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Hollow Nano Silica: Synthesis, Characterization and Applications

N. Venkatathri
Department of Chemistry, National Institute of Technology, Andhra Pradesh, India

1. Introduction

Since the discovery of mesoporous silica molecular sieves by Beck et al. (Beck et al., 1992; Kresge et al., 1992), mesoporous materials have opened many new possibilities for application in the fields of catalysis (Tanev et al., 1994), separation, and nanoscience (Wu & Bein, 1994; Agger et al., 1998; Li et al., 2003; Yu et al., 2005). In recent years, fabrication of silica materials with designed structure (e.g. thin films, monoliths, hexagonal prisms, toroids, discoids, spirals, dodecahedron and hollow sphere shapes) is an important research in modern materials chemistry. Among them the fabrication of monodispersed hollow spheres with control size and shape is fastest developing area (Schacht et al., 1996; Bruinsma et al., 1997; Fowler et al., 2001). It is generally accepted that hollow sphere with mesopores will exhibit more advantages in mass diffusion and transportation as compared with conventional hollow spheres with solid shell. They can serve as a small container for application in catalysis and control release studies (Mathlowitz et al., 1997; Huang & Remsen, 1999). The methods currently used to fabricate a wide range of stable hollow spheres include nozzle reactor processes, emulsion/phase separation, sol-gel processing, and sacrificial core techniques. The fabrication of hollow spheres has been greatly impacted by the layer-by-layer (LbL) self-assembly technique (Decher, 1997). This method allows the construction of composite multilayer assemblies based on the electrostatic attraction between nanoparticles and oppositely charged polions. By varying the synthetic methodology and reactants, it is highly probable to achieve the materials with interesting morphology and properties.

The presence of pores of uniform size lined with silanol groups confers these mesoporous materials as a potential candidate for hosting a variety of guest chemical species, such as organic molecules, semiconductor clusters, and polymers (Moller & Bein, 1998). For example, MCM-41 was reported as a drug delivery system (Vallet-Regi et al., 2001). Ibuprofen has been shown to readily adsorb from an n-hexane solution into the porous matrix of MCM-41, and to slowly release into a solution simulating physiological fluid. Furthermore, it has been found that in this host/guest system there is a strong interaction between the silanol groups and the carboxylic acid of the ibuprofen molecule. Having proven the feasibility of this system for drug retention and delivery, further effort should be made in gaining control of the amount of drug delivered, and its release rate. It can be thought that this delivery rate could be modulated by modifying the interaction between the
molecules can be stored in per gram nanocuboid and MCM-41, respectively from Ultraviolet ray absorbance according to Beer–Lambert Law (Jeffery et al., 1997). The surface area and pore volume of MCM-41 and nanocuboid are very close to each other, but much more ibuprofen molecules can be stored into nanocuboid than into MCM-41. This illustrates that the hollow cores could hold more than half drug molecules of total storage amount.

Tetraethylorthosilicate (TEOS) was hydrolyzed in the presence of basic triethanolamine. However the hydrolysis rate of TEOS using triethanolamine is very slow as compared to hydrolysis with NH$_3$. For example, using the molar ratio described above, TEOS can be hydrolyzed in 2h using NH$_3$ whereas triethanolamine took 24 h to hydrolyze the TEOS. In the present synthetic recipe, triethanolamine not only act as a catalyst for the hydrolysis but also it acts as a reactant. The hydrolyzed silica monomers react with triethanolamine to give respective oxide. Such silicate-triethanolamine adduct are held together with hydrogen bonding. The triethanolamine sandwiched silica layer condensed and form nanocuboids. MCM-41 is reported to crystallize by self assembly of surfactant/template (Grun et al., 1999) in similar to nanocuboids.

4. Conclusion
A novel procedure was invented to synthesize mesoporous Silica Nano hollow cuboids with uniform size and morphology. It is characterized by various physicochemical techniques. The results are compared with Nanocrystalline silica MCM-41. Transmission electron micrographs shows, 150 nm hollow diameter and 50 nm shell thickness in hollow cuboids. Further, the mesoporous silica Nanohollow cuboids were found to store much more guest molecules than conventional mesoporous silica Nanocrystalline MCM-41.

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6. References

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In the last few years, Nanoparticles and their applications dramatically diverted science in the direction of brand new philosophy. The properties of many conventional materials changed when formed from nanoparticles. Nanoparticles have a greater surface area per weight than larger particles which causes them to be more reactive and effective than other molecules. In this book, we (InTech publisher, editor and authors) have invested a lot of effort to include 25 most advanced technology chapters. The book is organised into three well-heeled parts. We would like to invite all Nanotechnology scientists to read and share the knowledge and contents of this book.

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