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Carbon-coated metallic magnetic nanoparticles for application on bioremediation

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Over the last few years, there has been an increased interest in studying superparamagnetic nanoparticles (SMNP) due to their unique magnetic properties and potential applications in several areas such as biomedicine/biotechnology, catalysis, magnetic sensors and magneto-optical devices [1]. Carbon materials are widely used as catalyst supports, but their use as a catalyst is attracting a great deal of attention [2]. MNP can be coated with a layer of different materials to improve their stability and to introduce new surface properties and functionalities. Therefore, the aim of this study was the synthesis and characterization of metallic magnetic nanoparticles coated with carbon (C-MNP) for subsequent application in catalysis, particularly in the anaerobic bioreduction of azo dyes. The use of magnetic nanoparticles coated with carbon will enable the catalyst recovery by magnetic separation and also taking advantage of the catalytic properties of the carbon materials.
In this work, the metallic (Fe, Co or Mn) MNP were based on FeO cores coated with carbon by chemical vapor deposition process (CVD) using ethane at different temperatures. The textural and chemical properties of the materials were characterized by N_2 adsorption at -196 °C, temperature programmed reduction (TPR), elemental analysis (EA) and thermogravimetric analysis (TG).
The carbon content of the materials was determined from the TG weight loss (Table 1). The presence of carbon was observed for all the materials prepared by CVD. It was also observed that the deposition of carbon decreases significantly the surface area of the starting material. In addition, the characteristic reduction peaks of the Fe_2O_3 observed in the TPR profiles, between 300 and 400 °C due to their reduction to Fe_3O_4 and between 400 and 700 °C related to the sequential reduction of Fe_3O_4 to FeO and Fe^0 [3], were not observed in the materials prepared by CVD.

Table 1 : Carbon and Metal content of the C-MNP materials

Sample	% Carbon	% Metal
CFeO@CVD 750	8	92
CFeO@CVD850	35	65
CMnFeO@CVD750	22	78
CCoFeO@CVD750	34	66

The prepared materials exhibited high catalytic performance for the anaerobic bioreduction of azo dyes. Among the samples, better results were obtained with the composite CFeO@CVD850 resulting in 27-fold rate increase as compared with the control without carbon materials. The final colour removal was also improved 63%, reaching 92%. Due to their magnetic character, at the end of the first cycle, materials were removed from the reaction media and applied in successive bioreduction cycles without losing their catalytic properties.

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