Magnetic and Crystallographic Investigations of Some Rare Earth Ferrite Compounds

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Magnetic susceptibility, Lattice constants, Rare earth ferrites

Lattice parameters and magnetic moments are given for a number of ternary compounds isomorphous with Sr₂EuFeO₅. These compounds are paramagnetic above 80 °K. The magnetic susceptibility data can be interpreted by a simple paramagnetism.

Introduction

A number of ternary compounds Sr₂REAIO₅ with RE (Pr, Nd, Sm, Eu, Gd, Tb) and Sr₂REFeO₅ with RE (Nd, Sm, Eu, Gd) have been prepared and characterized. Among these two groups of compounds with one and two magnetic ions per formula unit could be distinguished, namely Sr₂REFeO₅ and Sr₂REAIO₅. Both groups of compounds are isomorphous with Sr₂EuFeO₅ which has tetragonal structure and I₄/mmm space group. Magnetic properties of the first group of compounds Sr₂REFeO₅ resemble to the other rare earth ferrites present in the ternary system Sr₀-Eu₀-Fe₀ as Sr₂EuFeO₅ and Sr₂Eu₃Fe₂O₇. The second group of compounds have properties similar to the rare earth galenobis-muthit oxides such as paramagnetic behavior due to localized electrons.

Experimental

In order to prepare the appropriate compounds, equimolar mixtures of SrCO₃, R₂O₃, and AIO₃ or Fe₂O₃ were fired at 1400 °C. To ensure homogeneity, fired samples were crushed, mixed repressed and fired again several times.

A Geiger-counter diffractometer using N-filtered CuKα radiation at a scanning rate of 1°/20/min was used to obtain diffraction data. The 20 values were calibrated against the reflection of pure Au. The diffraction data of the compounds were indexed in the temperature range 80 to 300 °K. The magnetic susceptibility measurements were performed using the Faraday method on a modified Newport Instruments apparatus. The instrument was calibrated with mercury (2+ thioycanato-cobaltat(II)). The measurements were carried out in the temperature range 80 to 300 °K. The measurements and temperature control were very similar to those described by Danley and Mulya. In the measured temperature region all weighings were carried out on a Cahn RG electrobalance connected to a digital voltmeter. Since small fluctuations in the weighings at different fields were observed, each susceptibility value at one temperature point was expressed as an average obtained by measurements at five magnetic field strengths.

Results and Discussion

Lattice parameters for the compounds are given in Table I. The shifts of the line positions between two groups of compounds is due to the different size of Fe³⁺ and Al³⁺ ions.

<table>
<thead>
<tr>
<th>Compound</th>
<th>a [Å]</th>
<th>c [Å]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sr₂PrAlO₅</td>
<td>6.771</td>
<td>11.044</td>
</tr>
<tr>
<td>Sr₂NdAlO₅</td>
<td>6.672</td>
<td>11.057</td>
</tr>
<tr>
<td>Sr₂SmAlO₅</td>
<td>6.743</td>
<td>11.001</td>
</tr>
<tr>
<td>Sr₂EuAlO₅</td>
<td>6.726</td>
<td>10.998</td>
</tr>
<tr>
<td>Sr₂GdAlO₅</td>
<td>6.704</td>
<td>10.989</td>
</tr>
<tr>
<td>Sr₂TbAlO₅</td>
<td>6.688</td>
<td>10.935</td>
</tr>
<tr>
<td>Sr₂NdFeO₅</td>
<td>6.830</td>
<td>11.279</td>
</tr>
<tr>
<td>Sr₂SmFeO₅</td>
<td>6.801</td>
<td>11.294</td>
</tr>
<tr>
<td>Sr₂EuFeO₅</td>
<td>6.812</td>
<td>11.265</td>
</tr>
<tr>
<td>Sr₂GdFeO₅</td>
<td>6.819</td>
<td>11.197</td>
</tr>
</tbody>
</table>

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Magnetic properties of transition metal compounds were interpreted on the basis of room temperature magnetic moments relevant to the number of electrons of magnetic ions concerned.

The Curie constants $C$(RE), Weiss constants $\theta$ and effective Bohr magneton numbers $\mu_{\text{eff}}$ at room temperature for the first group of compounds are listed in Table II.

### Table II. Curie constants, Weiss constants and effective Bohr magnetic numbers.

<table>
<thead>
<tr>
<th>Compound</th>
<th>C (RE)</th>
<th>$\theta$</th>
<th>$\mu_{\text{eff}}$(exp)</th>
<th>$\mu_{\text{eff}}$(calcd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Sr}_2\text{PrAlO}_5$</td>
<td>1.44</td>
<td>34</td>
<td>3.4</td>
<td>3.62</td>
</tr>
<tr>
<td>$\text{Sr}_2\text{NdAlO}_5$</td>
<td>1.36</td>
<td>33</td>
<td>3.3</td>
<td>3.68</td>
</tr>
<tr>
<td>$\text{Sr}_2\text{SmAlO}_5$</td>
<td>0.32</td>
<td></td>
<td>1.6</td>
<td>1.65</td>
</tr>
<tr>
<td>$\text{Sr}_2\text{EuAlO}_5$</td>
<td>1.53</td>
<td></td>
<td>3.5</td>
<td>3.51</td>
</tr>
<tr>
<td>$\text{Sr}_2\text{GdAlO}_5$</td>
<td>8.69</td>
<td></td>
<td>8.0</td>
<td>7.94</td>
</tr>
<tr>
<td>$\text{Sr}_2\text{TbAlO}_5$</td>
<td>11.28</td>
<td>19</td>
<td>9.5</td>
<td>9.70</td>
</tr>
</tbody>
</table>

Magnetic parameters for the second group of compounds are listed in Table III. Besides values for $C$, $\theta$, $\mu_{\text{eff}}$(exp), $\mu_{\text{eff}}$(calcd) the table contains also the values for $\mu_{\text{eff}}$(Fe) calculated from $\mu_{\text{eff}}$(Fe) = $\sqrt{8C(\text{Fe})}$ and $C=C(\text{RE})+C(\text{Fe})$, taking value $C(\text{RE})$ from Table II.

### Table III. Magnetic parameters.

<table>
<thead>
<tr>
<th>Compound</th>
<th>C</th>
<th>$\theta$</th>
<th>$\mu_{\text{eff}}$(Fe)</th>
<th>$\mu_{\text{eff}}$(exp)</th>
<th>$\mu_{\text{eff}}$(calcd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Sr}_2\text{NdFeO}_5$</td>
<td>5.43</td>
<td>55</td>
<td></td>
<td>47.9</td>
<td>5.7</td>
</tr>
<tr>
<td>$\text{Sr}_2\text{SmFeO}_5$</td>
<td>4.81</td>
<td>54</td>
<td></td>
<td>33.5</td>
<td>5.9</td>
</tr>
<tr>
<td>$\text{Sr}_2\text{EuFeO}_5$</td>
<td>6.30</td>
<td>83</td>
<td></td>
<td>47.7</td>
<td>6.1</td>
</tr>
<tr>
<td>$\text{Sr}_2\text{GdFeO}_5$</td>
<td>11.49</td>
<td>12</td>
<td></td>
<td>92.1</td>
<td>97.8</td>
</tr>
</tbody>
</table>

The magnetic properties of the compounds obey Curie-Weiss law. The exception are $\text{Sr}_2\text{SmAlO}_5$ and $\text{Sr}_2\text{EuAlO}_5$ because of the anomalous behavior of $\text{Sm}^{3+}$ and $\text{Eu}^{3+}$ ions. The temperature dependence of $\mu_{\text{eff}}$ for $\text{Sr}_2\text{REAlO}_5$ compounds is shown on Fig. 1. The strong variation of $\mu_{\text{eff}}$ with temperature for $\text{Eu}^{3+}$ and $\text{Sm}^{3+}$ is in accordance with their multiplicity level distribution.

The iron contribution to the total magnetic moment of the $\text{Sr}_2\text{REFeO}_5$ compounds is nearly that of spin only value (Table III). No interaction between magnetic ions could be observed in these compounds. The magnetic susceptibility data can be accounted for by simple paramagnetism with so little interaction between the magnetic ions that there is no long range magnetic order above 80 K.

Financial support from Boris Kidrič Foundation is gratefully acknowledged.

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4 L. Holmes and M. Schieber, J. Appl. Physics 37, 968 [1966].