodextrin and azobenzene-modified polymetallic oxygen clusters to obtain double-headed guest hybrids.

2.2. Cyclodextrin inclusion compound

In order to characterize the inclusion properties of inclusion compounds,when studying the inclusion process of guest molecules and cyclodextrins,an important parameter inclusion ratio is introduced,which is closely related to the inclusion constant.Guest molecules and cyclodextrins can usually form inclusion complexes in various proportions,the main forms are single,binary,ternary or even multiple[21].The most common is the inclusion ratio.The inclusion ratio of the inclusion compound can usually be measured by the equimolar continuous change method,phase solubility diagram method,ultraviolet absorption spectroscopy,fluorescence spectroscopy,differential scanning calorimetry,optical rotation,and nuclear magnetic resonance.Method molar ratio method,mole series method,etc.Cyclodextrin inclusion compounds have different structures,mainly including three types:cage type,layered,and pipeline type.

Because cyclodextrin itself is low-toxic and easy to modify,it can bridge or clathrate with some organic compounds containing N,S,O,P and other elements,so its derivatives are more widely used than cyclodextrins..Cyclodextrin derivatives are widely used in organic synthesis,catalysis,textiles and other fields.In addition,they have also been widely used in environmental protection,analytical chemistry,polymer chemistry,and pharmaceutics.

3. Application of β-cyclodextrin and its derivatives in the field of environmental protection

The application of cyclodextrin and its derivatives in the field of environmental protection is mainly in the detection and removal of pesticide residues, and the detection of various toxic substances in soil and sewage. Hu Yijun et al. prepared the inclusion compound of p-bifenthrin/β-cyclodextrin, which provided a reference for the detection and removal of pesticide residues. Ehsana et al[23-25]. obtained cyclodextrin derivatives through the reaction of β-cyclodextrin and disodium ethylenediaminetetraacetic acid to detect chromium, cadmium and other heavy metal ions that are harmful to human health in soil and sewage, and proposed an effective method to remove these heavy metals.

3.1. Application of β-cyclodextrin and its derivatives in analytical chemistry

The application of *β*-cyclodextrin in the field of analytical chemistry is mainly realized through inclusion and interaction. In recent years, it has attracted great attention from the researchers of Guangda University in two aspects of capillary electrophoresis analysis and chromatographic analysis. Palmarskottir et al. prepared 2-hydroxypropyl-β-cyclodextrin and used it as a chiral selector for the separation of certain drug enantiomers. Experiments have shown that the product has significant separation effect and high efficiency, and is very suitable for Chiral selector for capillary electrophoresis.

3.2. Application of β-cyclodextrin and its derivatives in the field of polymers

In recent years, chemical researchers from various countries have focused their research on the application of cyclodextrin in the field of high-molecular polymers. Studies have shown that the application of cyclodextrin in the field of high-molecular polymers is mainly to improve the synthesis process of polymers and characterize polymerization. The structure of things[26]. Alupei et al. showed through experiments that using isoprene as a catalyst, β-cyclodextrin can be D-A addition to polyester with greater saturation to prepare a new type of polymer, namely polypseudorotaxane.

3.3. Application of β-cyclodextrin and its derivatives in the field of pharmacy

In addition to applications in environmental protection, analytical chemistry, and polymer fields, cyclodextrin has become increasingly prominent in the field of pharmaceutics. The application of cyclodextrin derivatives in the field of pharmacy is mainly manifested in increasing the solubility of the drug, improving the irritation and toxic side effects of the drug, increasing the stability of the drug, and improving the bioavailability of the drug. In addition, the cyclodextrin inclusion compound can also play a role in slow-release of drugs and improvement of drug dosage forms. Ning et al. showed through experiments that the inclusion compound of berberine hydrochloride and trimethoprim/β-cyclodextrin can greatly increase the solubility of the drug; Xue Ming et al. successfully prepared the volatile oil/hydroxypropyl- β-cyclodextrin inclusion compound. Volatile oil can greatly increase its stability after inclusion.

4. Conclusion

Although the preparation of cyclodextrin derivatives vary,but generally not high because the yield,still need further improvement.At the same time,the excellent properties of cyclodextrin and its derivatives make it widely used in the fields of environmental protection,analytical chemistry,polymer and pharmaceutics,especially in the medical field.It is very good as a drug carrier and biological material.The biocompatibility.Because of their use in some areas of research there are still some limitations,fundamental research still needs further improvement.Next,cyclodextrin and its derivatives in the adsorptive separation material and a flame-retardant material will have much room for development.It is believed that with the further in-depth research on cyclodextrin and its

derivatives,there will be more types ofβ-cyclodextrin derivatives,and their application fields will be deeper and wider.

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