Synthesis and Characterization of LaCrAl\textsubscript{11}O\textsubscript{19} (Magnetoplumbite) through Solid State Reaction

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Introduction

Today, hydrogen is one of the most promising alternative energy carriers for alternative fuels. Production of hydrogen usually leads to high emissions of CO, CO\textsubscript{2}, NO\textsubscript{x}, etc.

One solution is the use of catalytic combustion. It has been proposed that hexaaluminates ($\text{ABA}_3\text{O}_{19}$) with the magnetoplumbite crystal structure can be an effective catalysts.

Presented here is a direct synthesis method for the formation of LaCrAl\textsubscript{11}O\textsubscript{19}, a proposed catalysts.

Phase Characterization

Chromium (Cr) reduction step was carried out at different temperatures: 1000°C, 1200°C, and 1400°C. Powders from each temperature were characterized via X-Ray Diffraction (XRD) analysis. Pure LaCrAl\textsubscript{11}O\textsubscript{19} has never been synthesized, thus the XRD pattern for LaMgAl\textsubscript{11}O\textsubscript{19} was used as a comparison. From the data, the desired product begins forming at 1200°C. At 1400°C, one can be certain that the desired product is formed. (See Figure 3 for XRD Data).

Experimental Procedures

1. Initial Powder Preparation

Initial powder include: La(NO\textsubscript{3})\textsubscript{3}·6H\textsubscript{2}O, Cr(NO\textsubscript{3})\textsubscript{3}·9H\textsubscript{2}O, and Al(NO\textsubscript{3})\textsubscript{3}·9H\textsubscript{2}O. Powders are ground and mixed to ensure homogeneity.

2. Water Evaporation

Powders are placed in furnace at 150°C for 5 hours for water evaporation.

3. Nitrate Pyrolysis

Powders are crushed again, then placed in furnace at 500°C for 5 hours for the nitrate pyrolysis.

4. Cr Reduction

Powders are crushed again, then placed in furnace at 1400°C for 10 hours in 4% hydrogen in order to reduce the Cr.

Figure 1: Crystal structure of LaCrAl\textsubscript{11}O\textsubscript{19}

Figure 2: Images of powders at various steps:

1. Initial powders
2. Water evaporation
3. Nitrate pyrolysis
4. Cr reduction

Figure 3: X-ray diffraction patterns for powder reduced at 1000°C, 1200°C, and 1400°C. Below XRD patterns are standards used to identify each phase.

Figure 4: Scanning electron microscope images of powders reduced at 1400°C (see figure 2, image (4)). Scanning electron microscope (SEM) imaging revealed three phases. From XRD analysis, it was determined that in addition to LaCrAl\textsubscript{11}O\textsubscript{19}, Al\textsubscript{2}O\textsubscript{3} and possibly LaCrO\textsubscript{3} are present.

Based on the densities of LaMgAl\textsubscript{11}O\textsubscript{19}, Al\textsubscript{2}O\textsubscript{3}, and LaCrO\textsubscript{3}, it can be predicted that in the SEM images (white) is the LaCrO\textsubscript{3}, (grey) is the LaCrAl\textsubscript{11}O\textsubscript{19}, and the darkest color is the Al\textsubscript{2}O\textsubscript{3}.

Future Work

- From the XRD data, the synthesized product is not 100% pure.
- A refined synthesis method is required to achieve a 100% yield of LaMgAl\textsubscript{11}O\textsubscript{19}.
- Material properties such as catalytic, magnetic, and luminescence need to be measured.

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