Desalination and Water Treatment
www.deswater.com
doi: 10.5004/dwt.2017.20713

(2017) 1–9

Green zero-valent iron nanoparticles synthesised using herbal extracts for degradation of dyes from wastewater

Emilio Rosales[a,b,*], M. Ángeles Sanromán[b], Celia Dias-Ferreira[a,c]

[a]*Research Centre for Natural Resources, Environment and Society (CERNAS), College of Agriculture, Polytechnic Institute of Coimbra, Bencanta 3045-601 Coimbra, Portugal, Tel. +351 239 802 940; Fax: +351 239 802 979; email: celia@esac.pt (C. Dias-Ferreira)*
[b]*Department of Chemical Engineering, University of Vigo, Isaac Newton Building, Campus As Lagoas, Marcosende 36310, Vigo, Spain, Tel. +34 986 812 304; Fax: +34 986 812 380; emails: emiliorv@uvigo.es (E. Rosales), sanroman@uvigo.es (M.A. Sanromán)*
[c]*Materials and Ceramic Engineering Department, CICECO, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal*

Received 23 December 2016; Accepted 15 March 2017

ABSTRACT

Nano zero-valent iron (nZVI) is an effective way to degrade different compounds. The green synthesis of nZVI showed potential as an alternative to $NaBH_4$ synthesised nanoparticles. In this study, a comparison among different nanoparticles (green, bare and polyacrylic acid coated) was carried out. Based on the higher stability of green nanoparticles, new extracts obtained from herbal aromatic leaves (rooibos, lemon verbena and camphora) were evaluated for the synthesis of nZVI. Two different extraction procedures were compared: decoction and infusion. The results showed that using a constant temperature of 100°C during the extraction increases the quantity of polyphenols and antioxidants extracted. The antioxidant content was highest in green tea (*Camellia sinensis*), but reactivity of synthesised nanoparticles of zero-valent iron is higher when using rooibos (*Aspalathus linearis*) extracts. Synthesised rooibos green nZVIs have been applied to degrade a textile dye, Reactive black 5, directly and as catalyst in an electro-Fenton process, reaching a decolourisation of 90% and 70% in 60 min, respectively. The synthesised nanoparticles demonstrated a good performance in the treatment of the polluted wastewater.

Keywords: Green nZVI; Rooibos; Nanoparticles; Lemon verbena; Dye; Fenton; Zero-valent iron; Green synthesis

1. Introduction

Nanoparticles of zero-valent iron (nZVI) have attracted much attention for their potential to treat and degrade various soil contaminants, e.g., chlorinated compounds and pesticides. The use of nZVI in environmental remediation is increasing.

Production of nZVI has been tackled from different approaches: mechanical [1,2] or chemical [3]. One of the most common chemical processes is the synthesis using sodium borohydride ($NaBH_4$) [4,5]. However, the production of nZVI from $NaBH_4$ shows some disadvantages such as high cost and toxicity of iron nanoparticle production due to costly reagents, the generation of unsafe flammable gas (H_2) by-products, toxicity of sodium borohydride, tendency to form agglomerates and rapid oxidation of iron nanoparticles [6–8].

To overcome these problems, the synthesis of nZVI requires a different approach. The use of safer solvents and auxiliaries helps to design safer and greener nZVI alternatives.

These solvents and chemical products should be chosen to perform their desired function while minimizing their toxicity and cost. Moreover, the high reactivity with side

* Corresponding author.

Presented at the 13th IWA Specialized Conference on Small Water and Wastewater Systems & 5th IWA Specialized Conference on Resources-Oriented Sanitation, 14–16 September, 2016, Athens, Greece.