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Research Progress of Geopolymer Porous Materials

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Abstract: Compared with traditional inorganic ceramic membranes, geopolymer porous materials have the advantages of non-sintering, low cost and simple preparation process. In this paper, the raw materials and preparation methods of geopolymer porous materials are reviewed in order to provide scientific basis for the research and development of similar porous materials.

Keywords: Metakaolinite; Fly Ash; Slag; Solvent Evaporation.

1. Introduction

Porous material is a new material developed in the 20th century. It is proposed relative to dense material. It is a material with network structure composed of interconnected or closed pores and skeletons, with special functions and structures. It is characterized by low density, low thermal conductivity, large specific surface area, high specific strength, high porosity and light weight. Its porosity is based on the uniqueness of the porous structure on the basis of the original material, so that it has great changes in mechanical properties, photoelectric properties, chemical activity and so on. It can play a major role in separation, noise elimination, shock absorption and structure. Therefore, it is widely used in chemical building materials, environmental protection, aerospace and other fields.

The main parameters of porous material characterization are pore shape, pore size, pore surface properties and skeleton structure. The pore shape is spherical, tubular or reticular. The pore size and specific surface area are important parameters of the pore structure. The pore surface properties and the skeleton structure affect the physical properties of the material. According to the provisions of the International Association of Pure and Applied Chemistry, porous materials are divided into microporous (50 nm)materials according to the pore size. Microporous materials with pore size less than 0.7 nm are called ultra-microporous materials, and macroporous materials with pore size greater than 1μm are called macroporous materials.

2. Raw Materials of Geopolymer-based Porous Materials

Geopolymers are made from a wide range of raw materials, including a variety of aluminosilicate natural minerals and industrial wastes:

2.1. Metakaolinite

Metakaolin is produced by calcining kaolin clay at 500-800℃, and the calcination temperature is determined by the purity and crystallinity of kaolin. When metakaolin is the only source of aluminosilicate reactive materials, the preparation methods of porous materials mainly include solvent evaporation method, direct foaming method and adding porous filler method [1]. Its applications mainly include adsorption of metal ions and ammonium ions, building lightweight insulation material, etc. Metakaolin can also be mixed with fly ash, biomass ash, waste glass, slag, etc.to prepare geopolymer-based porous materials.

2.2. Fly Ash

Fly ash is the residue produced by coal combustion during the operation of thermal power plants. The particle size varies from less than 1 μm to more than 100 μm, and the unit specific surface area is usually 300-500 m^2/kg. When fly ash is the only source of aluminosilicate reactive materials, the preparation methods of porous materials mainly include solvent evaporation method, direct foaming method and particle stacking method [2]. Its applications mainly include building lightweight thermal insulation materials, adsorption of metal ions, pervious concrete, etc. Fly ash can also be mixed with slag, metakaolin, red mud, biomass ash, zeolite, etc.to prepare geopolymer-based porous materials.

2.3. Slag

Slag (granulated blast furnace slag) is a glassy granular material. The water slag produced by the melting process of blast furnace ironmaking is grayish white powder obtained by water quenching and grinding. It is mainly characterized by cementitious properties (potential hydraulic activity), but also shows some volcanic ash properties (reaction with lime). In many countries, slag is often used as an admixture to replace part of cement to produce blast furnace slag cement, and occupies a large market share. Slag is rarely used as the only source of aluminosilicate reactive materials for geopolymer-based porous materials [3]. It is often mixed with fly ash, metakaolin, red mud, clay, etc., especially with fly ash. This is because the fly ash-slag geopolymer system will form an aluminum-modified hydrated calcium silicate gel, which coexists with the hydrated aluminum silicate gel and can improve the mechanical properties and microstructure of the material.

3. The Preparation Method of Geopolymer-based Porous Materials

3.1. Particle Stacking Method

The particle stacking method means that the geopolymer

cannot occupy all the space outside the filling aggregate. The geopolymer-wrapped aggregate is used as a separate particle, and the particles accumulate to form pores. The filling aggregate can be large or small, and one can be various. The amount and size of the aggregate will affect the pore structure. The aggregate particle size and the pore size of the porous material are generally large and can be observed directly [4]. The geopolymer-based porous materials prepared by this method generally have good permeability and mechanical properties, and are mainly used in sub-permeable concrete and porous pavement.

3.2. Direct Foaming Method

The direct foaming method is the most studied and the most mature in several methods. By directly adding foaming agent or surfactant or both, the porous structure is produced by generating or maintaining foam inside it [5]. The pore size of the porous material prepared by this method is relatively large and can be observed directly [6]. Under the action of surface tension, there will be a small amount of circular holes on the surface of the material. Due to the mutual extrusion of bubbles inside the material, the size and shape of bubbles inside the material may be different.

3.3. Solvent Evaporation Method

Solvent evaporation method means that the porous structure of geopolymer is due to the volatilization of solvent, which leads to the existence of certain pores. The porous structure of geopolymer-based porous materials prepared by this method is difficult to be observed directly by the naked eye due to the small pore size. When observed by electron microscope, it can be seen that the material is composed of many regular or irregular particles [7]. Geopolymer-based porous materials prepared by solvent evaporation method have low porosity and small pore size, and are often used as adsorbents and membrane separation materials.

3.4. Adding Porous Filler Method

The method of adding porous filler is to add porous filler or filler that can form porous structure to make geopolymer materials have porous structure, such as adding cork, saw shoulder, porous polystyrene, porous siliceous material, recyclable lightweight aggregate, oil palm shell and so on. This method can select excellent performance in different fields.

4. Conclusion

Geopolymer is a kind of inorganic material with green environmental protection, wide raw material source and low preparation cost, and has excellent performance. High temperature resistance, chemical stability and mechanical properties. Compared with dense materials, geopolymer-based porous materials have. At present, most of the research still stays in exploring the laboratory preparation process and application of geopolymer porous materials, and there is still a large distance from large-scale industrial applications, which will also be the future research direction.

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