P-27: US-assisted Preparation of Photoactive TiO$_2$: Role of the Solvent on the Final Material Features and Photocatalytic Efficiency
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Powered TiO$_2$, with crystallites always in the range of nanometers, but larger than the common photoactive samples (P25 by Evonik, usually used as reference material for photocatalysis in literature, has with a crystallites size of 7 nm), was synthetized using ultrasound during the sol-gel process, in different solvents. The advantages of ultrasonication method are demonstrated as compared to the conventional stirring method of preparation of titania. Sonochemical process to obtain materials with improved or unusual properties is an alternative to traditional TiO$_2$ synthesis procedure, i.e. sol-gel method, hydrothermal technique, reverse micelle method or oxidation of metallic Ti powder. Ultrasound (US) assisted synthesis of titanium dioxide is well known in recent literature. The chemical effect of US arises from acoustic cavitation, i.e. the formation, growth and implosive collapse of bubbles in a liquid. Some of the interesting features resulting from the application of sonication as a synthetic method are nanoparticles showing a more uniform size distribution, higher surface area and a more controlled phase composition.

The influence of ultrasound during the preparation of photoactive TiO$_2$ was here investigated optimizing the growth of the crystallites size: in particular, we observe a modification of the material properties modifying the solvent used during the preparation (Figs. 1-2).

Five different organic solvents were chosen for the present study: n-hexane, decane, isopropanol, ethanol and 1-octanol.

The powders obtained have been tested in the photodegradation of sulfomethoxazole (SMX), that is most common antibiotics, very resistant molecule and it passes fully undegraded through the common purification plants. Besides being used for human therapy, antibiotics are extensively used for animal farming and for agricultural purposes. Residues from human environments and from farms may contain antibiotics and antibiotic resistance genes that can contaminate natural environments.

To try to solve this fact, Advanced Oxidation Processes seem to give very satisfactory answers. In particular, photocatalysis is a very efficient process which often allows the complete degradation of the pollutant molecules without the aim of new reactants like Fenton-process, for example. In fact, at the end of the photocatalytic process, TiO$_2$ can be removed from the environment by a simple filtration. However, this final step is not always so easy especially when TiO$_2$ is used as pure powder: the very small size of the particles (usually crystallites are less than 10 nm in size) allows a very good dispersion of the photocatalyst in the aqueous media, and thus a very efficient photodegradation process, but this requires a very difficult and expensive procedure to separate the treated water from the ultrafine nanoparticles, and the procedure is not always completely efficient.

Fig. 1: SEM images of TiO$_2$ synthetised in isopropanol: a) with Ultrasound b) without Ultrasound
Degradation results adding TiO$_2$ show a common trend: samples prepared via US are always more active than the corresponding TiO$_2$ prepared under common hydrolysis confirming the importance of US during the preparation. Moreover, polar solvents lead to better photocatalysts confirming that the presence of both pure anatase and good surface area are usually the best constituents for a photoactive material.

Fig. 2: SEM images of TiO$_2$ synthetised in decane: a) with Ultrasound b) without Ultrasound