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Synthesis Methods of Mesoporous Silica Materials

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Abstract

From the discovery of mesoporous materials in 1992 at Mobil oil company, these materials are continuously gaining attraction due to their superior properties like tunable pore structure, surface morphology, huge pore volume and ability of easy functionalization. In this paper historical background of mesoporous silica materials and methods which are used to synthesize these materials such as sol-gel method, microwave assisted technique, chemical etching technique, templating approach are discussed. In templating approach a template (structure directing agent) is used to create hollow porous structure but chemical etching technique uses a selective etching agent (basic/acidic) to create mesoporous structure, here no template (soft/hard) is required. Microwave technique is used for rapid synthesis of mesoporous silica nanoparticles. In microwave technique self assembly of organosilane precursors and blockcopolymer and successive hydrothermal treatment is carried out under the microwave oven.

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*Keywords:*Mesoporous materials, nanoparticle, synthesis, structure, porous;

1. Introduction

The materials havingsmall holes (ordered or disordered) are called porous materials. The skeletal portion of the material is often called the "matrix" or "frame" (as shown in figure 1). Nano porous materials consist of a regular organic or inorganic framework supporting a regular porous structure. Examples of porous materials include: dry wall, wood, concrete, gunite, rubber, some plastic, porous silica nanoparticles, and porous carbon nanoparticles [1].

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Nomenclature

MCM	Mobil Crystalline Material
M41S	Molecular 41 Sieves
MSNs	Mesoporous Silica Nanoparticles
SBA-n	Santa Barbara Amorphous Number
FDU	Fudan UniversityShanghai Materials
IUPAC	International Union of Pure and Applied Chemistry
HMS	Hexagonal Mesoporous Silica

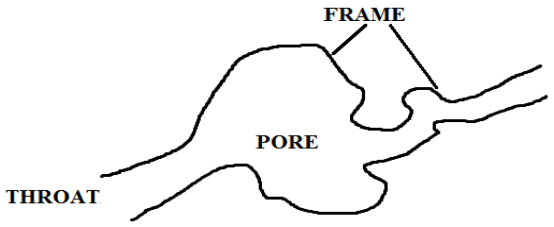

Fig 1. Porous materials

On the basis of their pore diameter IUPAC has classified porous materials into three categories shown in figure 2 [2].

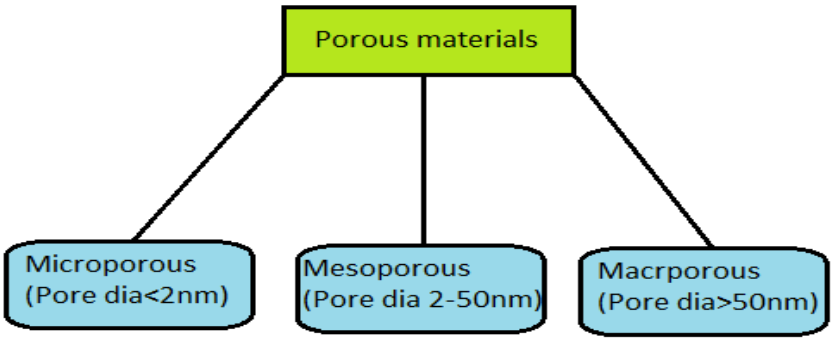

Fig. 2. Classification of porous materials.

(I) Microporous materials are the materials with pore diameters less than 2 nm. Examples of microporous materials include zeolites and metal-organic frameworks. (ii) Materials having pore diameter between 2-50 nanometer ranges are mesoporous materials. (iii) Materials having pore diameter greater than 50 nanometer are macroporous materials.

From last two decades much interest ofresearchers are continuously growing towards mesoporous silica nanoparticles (MSNs) because they are chemically and thermally stable with controllable morphology and porosity. It is observed the internal and external surfaces of these nanoparticles can be selectively modified with multiple organic and inorganic functional groups. On the basis of these features, the biocompatibility of silica, and theirefficient uptake by mammalian cells, MSNs are proposed as the basis of nanodevices for the controlled release of drugs and genes into living cells [3].For example recently chlorophyll entrapped luminescent mesoporous silica nanoparticles were synthesized for biological imaging application [4].