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Photocatalytic performance of chromium-doped TiO_2 nanoparticles for degradation of Reactive Black 5 under natural sunlight illumination

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ABSTRACT

Azo dyes are widely used in textile industries throughout the world. Discharging partially treated or untreated effluents of such industries can bring about environmental issues in receiving water bodies. The present investigation focuses on synthesis, characterization, and degradation application of chromium-doped TiO_2 nanoparticles. The mild hydrothermal synthesis protocol was applied for the preparation of chromium-doped TiO_2 nanoparticles. Nanoparticles fabricated were characterized using X-ray diffraction, scanning electron microscopy, energy dispersive X-ray analysis, and attenuated total reflection analysis techniques. The characterization results confirmed the successful doping of chromium, and textural properties results reveal higher crystallinity, spherical morphology, and excellent purity of Cr-doped TiO_2 nanoparticles. The photodegradation efficiency of chromium-doped TiO_2 was investigated for the treatment of hazardous Reactive Black 5 dye from aqueous solution. The degradation efficiency was systematically optimized through varying operational parameters including dopant mol% ratio (1, 1.5, and 2 mol%), influence of solution pH (4, 7, and 10), nanomaterial dosage (0–5 g/L), dye concentration (10–300 mg/L), H_2O_2 concentration (5–50 mmol/L), and contact time (0–120 min) under natural sunlight illumination. The catalytic performance was highly improved due to 1 mol% Cr-doping, at pH 4, 20 mmol/L of H_2O_2, 5.0 g/L of nanomaterial dosage, and 120 min of contact time where maximum degradation efficiency was achieved to 96.6% (50 mg/L Reactive Black 5 dye) under sunlight illumination.

Keywords: Chromium-doped TiO_2; Reactive Black 5; Sunlight; Photodegradation; Hydrothermal; Nanostructure

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