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Sodium alginate surface-modified magnetic materials for microplastics separation

Eugenio Bringas[1], Maria J. Rivero[1], Inmaculada Ortiz[1], Daniel Aragón[1]

[1] *Departamento de Ingenierías Química y Biomolecular, ETSIIT, Universidad de Cantabria, Avda. Los Castros s/n, 39005 Santander, Spain.*

1. Introduction - The accumulation of plastic debris in the environment is one of the major environmental problems nowadays. Plastics that have a smaller size than 5 mm are classified as microplastics (MPs) and have been described as an emerging threat due to their long durability and resistance to biodegradation, assuming a global problem. For this purpose, a magnetic treatment and separation by functionalized nanoparticles has been developed. In addition, the capture of polyethylene microspheres provided by Cospheric with a size of 231 ± 19 µm in aqueous solution with functionalized magnetic nanoparticles has been selected as a case of study.

2. Experimental – Fe_3O_4 has been synthesized according to the coprecipitation method and sodium alginate (SA) has been integrated to enhance the interaction towards MPs. The experimental procedure consists of three steps. First, a 1.3 g L^{-1} concentration of the magnetic nanoparticles are suspended in UP water and sonicated for 20 min to ensure homogeneous dispersion. Subsequently, 0.5 g L^{-1} of MPs were added. The resulting mixture was stirred for 20 min at ambient temperature. Then, a rare-earth magnet (NdFeB) is introduced into the suspension to separate MPs that had interacted with the magnetic nanoparticles. Finally, the unseparated MPs are filtered and dried to evaluate the capture efficiency of the process.

3. Results - The synthesized materials have been characterized to evaluate their properties and to verify that the surface modification of the nanoparticles is effective and their feasibility for MPs separation experiments. Capture experiments showed that bare coprecipitation nanoparticles do not present a high affinity to the separation of MPs with efficiency due to the existing weak interactions with the MPs. By modifying the surface of the magnetic nanoparticles with sodium alginate, the separation of microplastics increases up to 82.4 ± 0.3% at pH 4.5. However, the capture percentages do not vary when changing the surface charge with the pH, which means that electrostatic forces are not the main force. The enhancement in the capture of MPs is attributed to the formation of hydrogen bonds with MPs due to the carboxyl and carbonyl groups on the surface of the particles.

4. Conclusions - Surface-modified magnetic nanoparticles are a promising alternative to separate MPs from water, since by modifying the surface of the magnetic nanoparticles, the interaction between magnetic nanoparticles and MPs can be increased. In this case, the integration of sodium alginate favors the interactions by the presence of polar interactions with the MPs.

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