Development of photocatalytic nanomaterials for pollution control, using thin film deposition techniques (*sol-gel*, PVD)

L.F. Oliveira, P.J.G. Coutinho, C.J. Tavares

Centre of Physics, University of Minho, Braga, Portugal

filipasoliveira@gmail.com

The aim of this study regards the development of photocatalytic titanium dioxide (TiO_2) based nanomaterials for pollution control. Particularly, by synthesizing nanostructured coatings using physical vapor deposition (PVD) and Langmuir-Blodgett (LB) deposition techniques.

These materials have a good hydrophilicity and an optimum photocatalytic efficiency, when comparing to a commercial standard. Therefore, this self-cleaning capability foresees potential applications in the building materials, particularly for ceramic panels (tiles, bricks) and glass panes [1].

The PVD thin films were produced in reactive sputtering mode, using a pure titanium target in a atmosphere of $Ar/O_2:N_2$, whereas the LB thin film deposition consisted in using a water floating monolayer of TiO_2 nanoparticles in a matrix of DTAB or CTAB surfactant.

The photocatalytic efficiency was evaluated by monitoring the degradation of an organic dye (Methylene Blue 0.1 μM) following an irradiation with UV-A light in the presence of the photocatalyst.

For the PVD films, it was possible to correlate the relationship between the working gas flow (argon) used during the deposition and the first-order rate constant (k) for the degradation of the dye [2].

It was found that for the PVD films produced with an argon flow of 275 sccm a better photocatalytic performance was attained, with a first-order rate constant equal 2.6×10^{-3} min^{-1}. (figure 1). This evidence can be ascribed that for a higher deposition pressure a subsequent enhancement of porosity in the films is achieved, resulting in a larger surface area for the dye (pollutant) adsorption. Furthermore, the thickness of the films increases up to a threshold of 275 sccm, decreasing afterwards due to the decrease in mean free path of the impinging flux on the substrates during deposition and inherent inhibition of adatom mobility. The optical band-gap was determined from Tauc plots and was calculated to be 3.18 eV for the best coatings. The crystallinity of these films was characterized by X-ray diffraction (XRD) and the results show that anatase is the polymorph phase which is more stable and provides better photocatalytic efficiency (figure 2) [3].

The TiO_2 nanoparticles obtained by sol-gel method were characterized by dynamic light scattering (DLS) and scanning electron microscopy in transmission mode (STEM). These results yield evidence that the nanoparticles are spherical and have size distributions centered between 100 and 400 nm, as seen in figure 3.

References

[1] T. Tölke, A. Kriltz, A. Rechtenbach, *Thin Solid Films*, 518, **2010**, 4242–4246.

[2] C. J. Tavares, S. M. Marques, T. Viseu, V. Teixeira, J. O. Carneiro, E. Alves, N. P. Barradas, F. Munnik, T. Girardeau, J.-P. Rivière, *Journal of Applied Physics,* 106, **2009,** 113535;

[3] N. R. Mathews, E. R. Morales, M.A. Cortés-Jacome, J.A. Toledo Antonio, *Solar Energy*, 83, **2009**, 1499–1508.

Figures

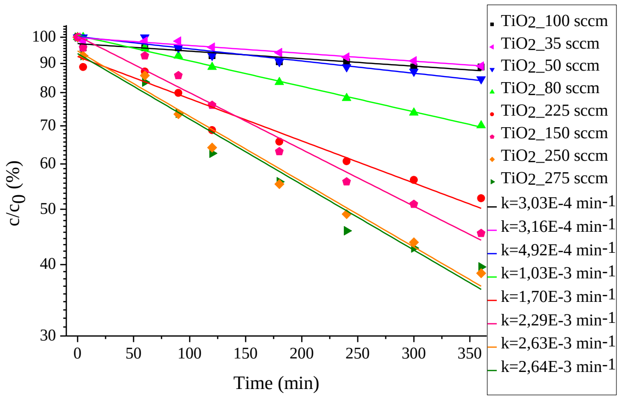

Figure 1 - Relative decrease in Methylene Blue concentration as a function of UV-A irradiation time for titania thin films deposited by sputtering with varying argon (working gas) flow rate.

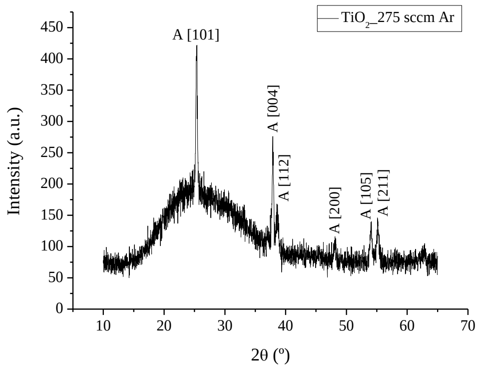

Figure 2 - XRD pattern for titania thin film deposited with a 275 sccm flow of argon.

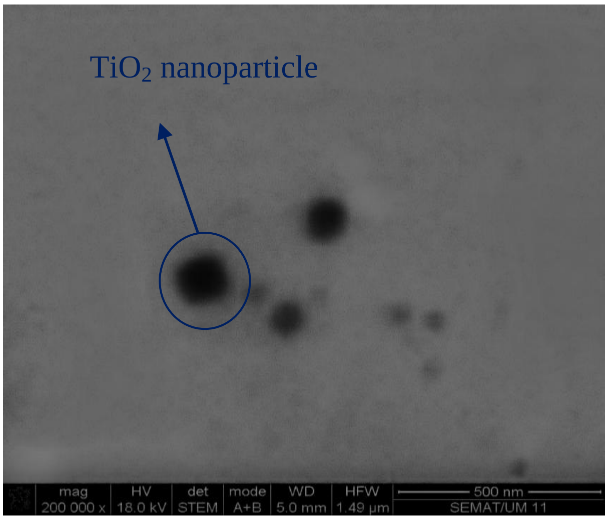

Figure 3 - Scanning electron microscopy image acquired in transmission mode (STEM) for the TiO_2 nanoparticles produced by sol-gel method.

Acknowledgements

The authors kindly acknowledge the financial support from the Portuguese FCT scientific program NANO/NTec-CA/0046/2007.