Nanotechnology applied to environmental remediation

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Abstract

Nanomaterials have an increasing importance and relevance in our way of life by influencing several distinct areas. As a consequence, numerous innovative products have been introduced on the market, such as chemical and medical equipment, information technology, and energy utilities, among others. The advantages of the use of nanomaterials, which are related to their properties that are completely different from the bulk materials, turns them extremely attractive and with enormous potential. Among the areas that are influenced by nanotechnology, environmental remediation is highlighted in this paper.
This so-called nanoremediation is based on the usage of extremely reactive nanomaterials for the transformation of contaminants. The developed nanomaterials have properties that allow chemical reduction, as well as catalysis to degrade/transform, of the contaminants [1]. Besides this, the size of these particles allows them to percolate more easily through the soil, reaching smaller pores than other materials. Therefore, they improve the efficiency of the remediation process. However, and according to some real applications, nanomaterials show low mobility [2].
Several nanomaterials, such as nanoscale zeolites, carbon nanotubes and nanofibers, metal oxides, various noble metals, and titanium dioxide, have been tested and explored for environmental remediation. Among these, zero-valent iron nanoparticles (nZVIs) are currently the most widely used.
The size of nZVIs commonly ranges from 10 to 100 nm and use the reduction capacity of iron to degrade contaminants, especially chlorinated solvents. The application of iron to degrade this type of contaminants is widely known and studied since its utilization in permeable reactive barriers to treat groundwater [3]. The traditional methods for the production of nZVIs involve either aggressive reactions with toxic reagents (such as sodium borohydride) in which hydrogen gas is produced (liquid method) or expensive mechanical grinding (attrition method) [4]. Nevertheless, recently green production methods have been developed and are presenting promising results. These green methods use extracts of plants parts (leaves, peels, fruits or branches) that contain high concentrations of polyphenols. When these polyphenols (reducing agents) react with iron(III) nZVIs are produced [5] (Figure 1).

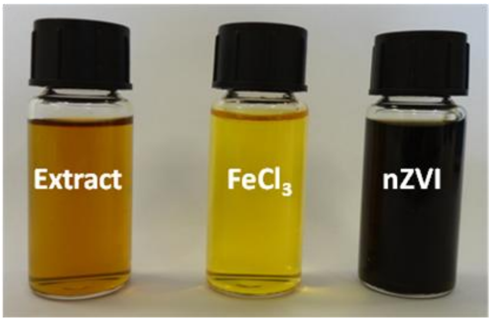

Figure 1 – Samples of a natural extract, an iron(III) solution, and the resulting nZVI dispersion.

However, the knowledge concerning this production method is yet scarce and requires further investigation of the process itself, but also of the application of the produced nanoparticles in environmental remediation.
The objective of this paper is to present the developments achieved by our research team in the production of nZVIs using natural products, such as leaves from different forest and fruit trees. Furthermore, the capacity of the produced nZVIs to degrade pharmaceutical products in aqueous solutions and soils was also evaluated. The results showed that the used method effectively produces nZVIs, with particle sizes ranging from 10 to 100 nm (Figure 2), and that these nanomaterials show an excellent capacity to degrade ibuprofen, one of the most frequently used non-steroidal anti-inflammatory drugs.

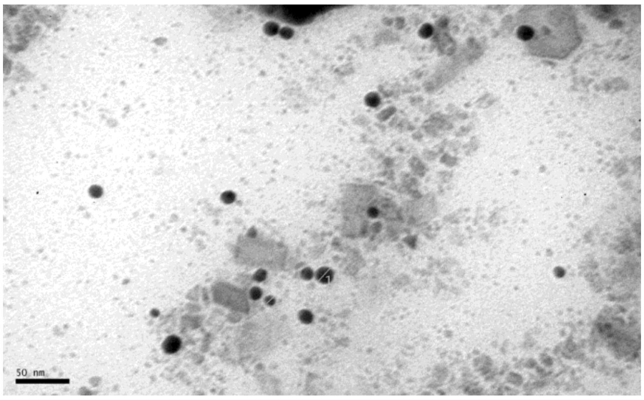

Figure 2 – Zero-valent iron nanoparticles produced using the green production method.

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