Organo-modified silicas for the removal of dye molecules from water media

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Many anthropogenic activities unfortunately introduce pollutant species that deteriorate the quality of water, one of the essential life components. Various methods can be used to remove pollutants from water (*e.g.*, filtration, precipitation, electrochemical methods, bioremediation, catalysis, etc.), but adsorption onto solids (such as clays, zeolites, porous silicas) is considered an advantageous, cost-effective, and high-performance method [1]. For this purpose, interest was directed towards the study of an organic-inorganic hybrid silica material named Swellable Organically Modified Silica (Silica-SOM), which possesses the unique property of swelling, *i.e.*, expanding porous volume under appropriate conditions, being potentially capable of storing significant amounts of pollutants [2]. Silica-SOM is synthesized by sol-gel method using bis(trimethoxysilylethyl)benzene as a precursor and tetrabutylammonium fluoride as a catalyst. As the gel ages, a three-dimensional network of Si-O-Si bonds with aryl and aromatic groups forms, producing a porous and flexible material [3]. The physico-chemical properties of the Silica-SOM were determined by means of a multi-technique approach: the morphology was found to be composed of aggregates of particles of submicron size and irregular shapes; as Silica-SOM are hydrophobic and tend to aggregate in water, the particle size in aqueous suspension is higher (700 nm) than in organic solvents (< 250 nm); the material is mesoporous with a surface area of 414 m^2/g and possesses a negative surface charge at pH values above 3.7.
The adsorption performance of Silica-SOM against two soluble organic dye pollutants in aqueous phase (Rhodamine B and Methyl orange) was studied. Silica-SOM was placed in contact with an aqueous dye solution and the solutions were analyzed for successive times up to a maximum of 24 hours. Silica-SOM showed very promising removal capacities: after 1 hour of contact 99.5% of Rhodamine B (Fig. 1) and more than 98% of Methyl Orange (Fig. 2) was removed. Adsorption cycles of Rhodamine B were carried out, after desorption of the pollutant in alcohol solution by sonication. These tests showed that Silica-SOM is fully regenerable and reusable under the conditions tested. In comparison to other commonly used materials in the literature for the removal of pollutants, Silica-SOM showed the best performance in terms of kinetics and quantity removed (Figg. 1 and 2).

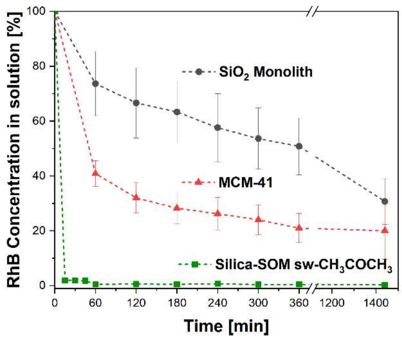

***Figure 1**: Rhodamine B residual percentual concentration in solution over time. A comparison of different materials studied at same conditions: Silica monoliths (●), MCM-41 (▲) and Silica-SOM pre-swollen with acetone (■).*

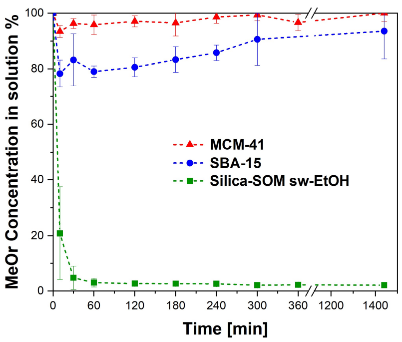

***Figure 2:** Methylorange residual percentual concentration in solution over time. A comparison of different materials studied at same conditions: SBA-15 (●), MCM-41 (▲) and Silica-SOM pre-swollen with ethanol (■).*

Finally, the synthesis procedure of Silica-SOM was optimized using an experimental factorial design approach to decrease the synthesis time.

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