Intermatrix synthesis of polymer-copper nanocomposites with predetermined parameters by using coproportionation reaction.

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Synthesis and characterization of metal nanoparticles (MNPs) is one of the hottest topics in Nanoscience and Nanotechnology. The physical and chemical properties of MNPs substantially differ from those of both bulk material and single atoms that can be in certain instances purposely used to improve the properties of MNP-containing materials. The main drawback, which still limits wide application of MNPs, is their insufficient stability due to the high trend to aggregation. Stabilization of MNPs during their growth allows for preventing their aggregation (e.g., by Oswalt Rippening mechanism) and allow for their dissolution/dispersion in some solvents. Stabilization of MNPs in polymeric matrices is one of the most promising ways to solve MNPs stability problem [1-3]. Electroanalytical applications of MNPs (e.g., in sensors and biosensors) are based in many instances on the use of noble metals due to their unique catalytic properties. The decrease of the noble metal loading without a change in the sensitivity of electroanalytical devices is one of the important problems, which still is unsolved. A possible solution in this case can be the use of core-shell MNPs composed by a cheap metal core (e.g., Cu) coated with a thin noble metal shell. In this context optimization of the synthesis of core-MNPs stage is of particular interest.

In this presentation we report the results obtained by the study of the intermatrix synthesis (IMS) of Cu-MNPs, which is based on the use of functional polymer (sulfonated polyetherether ketone, SPEEK, in our case) as a nanoreactor. The Cu-MNPs were synthesized by using either one or two sequential copper-loading-reduction cycles when varying copper concentration in the loading solution and the loading time. The second loading of SPEEK membrane with pre-formed Cu-MNPs has been shown to result in the copper coproportionation reaction [4] what allows for doubling the quantity of Cu-MNPs in the membrane. The characterization of Cu-MNPs and SPEEK-metal nanocomposite membranes was done by TEM and ICP-OES techniques.

The results obtained indicate that both the metal concentration and the time of second loading can be use as "tuning parameters" to optimize both the MNPs size and the number of nanoparticles in the membrane (N_{np}). The synthesis of Cu-MNPs is the first step in the synthesis of core-shell nanoparticles (e.g. Pt@Cu-MNPs), and optimization of this particular step can be used for the posterior optimization of core-shell MNPs.

References:

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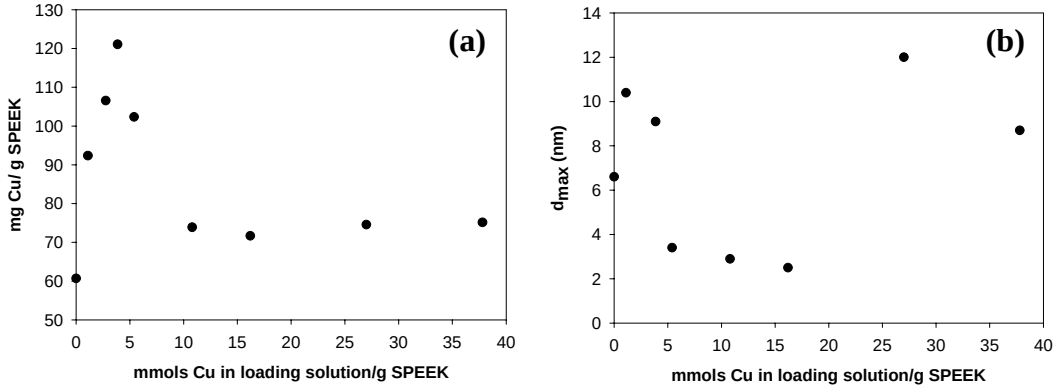

Figure 1: Copper content (a) and diameter of Cu-MNPs (b) in samples of Cu-SPEEK nanocomposite membranes after second loading with different copper concentrations.

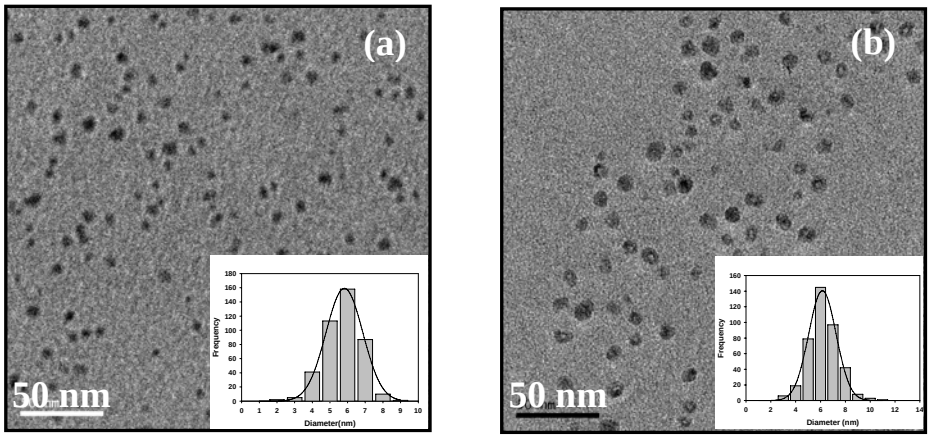

Figure 2: TEM images and corresponding size-distribution histograms (see inserts) of Cu-MNPs obtained after second loading with 4.5 (a) and 8.4 mmols Cu/g SPEEK (b), respectively.

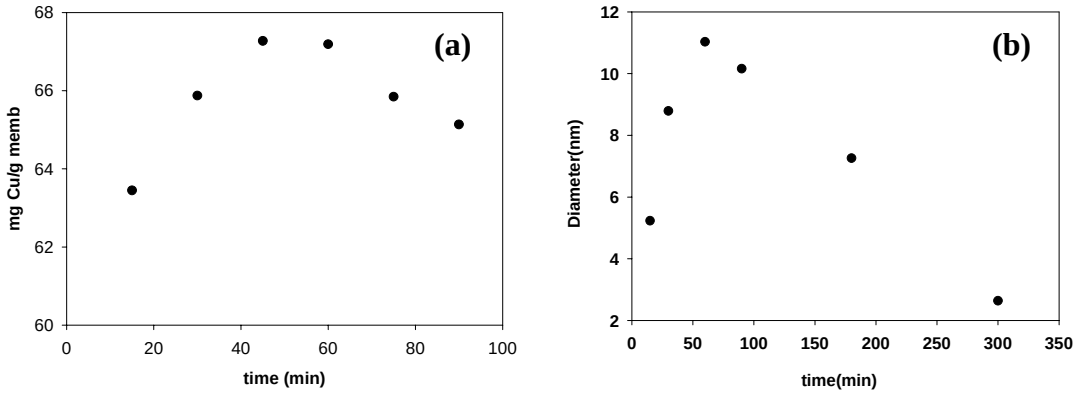

Figure 3: Copper content (a) and diameter of Cu-MNPs versus time of second metal loading at copper concentration in loading solution of 1.46 mmols Cu/g SPEEK.