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Production and characterization of magnetic double perovskite Sr_2HoRuO_6

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Abstract – In this paper, we analyze the structural, morphological and magnetic properties of Sr_2HoRuO_6 (SHRO) compound by using X-ray diffraction, scanning electron microscope and a SQUID magnetometer. This sample was synthesized via solid-state reaction. The powder X-ray diffraction measurements and Rietveld analysis indicate that SHRO corresponds to double perovskite structure within the monoclinic system, space group $P2_1/n$. SEM analysis reveals that SHRO presents a homogeneous morphology and grain size between 2-10 μm, which is appropriate for the synthesis of ruthenocuprate Ru-1212Ho. Magnetic characterization indicates an antiferromagnetic behavior.

The double perovskite Sr_2HoRuO_6 is a precursor in the synthesis of ruthenocuprate $RuSr_2HoCu_2O_8$ (Ru-1212Ho). Ruthenocuprates are ceramic materials which show a magnetic and superconducting behavior simultaneously [1]. They have a multilayer structure similar to YBaCuO superconductor, with the atomic substitution of Y-Ba elements by Gd-*R*, with *R* a rare earth element. It is believed at present that the RuO_6 octahedron play a role similar to the Cu chains in YBaCuO, as a reservoir of charge carriers, generating the superconductivity in the CuO_2 planes [2]. The magnetic ordering could be explained considering that the ions in the Ru sublattice present an antiferromagnetic behavior with a tilt relative to the *c*-axis, leading to a resultant ferromagnetic component in the *a-b* plane [3]. Previous works have reported the production Ru-1212Ho ruthenocuprate by HPHT (High Pressure High Temperature) method by using Sr_2HoRuO_6 and CuO [4]. Although it has not been observed existence of the superconducting state above the 4.2 K, there is a metal-insulator transition at 22 K and evidence of an interesting magnetic ordering at 136 K. The resultant magnetic moment indicates that Ho and Ru ordering is antiparallel.

In the present work Sr_2HoRuO_6 compound was obtained by an enhanced solid-state reaction method, resulting in a high purity sample, in contrast with other reports [5-7]. It presents a double perovskite structure, into monoclinic system with space group $P2_1/n$. X-ray patterns were studied by Rietveld refinement, through GSAS software. The lattice parameters founded and refinement parameters are listed in Table 1. The chemical formula of this perovskite is $A_2(B,B')_2X_6$, where B and B' positions are occupied by Ho^{3+} and Ru^{5+} ions, respectively [5]. SEM analysis indicates that the sample has a grain size between 2-10μm suitable for the synthesis of Ru-1212Ho. Magnetization measurements in function of applied field and temperature were carried out, which indicate an antiferromagnetic behavior with Néel temperature $T_N \approx 15K$. The implications of our results and a proposal of a new synthesis method of $RuSr_2HoCu_2O_8$ are widely discussed.

a (Å)	b (Å)	c (Å)	α (°)	β (°)	γ (°)	V (Å^3)	χ^2
5.7702(5)	5.7785(5)	8.1465(6)	90.000	90.22(1)	90.000	271.62(4)	1.76

Table 1. Parameters obtained by Rietveld refinement for SHRO compound.

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