Recyclable Catalytically Active Superparamagnetic Polymer-Metal Nanocomposites with Enhanced Structural Parameters

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The Metal Nanoparticles (MNPs) have found numerous applications lasting recent years due to their unique physical and chemical properties. One of the routes to overcome the high instability of MNPs (resulting in their agglomeration and aggregation) lies in the use of polymeric materials for the synthesis and stabilization of MNPs [1, 2]. Additionally, a serious concern associated with the growing production and the use of MNPs deals with a possibility of their uncontrollable release to the medium under treatment. A possible solution to this problem can be based on: 1) the immobilization of MNPs in polymers and 2) the synthesis of superparamagnetic MNPs, which would allow both the prevention of their escape and MNPs recovery and reuse by simply using a magnetic trap. This is particularly important in the case of catalytically-active nanoparticles containing platinum group metals (mainly for economical reasons).

In this presentation we report the synthesis, characterization and application of superparamagnetic core-shell MNPs with a Co-core and a functional Pd-shell. The MNPs were synthesized by using Intermatrix Synthesis (IMS) technique within the matrix of functional polymer [3,4]. The final material was characterized by ICP-OES, SQUID techniques and Electron Microscopy to determine the total metal content, the magnetic properties of polymer-metal nanocomposite and the size of nanoparticles and their distribution inside the polymeric matrix, respectively.

It has been shown that MNP-polymer nanocomposites are characterized by superparamagnetic properties and MNPs are distributed on the periphery of the fibers as shown in Fig. 1 (a, b) and also illustrated by EDS measurements presented in Fig. 1 (c). The distribution of Pd@Co core-shell MNPs at the surface of polymer fibres (the most favourable site for catalytic applications) can be explained by the action of Donnan-exclusion effect [5] during the reduction step (by using $NaBH_4$ as reducing agent) in the IMS of metal nanoparticles.

One of the applications of this material is as a nanocatalalyst in some organic Cross-Coupling reactions [6] (e.g. Suzuki reaction in our case, see Scheme 1). In our presentation we report also some advantages of the use of this new nanocomposite in catalytic reactions, which follow from the results of studying the most important experimental parameters affecting in the efficiency of reaction (temperature, time, catalyst loading, solvents, catalytic cycles, etc.).

References:

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Figures:

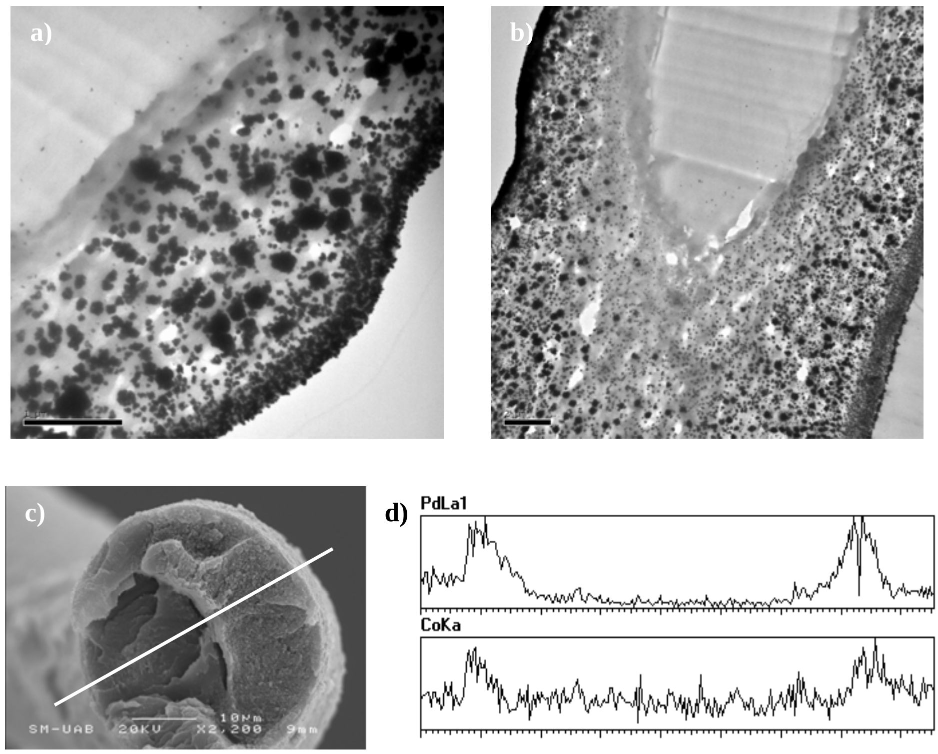
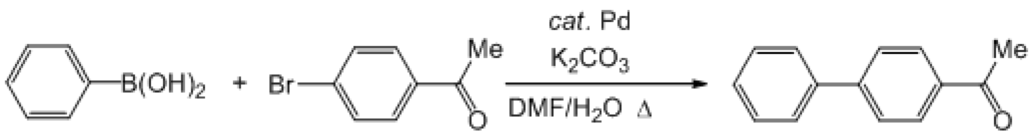


Fig 1. TEM images of fibre cross section after loading with Pd@Co nanoparticles (a, b), SEM image of fibre cross section after loading with Pd@Co nanoparticles (c) and Pd and Co LineScan EDS spectra (d).



Scheme 1**.** Suzuki Cross-Coupling reaction and the experimental conditions.