Preparation of structured meso–macroporous silica materials: Application as delivery system

Santamaría. E, Maestro.A, Gutiérrez, J.M* and González. C.
Chemical Engineering Department, Faculty of Chemistry, University of Barcelona, Martí i Franqués 1-11, Barcelona 08028, Spain
**e-mail: carme.gonzalez@ub.edu*

Meso–macroporous silica materials with a well-ordered array of mesopores were prepared from oil-in-water emulsions. The influence of the following three composition variables on material characteristics was studied: emulsion dispersed phase fraction, concentration of silica and concentration of surfactant. The obtained materials were characterized via small-angle X-ray diffraction scattering, scanning electron microscopy, transmission electron microscopy, Hg intrusion porosimetry and nitrogen adsorption–desorption isotherms. A network of structured mesopores was obtained even when using a highly concentrated emulsion (volume of the dispersed phase, > 0.75). The mesopore network presented a hexagonal arrangement, with mesopore diameters between 4 and 7 nm. Non-ordered macropores, with diameters between 50 nm and 10–15 μm were also present, depending on composition variables. The isotherms were of type IV, typical of mesoporous materials, but at high p/p_0 they were the usual shape for the macroporous materials. The possibility of tailoring mesopore and macropore structures by modifying composition variables could extend the application of these materials.

In figure 1, example of meso-macroporous material with macroporous and mesoporous ordered are presented.

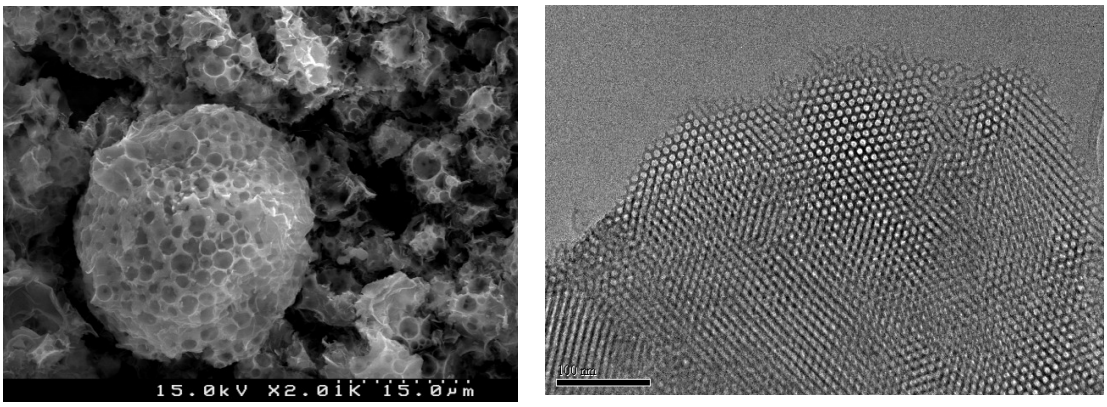


Figure 1. SEM and TEM images showing macroporous and mesoporous structures obtained

The effect of the materials' properties on ibuprofen (IBU) drug loading and release was studied. The results showed that the loading of IBU increases as the macropore presence in the material is increased. The IBU adsorption process followed the Langmuir adsorption isotherm. A two-step release process, consisting of an initial fast release and then a slower release was observed. Macropores enhanced the adsorption capacity of the material; this was probably due to the fact that they allowed the drug to access internal pores. When only mesopores were present, ibuprofen was probably adsorbed on the mesopores close to the surface. Moreover, the more macropore present in the material, the slower the release behavior observed, as the ibuprofen adsorbed in the internal pores had to diffuse along the macropore channels up to the surface of the material. The material obtained from a highly concentrated emulsion was functionalized with amino groups using two methods, the post-grafting mechanism and the co-condensation mechanism. Both routes improve IBU adsorption in the material and show good behavior as a controlled drug delivery system.

Another application of mesoporous materials is in the cosmetic world. Most sunscreen formulations are emulsions or creams. However, formulations based on nanoparticles as the delivery vehicle for the sunscreen compounds potentially have advantages in terms of retention on the skin, lack of penetration across the epidermal layer and UV attenuation by both absorption and scattering. Polyphenols were also adsorbed in the materials in order to obtain an efficient UV filter mixed with the cosmetic cream.

Keywords: Silica, emulsion, meso-macroporous, ordered mesopores, cooperative templating mechanism, ibuprofen, polyphenols, cosmetic cream.

Financial support from CYCYT CTQ2011-29336-C03-02 is gratefully acknowledged