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Bionanocomposite hydrogel for the adsorption of dye and reusability of generated waste for the photodegradation of Ciprofloxacin: A demonstration of the circularity concept for water purification

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ABSTRACT:

Adsorption has emerged as a simple and economical approach to water decontamination; however, it creates large amounts of secondary toxic waste following the removal of the effluents from the water. The present investigation introduces an innovative circular approach that tackles the serious problem of environmentally toxic secondary waste. Herein, TiO_2 nanorods (NRs) and a functionalized gum ghatti (Gg) biopolymer-based bionanocomposite hydrogel (TGB-hydrogel) were synthesized by free-radical graft polymerization and used to remove brilliant green (BG), which is a toxic dye. The dye-adsorbed TGB-hydrogel waste was then processed at 550 °C for 3 h and re-employed for the photocatalytic degradation of the antibiotic ciprofloxacin (CIP), after which the spent photocatalyst was reinstated for the adsorption of BG dye to complete the cycle. The ability of the TGB-hydrogel to adsorb the dye was studied in detail by varying the adsorbent dosage, initial dye concentration, pH, and temperature. Adsorption kinetics followed a pseudo-second-order kinetics model, whereas the adsorption isotherm followed the Langmuir isotherm model with a maximum adsorption capacity of 740.97 mg g^{-1}. The thermodynamic studies highlighted that the adsorption process was endothermic in nature. Furthermore, the obtained photocatalyst exhibited high photocatalytic efficiency, with 88.7% CIP degradation over 180 min due to a recombination delay of charge carriers, high light absorption, and the high surface area (179.33 m^2 g^{-1}). The introduced circular approach concept is envisaged to be applicable to other processes that need to avoid unwanted secondary waste.