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Effective removal of anionic and cationic dyes by kaolinite and TiO_2/kaolinite composites

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ABSTRACT: The present study investigated the removal of methylene blue (MB) and orange II (OII) dyes from synthetic wastewater by means of adsorption and photocatalysis using natural kaolins. For MB adsorption, the raw kaolinite-rich samples showed the greatest adsorption capacity, with rapid uptake (90% after 20 min). The experimental results were fitted better using the Langmuir isotherm model parameters compared to the Freundlich model, suggesting that the adsorption corresponds to monolayer coverage of MB molecules over the kaolinite surface. For OII, neither the Langmuir nor the Freundlich model gave reliable results, because the adsorption of anionic dye molecules by the clayey particles is not favoured.

Mixtures of kaolinite/Degussa TiO_2 were also prepared, and their photocatalytic properties under UV-light exposure were investigated. Decolourization of MB solutions was observed, even in a mixture with low TiO_2 content. This is related to the combined effect of adsorption and photocatalysis and, unlike the pure clay samples, the efficiency of such mixtures against OII was only slightly weaker (80–94%).

For TiO_2-impregnated clays, with the kaolinite layers separated by sol-gel TiO_2 particles, the MB removal was slow and effective only after >24 h due to the complexity of the bonding of MB molecules. On the other hand, the removal performance against OII solutions was very efficient (nearly 100%) within only 2 h. This excellent performance was attributed to morphological changes in clay particles.

KEYWORDS: kaolinite, TiO_2, dyes, adsorption, photocatalysis.

Because of their many useful properties (*e.g.* porosity, plasticity, inertness), clay minerals are currently being investigated as attractive, low-cost materials for waste treatment. With the ever-increasing growth in manufacturing and consumption, the problems caused by industrial wastes and wastewater have become a major issue. Dyes are common pollutants from many different industries, ranging from textiles to pharmaceutical plants (Hunger, 2002). They pose serious environmental and health hazards to both humans and aquatic and marine ecosystems (Christie, 2007; Gupta & Suhas, 2009). Their removal from industrial effluents before discharge into the environment is of paramount importance because of their toxicity and possible accumulation in the environment. Among the various techniques to remove dyes from effluents, adsorption,

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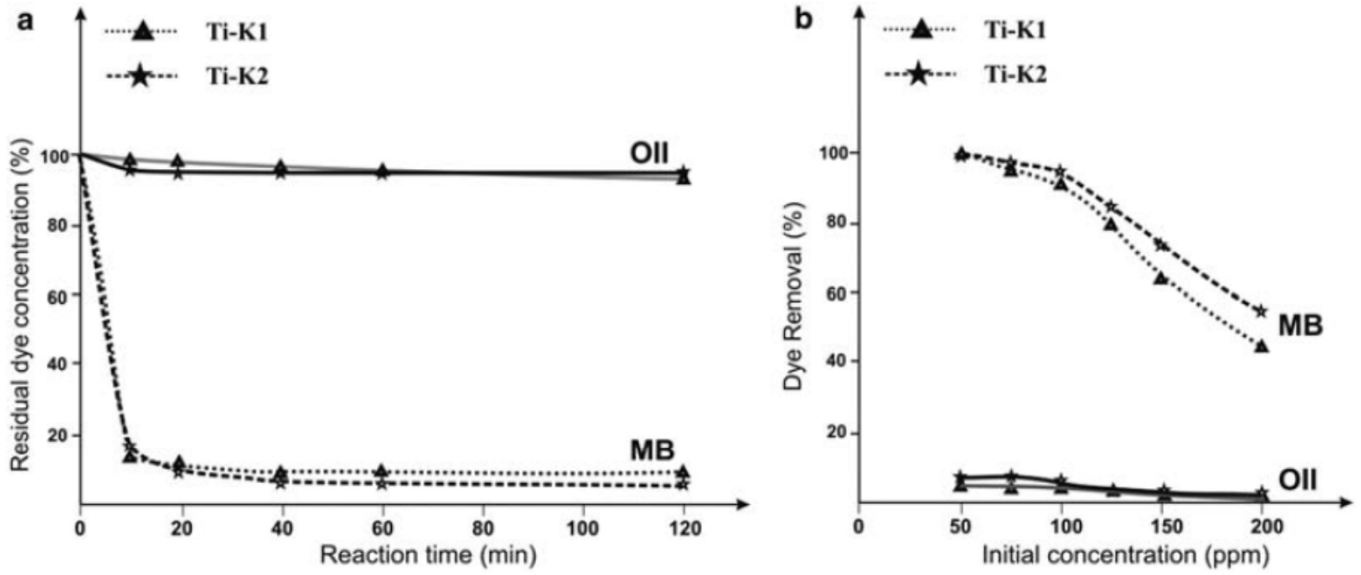

FIG. 2. Adsorption kinetics: (a) residual dye concentration with contact time for an initial dye concentration of 10 ppm; and (b) % dye removal with initial dye concentration after a reaction time of 1 h, for MB and OII dyes, for the pure clays K1 and K2.

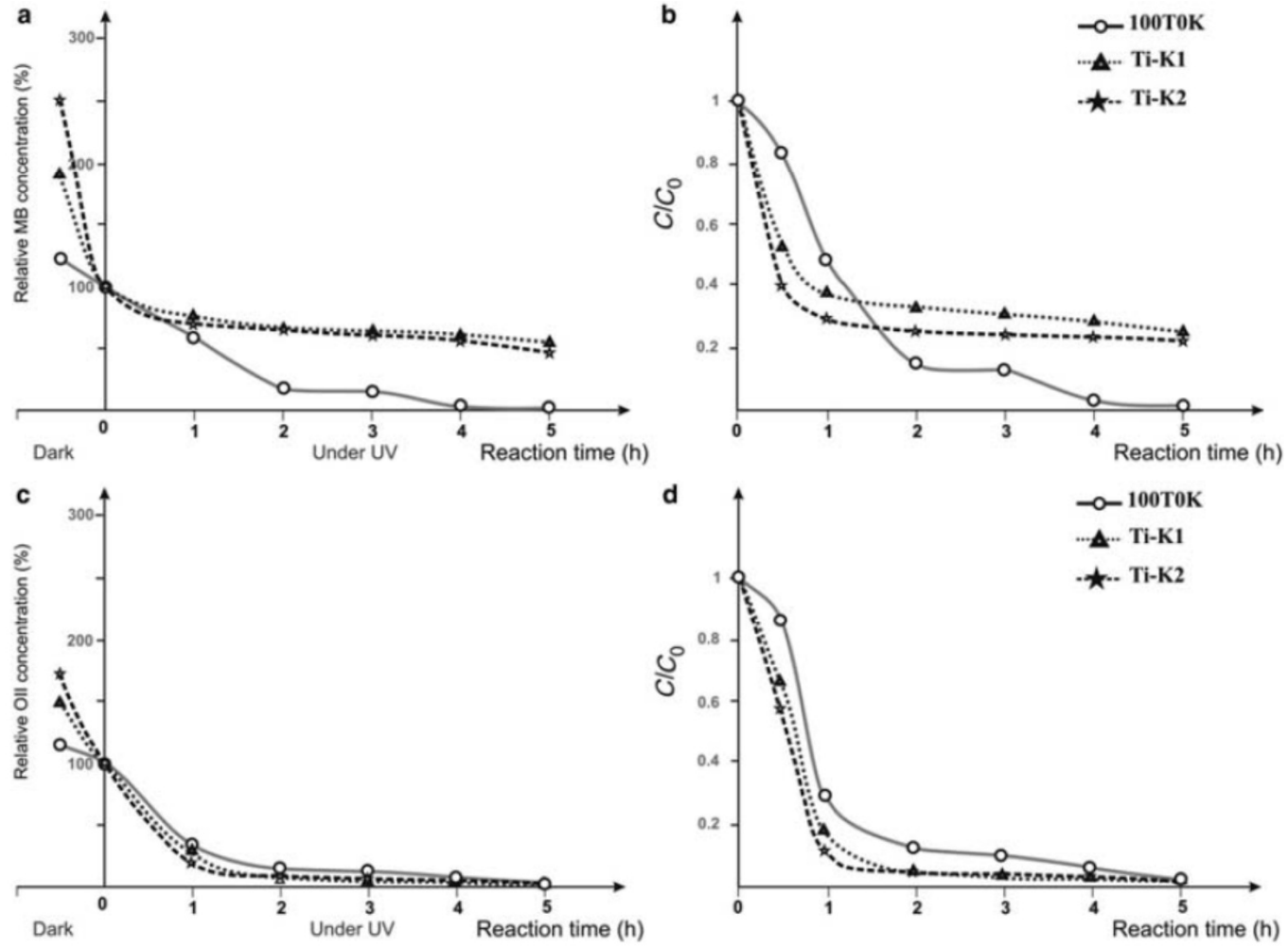

FIG. 4. Photocatalysis removal kinetics of MB (a,b) and OII (c,d) dyes by pure Degussa P25 titania, and by the titania-sol-modified clays Ti-K1 and Ti-K2. (a) and (c) show relative dye concentrations after adsorption has occurred in the dark for 30 min, normalized to 100% after this time; (b) and (d) show the absolute change in dye concentration with time.