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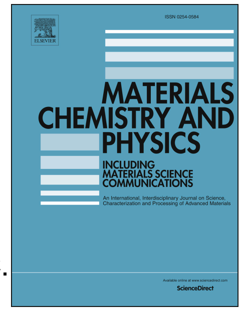

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Obtaining superhydrophopic magnetic nanoparticles applicable in the removal of oils on aqueous surface

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KEYWORDS: Iron oxide, Glycerol, superparamagnetic, superhydrophobicity and oil removal in aqueous surface

ABSTRACT: Iron oxide nanoparticles have high saturation magnetization values and their surfaces are easily modified by the insertion of functional groups such as carboxylic acids, surfactants, and polymers. In this work, iron oxide nanoparticles were functionalized with glycerol molecules modified by an esterification reaction with monocarboxylic acid, for their application in the removal of oils in aqueous surface. The nanoparticles were prepared by the coprecipitation method by alkaline hydrolysis of Fe^{2+} and Fe^{3+} ions in aqueous medium. The precursor used in the coating was obtained from functionalization of glycerol with stearic acid. The surfaces of iron oxide were coated by two different procedures: i) adding the precursor to the aqueous suspension of the purified iron oxide particles; and ii) preparation, purification and drying of the iron oxide particles and subsequent mixing with the precursor in isopropanol. The results obtained by the FTIR and NMR techniques showed that modification of glycerol with stearic acid occurs by esterification of the primary hydroxyl forming 2,3-dihydroxypropyl stearate. The characterizations carried out in the nanoparticles suggest the presence of cubic structure of inverse spinel, with lattice parameter and stoichiometry close to that of magnetite, which would be described as partially oxidized magnetite. The results obtained by FTIR, TGA and VSM of nanoparticles coated with 2,3-dihydroxypropyl stearate indicate the presence of organic material coating the magnetic nanoparticles. The particles showed certain sphericity with an average size of 11.17 nm and superhydrophobicity (164°). These samples exhibit chemical affinity for oil and are able to move and remove high and low viscosity oils on the water surface by applying an external magnetic field, obtaining an oil removal capacity of about 68 g of Bardahl oil per gram of nanoparticles. In addition, the nanoparticles are easily removed from the oil by a simple treatment with organic solvent, preserving its hydrophobic and oil removal characteristics.

1. INTRODUCTION

Iron oxide nanoparticles represent a class of materials that are typically smaller than 100 nanometers and play an important role in the field of nanoscience and nanotechnology since they are extensively studied and applied in various research fields [1,2]. Among these the highlight are magnetite (Fe_3O_4) and maghemite (γ-Fe_2O_3) since they have high magnetization, high superficial area and easily modified surfaces by inserting of inorganic materials, organic and/or polymeric [3–5]. Among the applications, we would emphasize the use as ferrofluids [6], magnetic recording media, gas sensors [7], heavy metal removal [8–10], of organic dyes [11,12] and oils in aqueous surface [13–15], as contrast agent for magnetic resonance, release of drugs in the body and cancer treatment [16–18].

Due to the potential applications of the nanoparticles, different methods of obtaining are being extensively used. These include the reduction-precipitation method [19,20], polyol [21–23], hydrothermal [24], sonochemistry [25], electrochemical deposition and microemulsion [26], oxidative hydrolysis of ions Fe^{2+} [27] and others. However, a common and economical method for the synthesis of large amounts of nanoparticles is the co-precipitation in a basic medium, which consists of coprecipitation of Fe^{2+}/Fe^{3+} ions (with a stoichiometric ratio of 1: 2) by adding an alkaline solution as shown in Eq. 1 [28,29]. The complete precipitation of magnetite occurs in pH values between 9 and 14 [30]. This method typically produces particles with average diameter less than 20 nm and is relatively easy synthesis [31].

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