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Hybrid materials for the adsorption removal of dyes from water

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The problem of environmental pollution is well-known by the scientific community. In these last years, it is estimated that 7 x 10^5 tons of toxic wastewater containing dyes are produced every year. Dyes are known for their low biodegradability, high solubility in water and toxicity in the environment. Therefore, it is necessary to find a strategy for the removal of these pollutants from wastewater. The removal of organic molecules from water media through adsorption on solid sorbents deserved a lot of attention in the last years. An ideal adsorbent should remove in a short time high quantities of dyes and should be inexpensive, regenerable and reusable. Different materials, for instance carbons, zeolite, clays, polymers are used to this purpose, but the class of hybrid organic-inorganic silica materials is deserving increasing interest for their peculiar adsorption performances [1].

Among the class of hybrid silicas, Swellable Organo-Modified Silicas (SOMS) possess the peculiar ability to swell, thus expanding their volume, when in contact with organic solvents. The swelling property gives SOMS more enhanced adsorption performances towards organic moieties in water, including dyes, if compared to inorganic or organic-grafted silicas [2]. SOMS are synthesized by a base-catalysed sol-gel process of bis(trimethoxysilylethyl)benzene that possesses an aromatic ring linked to the silicon atom by an ethyl group. SOMS can also be functionalized with a quaternary amino group, which gives a positive surface charge to the final material (QA-SOMS) [3]. These materials will be used for the removal of dyes from water by adsorption, considering their promising performances.

Moreover, different mesoporous silicas (SBA-16 type) were synthesized and functionalized with organic groups to perform a comparison in adsorption performances.

The characterization of the materials was made through a multi-technical investigation (elemental analysis, XRD, FT-IR, ss-NMR, DLS, Z-Potential) to obtain morphological, textural, and chemical information. Finally, the adsorption kinetics, isotherm, pH-effect, and reutilization towards dye molecules were tested for the materials synthesised, in particular for SOMS which resulted to be the most promising adsorbent (Figure 1).

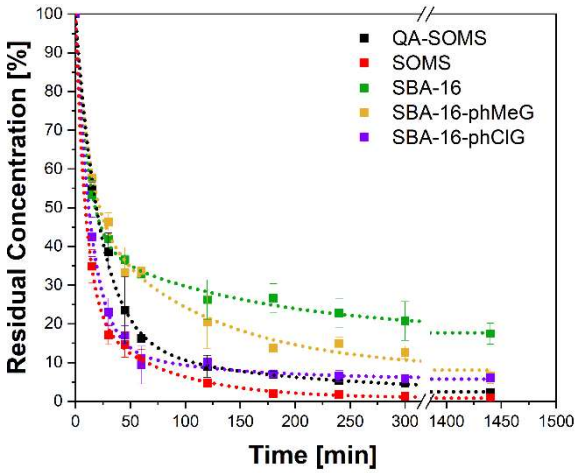

Figure 1: Adsorption kinetics of a 100 ppm solution of crystal violet by SOMS, QA-SOMS and mesoporous silica SBA-16 both organo-functionalized (SBA-16-phClG and SBA-16-phMeG) and not (SBA-16).

[1] J. Guo et al., *Separation and Purification Technology*, **2024**, *330*, 125480.
[2] V. Miglio et al., *J. Phys. Chem. C*, **2024**, *128*, *5*, 2179–2189.
[3] E.K. Stebel et al., *Environ. Sci.: Water Res. Technol.*, **2019**, *5*, 1854.