Monitoring of Nd-Fe-B permanent magnets transformations during a hydrothermal recycling process

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The demand and the wide use of REEs in several industries are expected to increase in the next couple of years. Until now, China is the world's largest producer of REEs, with over 80 % of global production. This creates a large instability in the REEs market [1]. To reduce dependency on China for REEs, new strategies and measures should be adopted to satisfy future REE supply or demand. Recycling techniques from end-of-life products is one of the ways to ensure in the future a steady supply of critical REEs. To date, less than 5% of rare earths are recycled [2]. The permanent magnet sectors dominate consumption of REEs with 28 % of total demand in 2019 [3].

The aim of our work is to develop a new and environmentally friendly route for recycling rare earth Nd-Fe-B permanent magnets, employing green chemistry design principles [4-5]. Such a solvothermal process, leading to the pulverization of the magnet and, at the end, to the separation of iron and REE, is easy to set up and can be applied to large amounts of magnetic waste because only water and sodium chloride are used as cheaper chemicals.

The recycling process is very sensitive to experimental conditions such as pressure, temperature, time and type of solvent (water and ethanol). In this work, several ratios ethanol/water have been studied. Depending on this ratio, the powder can contain a mixture of different phases like iron, RE hydroxides, magnetite and a hydrided phase with $Nd_2Fe_{14}BH_x$ ($0<x<3$) stoichiometry. By optimizing physical parameters, iron and magnetite phases can be avoided. Furthermore, by dehydration of the resulting powder, one can obtain a magnetic powder made of $Nd_2Fe_{14}B$ particles, which can be used to make bonded magnets. Microstructural properties have been obtained by Scanning Electron Microscopy and X ray Diffraction. Mössbauer Spectrometry has been used to overcome limitation of conventional techniques in determining the presence of iron and magnetite. This technique is sensitive to iron environment and also to the hydrogen content x in $Nd_2Fe_{14}BH_x$.

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