

Green chemistry preparation of superparamagnetic nanoparticles containing Fe₃O₄ cores into biochar.

Muhammad K. Younas (PG)^{1*}, Marta E. Doumer (PG)¹, Antonio S. Mangrich (PQ)^{1,2,3}, Fabio S. Grasel (PG)^{4,5}, Ney Mattoso(PQ)⁶, Dante H. Mosca (PG)⁶.

¹Departamento de Química, Universidade Federal do Paraná (UFPR), 81531-980, Curitiba, PR, Brazil

²Departamento de Química, Universidade Federal de Sergipe (UFS), 49100-000 São Cristóvão – SE, Brazil

³Instituto Nacional de Ciência e Tecnologia de Energia e Ambiente (INCT E&A) (CNPq), Brazil

⁴TANAC S/A, Rua Torbjorn Weibull 199, 95780-000, Montenegro, RS, Brazil

⁵Programa de PG em Engenharia e Tecnologia de Materiais, PUC-RS, 90619-900, Porto Alegre, RS, Brazil

⁶Departamento de Física, Universidade Federal do Paraná (UFPR), 81531-980, Curitiba, PR, Brazil

*younas_chemist@yahoo.com

Keywords: Biochar; tannin; nanoparticles; paramagnetic.

Introduction

Nanotechnology is an engineering science in which the aim is to develop procedures and structures at the nanoscale, with novel properties that might offer solutions to many current problems. The Superparamagnetic nanoparticles containing Fe₃O₄ cores into biochar (acronym: SPMIOBNPs) prepared here could, with the help of neodymium magnets, be used to collect spilled oil from seawater. In this work, we describe the synthesis of superparamagnetic iron oxide (Fe₃O₄) nanoparticles in biochar obtained from the condensed tannin extract of *Acacia mearnsii*, using a single step process that is compliant with the principles of green chemistry.

Results and Discussion

The SPMIOBNPs were synthesized according to a modified co-precipitation method.¹ Dry tannin biomass was ground and screened (using an 80-mesh sieve), and 200 g was added to 1 L of an aqueous solution containing (80 x 10⁻³ mol/L FeCl₃ and 40 x 10⁻³ mol/L FeCl₂). Under vigorous stirring, an aqueous solution of 5 mol/L NaOH was added drop wise to increase the pH of the suspension to 10. The stirring was continued for 0.5 h, and the precipitate formed was then separated by centrifugation and filled into a ceramic pot prior to pyrolysis in the inner glass tube of a microprocessor-controlled EDG FT-40 furnace. The material was first heated to 100 °C, maintained for 2 h, and then the temperature was raised to 400 °C, at a rate of 5 °C/min, and kept at this temperature for 6 h. After cooling (room temperature), the sample was washed and dried, resulting in the SPMIOBNPs. Characterization of this material was performed using Fourier transform infrared spectroscopy (FT-IR), scanning electron microscopy (SEM), transmission electron microscopy (TEM), and X-ray diffraction analysis (XRD). The XRD analysis showed that the magnetic biochar nanoparticles contained a phase of magnetite or maghemite that exhibited inverse spinel structure. TEM analysis was used to confirm the formation, size, and morphology

of the magnetic nanoparticles. The SPMIOBNPs included uneven iron oxide nanoparticles with diameters of around 18–35 nm, (Figure 1). The magnetic properties revealed that the SPMIOBNPs were superparamagnetic, with a saturation magnetization of 32 emu/g at 300 K. The FT-IR spectrum showed a band around 3500 cm⁻¹ reflecting O-H stretching of phenol hydroxyl groups and adsorbed water. A narrow band at 1740 cm⁻¹ was due to carboxylic acid C=O stretching, and a peak at around 1500 cm⁻¹ corresponded to symmetrical stretching of C=C bonds of aromatic structures.² Peaks near 600 cm⁻¹ were attributed to absorption of Fe–O in the Fe₃O₄ structure.³

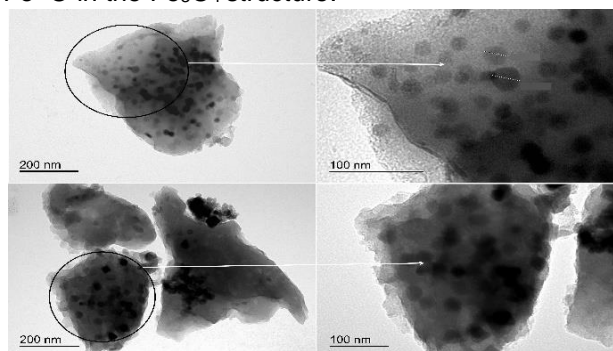


Figure 1. TEM micrographs of a SPMIOBNPs.

Conclusion

Superparamagnetic nanoparticles were successfully manufactured using tannin biomass as the raw material in a single-step green chemistry process in which none of the materials involved (reactants, products, and solvent) are harmful to the environment.

Acknowledgments

CNPQ, FUNPAR, LABPPAM, DQ-UFPR, INCT-E&A.

¹ Gubin, S.P.; Koksharov, Y.A.; Khomutov, G.B.; Yurkov, G.Y. *Russian chemical reviews*. **2005**, *74*, 489.

² Demir, A.; Topkaya, R.; Baykal, A. *Polyhedron*. **2013**, *65*, 282.

³ Kumar B.; Smita K.; Cumbal L.; Debut, A. *J. Saudi Che. Soc.* **2014**, *18*, 364.