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Ce ion-exchanged titanate nanotubes decorated with ceria nanoparticles

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Abstract – In this work, we report on the synthesis and characterization of Ce ion-exchanged titanate nanotubes decorated with ceria nanoparticles. The physical properties of these ion-exchanged nanotubes are discussed in comparison with their pristine titanate nanotubes counterparts. The results obtained from several characterization techniques allowed us to conclude that the Ce ion-exchanged nanotubes have their external walls decorated with ceria nanoparticles. The main effect on the optical properties of the nanotubes is a red-shift of the absorption band edge towards visible region. Therefore, this hybrid system is promising for applications in photocatalysis using the blue region of the electromagnetic spectrum.

Many technological applications that make use of the energy available in the sun light have been gaining importance because this energy is free and also environmental friendly. By combining the size dependent properties of nanomaterials such as band gap and surface to volume ratio allows one to think about a generation of very efficient materials for photocatalysis. Titanate nanotubes have a large surface area responsible for increasing the active surface. They have been tested to be used as catalysts in heterogeneous photocatalysis and have shown excellent performance for degrading textile dyes, which makes them very important ecomaterials. [1, 2] However, the absorption band edge of titanate nanotubes is in the ultraviolet region (below 400 nm), which makes them not very efficient for converting the free available photon energy from the sun in the visible range. The optical properties of titanate nanotubes may be effectively modified and controlled via ion exchange reactions or intercalation of other metals. Titanates nanotubes submitted to ion exchange reactions involving some transition metals showed that the absorption edge exhibited a dramatic red shift towards the visible range [1]. On the other hand, the CeO_2 has attracted much attention due to its technological applications. The band gap of CeO_2 was estimated about to 3,1 eV (≈ 400 nm) and consequently it can be used in catalysis activated near to visible light. The catalytic properties of ceria can be increased when we obtain particles in nanometric size with their higher surface/volume ratio, but its band gap energy increases (blue shift) due to the quantum effect in nanometric size. In this work, we present the synthesis and characterization of titanate nanotubes with Ce ion incorporated through an ion exchanging processes described by Ferreira et al [3] and CeO_2 nanoparticles formed at the nanotubes surface via precipitation mechanism. The physical properties of these ion-exchanged nanotubes are discussed in comparison with their pure titanate nanotubes counterparts. The results obtained from several characterization techniques allowed us to conclude that the Ce ion-exchanged nanotubes have their external walls decorated with ceria nanoparticles and the main effect on the optical properties of the nanotubes is a red-shift of absorption band edge towards visible region. Therefore, this hybrid system is promising for applications in photocatalysis using the blue region of the electromagnetic spectrum.

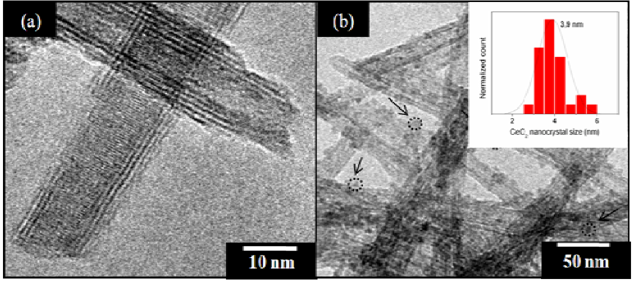

Figure 1: HRTEM images of the (a) NTTiOx and (b) NTTiOx_Ce. The normal distribution of nanocrystals size is also shown inset of panel (b).

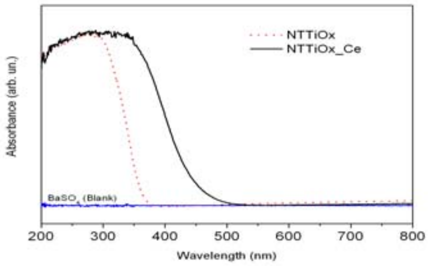

Figure 2: Diffuse reflectance UV-Vis spectra, plotted as absorbance, of NTTiOx (dash trace), NTTiOx_Ce (solid trace) samples and $BaSO_4$, used as blank reference, at the bottom.

[1] X. Chen, S.S. Mao, Chemical Reviews 107 (2007) 2891-2959.

[2] B.C. Viana, O.P. Ferreira, A.G. Souza Filho, J. Mendes Filho, O.L. Alves, J. Braz. Chem. Soc. 20 (2009) 167-175.

[3] O.P. Ferreira, A.G. Souza, J. Mendes Filho, O.L. Alves, J. Braz. Chem. Soc.17 (2006) 393-402.