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Synthesis, characterization and application of magnetic carbon materials as electron shuttles for the biological and chemical reduction of the azo dye Acid Orange 10

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Highlights

- A set of core(FeO)-shell(carbon) and carbon nanotubes@2%Fe composites were synthesised;
- Biological reduction of azo dye Acid Orange 10 (AO10) lead to 30% of colour removal;
- In the presence of carbon materials up to 98% AO10 decolourisation was achieved;
- The presence of carbon nanotubes@2%Fe improved the rate of AO10 reduction up to 79-fold;
- Carbon nanotubes@2%Fe were successfully applied in successive cycles of AO10 decolourisation.

Abstract

A set of core(ferrite, FeO)-shell(carbon, C) composites, C@FeO, C@MnFeO, C@CoFeO, and carbon nanotubes (CNT) impregnated with 2% of Fe (CNT@2%Fe) were prepared. The different composites were tested as redox mediators (RM) in the biological reduction of the azo dye Acid Orange 10 (AO10). Materials were tested at different concentrations from 0.1 to 1.0 g L^{-1}. In the absence of RM, the AO10 decolourisation after 24 h of reaction was only 30% at a rate of 0.2 d^{-1}. In the presence of the core-shell composites, better results were obtained with C@FeO materials at the amount of 1.0 g L^{-1}. The extent of AO10 decolourisation was above 90% and rate improved circa 29-fold. With CNT@2%Fe, the best efficiency (98±3%) was achieved with 0.5 g L^{-1} leading to a 79-fold rate increase. In abiotic controls, though at lower extent, the reduction of the dyes also occurred likely due to the electron transfer from Fe^{2+} to carbon and then to the dye. To prove this, assays combining single CNT and FeO materials were performed, and FeO had effect in the reaction only when combined with CNT. In the biological assay, the rate was the double and the percentage of decolourisation increased from (88±6)% to (97±1)%, when both materials were present in solution as compared with results in the presence of CNT alone. Under abiotic conditions, decolourisation occurred only in the presence of both materials, with a final