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

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Abstract
On the search for better cores for cryogenic magnetic refrigeration, magnetic and structural properties, such as synchrotron x-ray diffraction and magnetization of $\text{Tb}_{1-x}\text{Pr}_x\text{Ni}_2$ 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 $\text{Tb}_{1-x}\text{Pr}_x\text{Ni}_2$ 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 $\text{Tb}_{0.5}\text{Pr}_{0.5}\text{Ni}_2$ 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 $\text{Tb}_{0.5}\text{Pr}_{0.5}\text{Ni}_2$, $\text{Tb}_{0.5}\text{Pr}_{0.5}\text{Ni}_2$ (majority phase) and $\text{Tb}_{0.5}\text{Pr}_{0.5}\text{Ni}_2$. 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 $\text{Tb}\text{Ni}_2$ and $\text{Pr}\text{Ni}_2$ has, respectively, 0.056 Å and 0.053 Å difference from $\text{Tb}_{0.5}\text{Pr}_{0.5}\text{Ni}_2$ lattice parameter “a”. The curie temperature of $\text{PrNi}_2$ is much lower than $\text{TbNi}_2$, 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 $x$, $y = (-208 \pm 5)10^3x + (13932 \pm 3)10^5$ and $y = (-37 \pm 2)x + (38 \pm 1)$ describes the linear variation of the lattice parameters and the Curie temperatures, respectively.

Conclusions
It is possible to conclude that praseodymium rich alloys of $\text{Tb}_{1-x}\text{Pr}_x\text{Ni}_2$ 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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Image 1. Lattice parameter and curie temperature vs composition.

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