Magnetic carbon composites as recycling electron shuttles on anaerobic biotransformations

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The unique properties of magnetic nanoparticles (MNP), such as high surface area, magnetic, sorption and catalytic characteristics, make them very versatile for many applications in different areas including environmental remediation, as catalysts, adsorbents, immobilising agents for microorganisms and enzymes, and as supports for biofilm growth and water disinfectants. In order to improve their stability and to introduce additional surface properties and functionalities, MNP can be coated with carbon materials (CM) due to their chemical stability, biocompatibility and possibility of tailoring their textural and surface chemical properties for specific applications [1]. We have previously proved that various CM, including activated carbon, carbon xerogels and carbon nanotubes (CNT), can be used as redox mediators (RM) in anaerobic biotransformation, accelerating the electron transfer and, consequently, the reduction rates of organic compounds [1,2]. The combination of CM with MNP offers the possibility of creating magnetic carbon composites with synergistic properties: the adsorptive and catalytic properties of both and the magnetic character of MNP, improving the material performance and rendering it easier to be retained and recovered, by applying a magnetic field.
A set of core(ferrite, FeO)-shell(carbon, C) composites, C@FeO, C@MnFeO, C@CoFeO, and CNT impregnated with 2% of Fe (CNT@2%Fe) were prepared and tested as RM in the biological reduction of the azo dye Acid Orange 10 (AO10). 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, the extent of AO10 decolourisation was above 90% and rate improved circa 29-fold. With CNT@2%Fe, (98 ± 3%) of AO10 decolourisation was achieved at a 79-fold higher rate than the decolourisation in the absence of materials. Catalytic effect was also observed in abiotic reactors in the presence of composites, though at lower extent, likely due to the transfer of electrons from nanoscale iron to carbon and then to the dye. Owing to their magnetic character, the proposed materials were removed from the media and successfully applied in successive cycles. The high efficiency of proposed materials as RM, at low concentrations, and the possibility of easily recover with a magnet and being reused, make these materials preferential as compared with other soluble RM, which need to be continuously added and will be mixed with the treated solution. They are also advantageous than other non-magnetic insoluble materials to which costly techniques such as filtration need to be applied for recovery.

References

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