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Review on preparation methods and applications of Geological Polymer Microspheres

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Abstract

Geopolymer materials have molecular sieve-like network structure and adjustable pore structure. A number of research results have proved that geopolymers have good adsorption properties for heavy metal ions and dyes. Therefore, it is of great research significance and huge economic benefits to study the processing technology and characteristics of geopolymer microspheres. In this paper, the characteristics, applications and preparation methods of geopolymers are reviewed in order to provide scientific basis for research in this field.

Keywords

Geopolymer, Microspheres, Precipitation polymerization, Dispersion polymerization.

1. Introduction

Geopolymer material is a kind of inorganic polymer material composed of alkali activator and aluminum silicon raw material. Under alkaline conditions, cementitious hydration products with 3D network structure are formed by geological polymerization. The research and development of geopolymer materials has a long history, which can be traced back to the ancient Roman era. It mainly uses kaolin, plant ash and silicate as raw materials to form geopolymer under the action of alkali activator. Polymer microspheres are a kind of composite materials with high specific surface area and high adsorption characteristics. At present, it has shown good results in the application fields of adsorption materials, optoelectronic devices, chromatographic column fillers, coatings, and immunoassay materials. Due to the deepening research of researchers in related fields, new processes, new preparation techniques and new uses of polymer microspheres are also increasingly being discovered, which makes the functionality of polymer microspheres also develop in a diversified direction.

2. Research on geopolymer materials in the field of environmental pollution control

Geopolymer materials are widely used in wastewater treatment of heavy metals and organic dyes due to their porosity and low cost. Because geopolymers contain a large number of Al-O tetrahedrons, the charge imbalance of their skeletons leads to the presence of negative charges that enable geopolymers to attract cations. The raw material of aluminosilicate has a certain adsorption capacity, but the geopolymer material enhances this ability due to the overall pores

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and charges generated. Singhal et al. [1] used the reaction of CTAB modified metakaolin and alkali activator to prepare geopolymers, which were widely used to adsorb Cu^{2+}. The results showed that the specific surface area of geopolymers produced by CTAB modified metakaolin was as high as 216 m^2/g, and the adsorption capacity was 40 mg/g. Zhang et al. [2] also studied a fly ash-based geopolymer composed of nanoparticles with a particle size of 50 nm and a pore size of about 387 nm, which was used for photodegradation of methylene blue staining. Under ultraviolet light irradiation, the adsorption and semiconductor photocatalytic degradation efficiency was 92.79 %.

3. The characteristics of microspheres

Microspheres are spherical particles in the nanometer and micron scale. The spherical object is the most stable material form in nature. It is an ideal symmetrical body in three-dimensional geometric space and the smallest area of all three-dimensional forms in unit volume. Microspheres are spherical particles prepared by combining materials with different structures and properties in a certain way with inorganic materials or polymers as raw materials. Microspheres have various characteristics such as fluidity, biocompatibility and surface effect of functional groups, which make them fully applied in coatings, optical devices, catalytic materials and biomedicine [3].

The change in the shape of geopolymer microspheres can break through the limitations of shape and greatly broaden the application range of geopolymer materials. (1) Geopolymer has a relatively stable chemical structure. By introducing and loading functional groups, it is modified to have specific reaction functions. It can be used as a catalyst carrier for chemical and photocatalytic reactions. (2) Spherical geopolymers as adsorbents can be loaded into a fixed bed for continuous treatment. It can not only solve the problem of difficult recycling and easy agglomeration, but also greatly improve the processing efficiency and adapt to more application requirements. (3) Geopolymer materials have the characteristics of high strength and can be used as high strength support materials. (4) The traditional spherical molecular sieve often binds the molecular sieve powder into a ball through a binder, which not only complicates the process but also blocks part of the molecular sieve pores. Geopolymer gel contains the crystal structure of molecular sieve, which can be converted into molecular sieve by hydrothermal reaction under suitable conditions [4]. If the spherical geopolymer can be prepared, it can be converted into molecular sieve in situ by hydrothermal reaction, which avoids the disadvantages caused by secondary molding.

4. Preparation method of geopolymer microspheres

The preparation technology of microspheres generally includes chemical methods and physical methods. The microspheres prepared by physical methods have the advantages of uneven particle size and wider dispersion. The microspheres prepared by chemical method have high chemical stability and dispersion. In recent years, the preparation methods of microspheres generally include precipitation polymerization, suspension polymer method, hydrothermal polymer method, seed polymer method, etc.

4.1. Precipitation polymerization

Precipitation polymerization is a common method for preparing polymer microspheres. It has the characteristics of simple process, easy post-treatment and narrow particle size distribution. Since 1980, chemical precipitation polymerization has become the most common way to obtain microspheres [5]. The precipitation polymerization method is self-stable and does not require additional dispersants. These characteristics make the method require higher reaction

conditions, and the limitation of reaction conditions is also essential for the formation of polymer microspheres.

4.2. Dispersion polymerization

Dispersion polymerization is a widely used method for preparing large-sized polymer microspheres. Generally, the size of the polymer microspheres is about 0.1~10 μm. This polymerization method was invented by ICI Co., Ltd.in Canada in the early 1970 s. The whole mechanism is that at the beginning of the reaction, stabilizers, inducers, monomers, etc. are hydrolyzed in the reaction medium, and the polymer chain is not dissolved in the medium due to the extension of the polymer chain. In the medium, it slowly precipitates or diffuses into the medium [6]. The main characteristics of the method are simple process, fast reaction speed and narrow dispersion. In addition, in order to protect the environment, many working media that can diffuse polymers have been developed, such as water, ethanol, methanol / water mixed media.

4.3. Suspension polymerization

Suspension polymerization, also known as dispersion suspension solidification method, refers to the use of the interaction between the stirrer and the dispersant to float the droplets in the dispersion in the form of droplets. The droplet flow mode of each monomer is equivalent to one polymerization reactant. Under certain reaction excitation conditions, the monomer polymerizes and obtains the microspheres [7]. Suspension polymerization method is relatively simple, high efficiency, low cost, has been formed. It is one of the main preparation methods of polymer products in industrial production.

5. Conclusion

Heavy metal pollution control has become one of the major environmental issues of global concern. Adsorption method is widely used in the effective removal of heavy metal pollutants. Although there are many kinds of adsorbents, most of them are powdery. The adsorbents are difficult to recycle and regenerate, and there are hidden dangers of secondary pollution, which is not conducive to continuous application in industrialization. Microsphere adsorbents have high specific surface area, easy separation and recovery, and can be filled in a packed bed to achieve continuous treatment of wastewater. Therefore, the development of new processing technology and performance research of geopolymer microspheres has important research significance and huge economic benefits.

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