COMPOSITE POROUS MATERIAL, PROCESS FOR PRODUCTION AND SEPARATION OF METALLIC ELEMENT

This invention relates to a composite porous material, a process for producing the same, and a process for the separation of a metallic element. More particularly, the present invention is concerned with a composite porous material comprising a particulate inorganic porous material and, contained in the pores thereof, an organic resin having a micro-void, and a process for producing the composite porous material. It is also concerned with a process for the separation of a metallic element from a solution using the composite porous material.

Functional resins such as an ion exchange resin and a chelate resin, and functional polymer gels such as a crosslinked dextran and a crosslinked polystyrene, which have a high separating and adsorbing capacity for a substance, are widely used in separation and adsorption processes, particularly, in partition chromatography, adsorption chromatography, ion exchange chromatography, gel chromatography and the like. Known resins and polymer gels utilized for such purposes, however, are not sufficient in mechanical strength and dimensional stability of particles. Accordingly, due to the insufficient mechanical strength and dimensional stability of particles, use of such a resin or gel, for example, as a packing material for liquid chromatography is possible only under restricted conditions. That is, the height of the column, packing density of the resin particles, developing pressure, constructions of the pump and centrifuge and the like undergo severe restrictions. Because of these restrictions, it is not possible to conduct separation or adsorption of a metal ion or the like by the use of such a resin or gel in a desirable manner. Illustratively stated, in a separation process, the use of such a resin or gel tends to cause the separation time to disadvantageously increase and the yield and separation efficiency to disadvantageously decrease. In an adsorption process, the use of such a resin or gel tends to cause the adsorption time, the number of operation cycles and the needed adsorbent amount to disadvantageously increase. Further, dimensional changes due to swelling of the resin or gel by the developer cause the packing density of the packing material at the development to change, so that when several kinds of developers are to be passed through the column packed with the resin or gel, the packing density becomes unstable, whereby stable development cannot be attained by the use of the resin or gel.

These drawbacks are serious problems in utilizing such a resin or gel in a separation process, an adsorption process, and other various processes in industries. Therefore, efforts have been made in the art to solve the technical problems that the high separating and adsorbing capacity of the resin or gel which cannot be sufficiently exhibited due to the insufficient mechanical strength and dimensional stability of the resin or gel. As is apparent from the foregoing, there is a strong demand in the art for a packing material having a high mechanical strength and dimensional stability as well as a high separating and adsorbing capacity.

In order to obviate the above-mentioned problems of insufficient mechanical strength and dimensional stability, there has been proposed a composite material formed by coating a polymer over the exterior and interior surfaces of inorganic porous particles thereby, to take advantage of the excellence in such properties of the inorganic material. In this connection, reference may be made to, for example, U.S. Pat. No. 4,140,653. Likewise, there has been proposed a composite material comprising inorganic porous particles having a stationary phase coupled to the surfaces thereof through a coupling agent. See U.S. Pat. No. 4,049,496. These composite materials are, however, accompanied by the following drawback. In these composite materials, the layer of the coated resin or stationary phase is naturally very thin and, therefore, the volume amount thereof is extremely small as compared with the volume of the composite material. For this reason, the amounts of adsorption and separation of a substance per unit weight of such composite materials are extremely small. In order to atain adsorption and separation of a substance in a large amount as attained with a porous resin, a very large amount of the composite material is required. Accordingly, such composite materials have been practically employed only in specific fields in which adsorption and separation of a substance in a small amount is sufficient. In the case of the resin-coated composite material mentioned above, when the increased amount of resin is coated over the surfaces of the inorganic porous particles, the composite material is defective in that chemical species relating to the adsorption or separation diffuse into the coated resin at an extremely low rate, that the sites at which the adsorption or separation occurs are present only on the surfaces of the resin, and that hence it takes a relatively long time to begin to exhibit its adsorbing or separating capability. Further, when the amount of resin coated over the surfaces of the inorganic porous particle is too much, the micropores of the particles are closed whereby the adsorbing and separating capacity of the composite material is greatly reduced.

The above-mentioned conventional two types of composite materials comprise a large proportion of an inorganic porous particle and only a small proportion of a resin, so that the properties of the conventional composite materials are mainly affected by the properties of the inorganic porous particle. Therefore, such known composite materials have high mechanical strength and dimensional stability but cannot exhibit adsorption and separation performances comparable to those of the conventional porous resins.

With a view to obtaining a composite porous material having a high mechanical strength and dimensional stability while exhibiting excellent performance with respect to adsorption and separation, the inventors have made extensive and intensive studies. As a result, the inventors have unexpectedly found that a composite material suitable for the purpose can be obtained by incorporating an organic resin having a micro-void in the pores of a particulate inorganic porous material. Based on such a novel finding, the present invention has been completed.

It is therefore an object of the present invention to provide a composite porous material having a high mechanical strength and dimensional stability while exhibiting a high adsorbing and separating capacity comparable to those of the conventional porous resins.

It is another object of the present invention to provide a process for producing such a composite porous material of the kind mentioned above.

It is a further object of the present invention to provide a process for the separation of a metallic element