Study of structural and magnetic properties presented by Tb\(_{1-x}\)Pr\(_x\)Ni\(_2\) compounds

Francesco Giuseppe Carotti*, Érik Oda Usuda, Adelino de Aguiar Coelho, Alexandre Magnus Gomes Carvalho

Abstract
On the search for better cores for cryogenic magnetic refrigeration, magnetic and structural properties, such as synchrotron x ray diffraction and magnetization of Tb\(_{1-x}\)Pr\(_x\)Ni\(_2\) were studied. The results show the linear behavior of the lattice parameter and the Curie temperature.

Key words: Magnetism, Magnetocaloric effect, Structural properties

Introduction
This project was elaborated to evaluate the structural and magnetic properties of Tb\(_{1-x}\)Pr\(_x\)Ni\(_2\) compounds and its applications on cryogenic magnetic refrigeration. Magnetic refrigeration is based in the magnetocaloric effect, which consists in the material ability to change its temperature due to a variation on the applied magnetic field in an adiabatic process.

Results and Discussion
For the preparation of the Tb\(_{0.5}\)Pr\(_{0.5}\)Ni\(_2\) alloy, nickel 99.7%, praseodymium 99.9% and terbium 99.9% were melted in an arc furnace in an atmosphere of Ar. Then, synchrotron x ray diffraction data were collected to determine the quality of the compound, based on Rietveld refinement. An analysis of the diffraction pattern peaks position done with Mathematica software presented \(a = 7.2332 \pm 0.0001\) Å as the lattice parameter “a” of the compound. Later on, optical metallography showed that the compound presented 3 different phases identified as Tb\(_{0.5}\)Pr\(_{0.5}\)Ni\(_2\), Tb\(_{0}\)Pr\(_5\)Ni\(_2\) (majority phase) and Tb\(_{2}\)Pr\(_3\)Ni\(_5\). Furthermore, magnetization thermal variation from 10 to 320 K at an applied magnetic field \(H = 200\) Oe measurements were taken. Curie temperature \(T_C = 20.5\) K was obtained analyzing the differential plot of the magnetization vs temperature.

The lattice parameters of TbNi\(_2\)\(^2\) and PrNi\(_2\)\(^3\) has, respectively, 0.056 Å and 0.053 Å difference from Tb\(_{0.5}\)Pr\(_{0.5}\)Ni\(_2\) lattice parameter “a”. The curie temperature of PrNi\(_2\)\(^4\) is much lower than TbNi\(_2\), causing and abrupt fall as terbium is replaced by praseodymium. A fit of lattice parameters and curie temperatures shows that both of them vary linearly with \(x, y = (-208 \pm 5)10^{-5}x + (13932 \pm 3)10^{-5}\) and \(y = (-37 \pm 2)x + (38 \pm 1)\) describes the liner variation of the lattice parameters and the Curie temperatures, respectively.

Conclusions
It is possible to conclude that praseodymium rich alloys of Tb\(_{1-x}\)Pr\(_x\)Ni\(_2\) have a low Curie temperature, therefore better for cryogenic magnetic refrigeration. Also, the replacement of terbium by praseodymium causes an abrupt fall of nearly 40 K on the curie temperature, while the lattice parameter vary 0.109 Å, both of them with linear behavior.

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\(^3\) E. Burzo, J. Laforest, Inter. J. Mag. 3 (1972), 171-177.