CONDUCTIVE POLYMERS WITH EMBEDDED MAGNETITE NANOPARTICLES: SYNTHESIS AND CHARACTERIZATION.

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Composites of intrinsic conductive polymers containing magnetic nanoparticles have caught the attention because of their physical and chemical unique properties. This kind of composites are composed by polymeric materials and magnetic inorganic materials in the nanometric scale, such as magnetite (Fe_3O_4)[1]. This material exhibits characteristics from both components, and since composites are non-invasive systems, selective and magnetically controlled, they have a great demand. They have many applications in batteries, electrochemical digital instrumentation, electronics, electrochromic instruments, non-linear optic systems, among many other instrumental uses, like information recording[2]. Their use is not limited to the electronic area, they have great application in the areas of bioscience and medicine in the separation of proteins and biomolecules, transport for drug delivery, and hyperthermia treatment[3].

A lot of effort is being focused to the development of methodologies and processes for the incorporation of Fe_3O_4 nanoparticles into the intrinsic conducting polymeric matrixes, such as polyaniline or polypyrrole (Ppy). The efforts to prepare these composites have had limited success[4]. One of the synthetic problems is the use of strong acids for the generation of the polymeric matrix, since they can promote the decomposition of the magnetic material. In the case of Fe_3O_4 magnetic nanoparticles, the formation of aggregates must be avoided in order to allow the iron oxide to disperse in the polymeric matrix homogeneously[2].

The synthesis of nanometric Fe_3O_4 can be achieved by several methods, being the co-precipitation method the most used[5]. However, in this preparative route, there is a limited control over the particle size and usually wide particle size distributions are obtained. In addition, the aggregation phenomenon is difficult to avoid unless surfactants are used in the reaction media[6-9].

In this work, an electrochemical synthesis allowed the preparation of Fe_3O_4 with a control over the particle size distribution, and when generated in the presence of cationic surfactants, the phenomenon of aggregation of nanoparticles was avoided. The obtained product was mixed with the monomer pyrrole, followed by its chemical oxidation in order to obtain the magnetite-polypyrrole (Fe_3O_4/Ppy) composites.

Two iron electrodes were used as anode and cathode for the electrolysis. The Fe_3O_4 nanoparticles were obtained by oxidation of iron in the presence of tetraalkyl ammonium salts. For its synthesis, chronopotentiometric techniques were employed, where the conditions were optimized in order to generate nanoparticles of 20 nm. The iron oxide was then mixed with a solution of the pyrrole, which was oxidized with $FeCl_3$ in order to polymerize the monomer and obtain Ppy with Fe_3O_4 nanoparticles embedded in its matrix.

The characterization of the generated composite Fe_3O_4/Ppy was carried out by different techniques. The spectroscopic techniques involved X-ray diffraction, X-ray fluorescence, Mössbauer, and FT-IR. Analyses by thermogravimetry (TG), transmission electron microscopy (TEM), and magnetization curves were also performed. Figure 1 shows the Fe_3O_4/Ppy morphology, were it can be observed that the dispersion of the iron oxide nanoparticles is homogeneous within the polymer. Magnetization curves are also presented (figure 2), which show that properties such as coercive field, depend of the synthetic conditions.

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Figures:

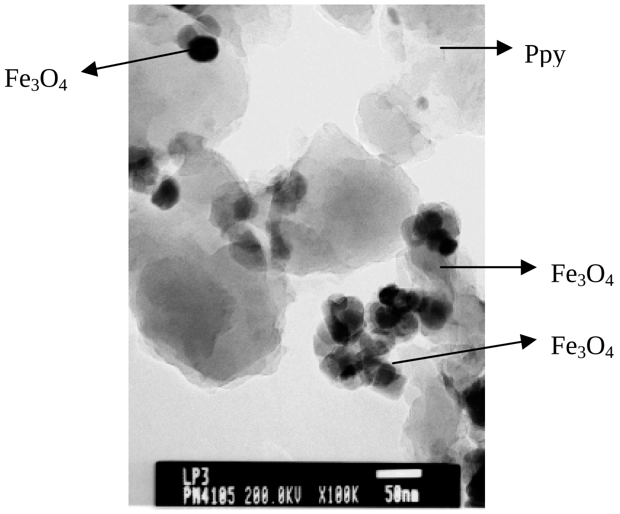

Figure 1. Fe_3O_4/Ppy composite, where Fe_3O_4 was obtained with $(CH_3)_4NCl$ as surfactant

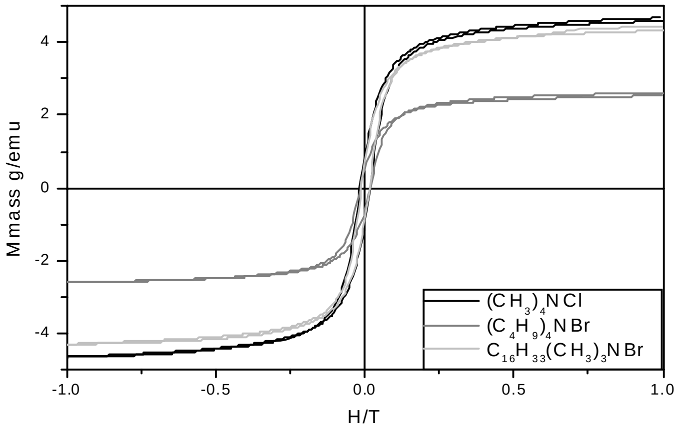

Figure 2. Magnetization curves of Fe_3O_4/Ppy obtained at room temperature, where Fe_3O_4 was prepared in each case with different tetraalkylammonium surfactants.