NANOSTRUCTURED LARGE-PORE SILICA NANOMATERIALS FOR DRUG RELEASE

Daniel Carmona, Francisco Balas and Jesús Santamaría
Dpto. Ingeniería Química y Tecnologías del Medio Ambiente,
Universidad de Zaragoza – Instituto de Nanociencia de Aragón (INA), c/ Pedro Cerbuna 12, 50009 Zaragoza (Spain), and
Networking Research Center for Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN), c/ María de Luna 11, 50018 Zaragoza (Spain)
dacarmon@unizar.es

The ceramics for medical practice have been traditionally classified into two main groups, those inert materials such as alumina, zirconia or carbon and those that undergo a specific interaction with the physiological environment when implanted leading to material integration in the living tissue [1]. In the latter years, it has been also reported that silica-based ordered mesoporous materials with certain porous frameworks can be used as biomaterials with both bioactivity and controlled drug delivery ability [2].

However, the adsorption of biological molecules, such as oligopeptides, requires tailoring the interaction between matrix and adsorbed molecules for avoiding the modification of their active centres. The present work is focused in developing cage-like mesoporous structures for an enhanced drug loading. For this purpose, SBA-16 and FDU-12 nanostructured silica-based materials were synthesized by templating and further functionalized by means of post-synthesis grafting of chloropropyl and aminopropyl groups. As an adsorption model, the well known anti-inflammatory drug ibuprofen (ibu) is chosen for study.

Pure silica SBA-16 and FDU-12 nanostructures were synthesised as it was previously reported [3,4]. The functionalization of silica materials was performed by post-synthesis reaction either with 3-chloropropyl trimethoxysilane ($(OMe)_3SiC_2H_2Cl$) or with 3-aminopropyl triethoxysilane ($(OEt)_3SiC_2H_2NH_2$) in refluxing toluene under Ar gas. Materials were loaded with ibuprofen by soaking 100 mg of material in saturated drug water/ethanol (1/2) solutions. The drug release tests were carried out in phosphate buffer solution (PBS) at pH 7.25.

N_2 adsorption isotherms show the reduction of both the pore volume after functionalization, which goes together with by the decrease on the lattice parameters of the hexagonally ordered array of mesopores. Moreover, the small-angle X-ray scattering (SAXS) studies prove the spherical arrangement of nanopores since the Porod's region shows a q^{-4} dependence with the scattered intensity [5] modification on the nanoporous structure of the materials when submitted to the functionalization process, which points to the formation of opener pore frameworks

Analysis by FTIR confirmed the grafting on the surface of the organic amine, where the bands of the CH group (ν_{CH}) and NH group (ν_{NH}) stretching modes were detected.

Maximum load of ibufprofen on the unfunctionalized silica surfaces was almost twice smaller than for functionalized materials. When loaded materials are exposed to releasing environments, the amino acid is slowly delivered to media as a function of the electrostatic interaction between molecule and substrate. Ordered mesoporous silica materials can be employed for loading peptides with diverse biological applications. Functionalization with the appropriate functional group assures the retaining of peptide as well as its controlled release to environment.

References:

[1] Vallet-Regí M et al. J Mater Chem, 15 (2005) 1.
[2] Vallet-Regí M, Balas F. Open Biomed Eng J, **2** (2008**)** 1.
[3] Yu T et al. J Phys Chem B, **110** (2006) 21467.
[4] Kleitz F et al. Langmuir, **22** (2006) 440.
[5] Feigin LA et al. Structure analysis by small angle X-ray and neutron scattering. (Plenum Press, 1987)

Figures

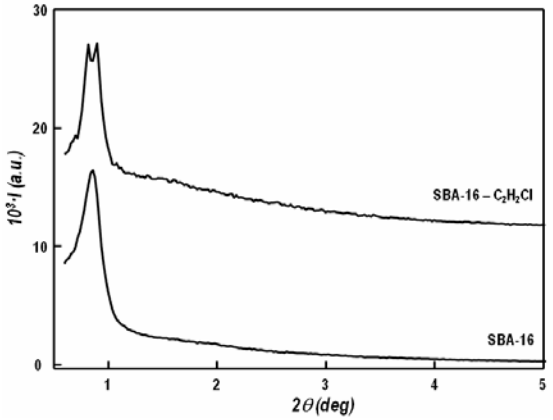

Figure 1. XRD patterns for SBA-16 and SBA-16-C_2H_2Cl materials

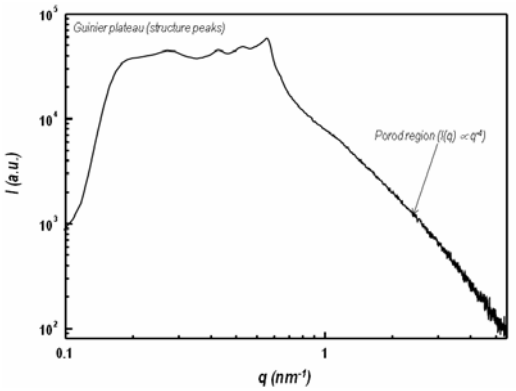

Figure 2. SAXS Guinier plots of for SBA-16 materials

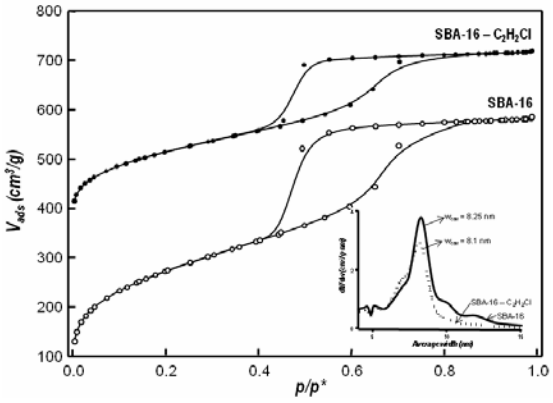

Figure 3. N_2 sorption isotherms and the DFT pore size distributions for SBA-16 and SBA-16-C_2H_2Cl materials (isotherms are deliberately shifted for clarity)