Mesoporous silica materials, with pores with diameters between 2 and 50 nm, have a highly organized porous structure with uniform pore size and vast surface area, being excellent candidates for drug delivery carriers. Due to their bioactive characteristics the walls of mesoporous silica can be coated on their surface with a bonelike apatite layer by immersion of the material in simulated body fluid (SBF) with ion concentrations nearly equal to those of human blood plasma. The tuneable mesopore structure and modifiable surface of mesoporous silica nanoparticles allows incorporation of apatite and of various classes of drug molecules and controlled delivery to the target sites.

In the present work the formation of the apatite layer in two mesoporous materials with different pore configuration, and the effect on drug delivery has been studied. The synthesis of the mesoporous materials was performed using supramolecular templates, Triblock copolymers: (EO20PO70EO20) (Pluronic P123), MW=5800 and (EO106PO70EO106) (Pluronic F127) and Tetraethylorthoxysilane (TEOS) as silica source. The former generates a hexagonal mesoporous structure of aligned channels (SBA-15) and the latter a structure of channels and cavities with a cubic arrangement (SBA-16). Once the mesoporous structures were obtained, the materials were soaked in inorganic body fluid solution for different periods, resulting in the formation of a thin layer of apatite over the internal and external surfaces of the mesoporous material. HRTEM, HAADF and EDS analysis were used to characterize the apatite formation. Also, FTIR, XRD and surface area measurements complemented the structural characterization. Drug adsorption and delivery was study using HPLC, UV and TGA.

Fig. 1 shows a HRTEM image of the mesoporous structure after 1 and 3 weeks (Fig. 1a and 1b) immersion in SBF. It can be observed that the arrangement of ordered mesoporous is broken (1c) after only one-week immersion, due to the apatite deposition that modifies the structure. Convoluted concentric cylinders coated with nanocrystals of apatite are observed (Fig 1d). The EDS analysis of these samples showed the presence of Si, O and small amounts of Ca and P, corroborating the presence of apatite forming the coating. These morphological characteristics give these materials unique features for drug carriers due to the high superficial area and therefore adsorption capabilities and on the other hand, the formation of the nanocrystalline apatite coating increases the biocompatibility of the materials enhancing osseointegration.

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Fig. 1: Fig. 1a HAADF image of Mesoporous SBA-apatite after 1 week SBF immersion

Fig. 2: Fig. 1b HRTEM showing the effect of apatite deposition breaking the regular mesoporous arrangement

Fig. 3: Fig. 1c Apatite nanocrystals on mesoporous structure forming a concentric arrangement

Fig. 4: Fig. 1d Apatite nanocrystals formed outside of the mesoporous materials after 3 weeks immersion in SBF. The inset is an EDS spectrum showing Ca and P presence