Synthesis and Characterization of $LaCrAl_{11}O_{19}$ (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_2, NO_x, etc.

One solution is the use of catalytic combustion. It has been proposed that hexaaluminates ($ABAl_{11}O_{19}$) with the magnetoplumbite crystal structure can be an effective catalysts.

Presented here is a direct synthesis method for the formation of $LaCrAl_{11}O_{19}$, a proposed catalysts.

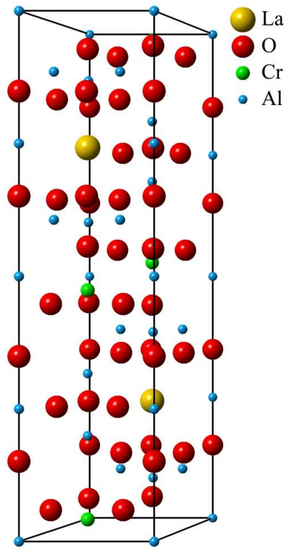

Figure 1: Crystal structure of $LaCrAl_{11}O_{19}$

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 $LaCrAl_{11}O_{19}$ has never been synthesized, thus the XRD pattern for $LaMgAl_{11}O_{19}$ 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: $La(NO_3)_3 \cdot 6H_2O$, $Cr(NO_3)_3 \cdot 9H_2O$, and $Al(NO_3) \cdot 9H_2O$. 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.

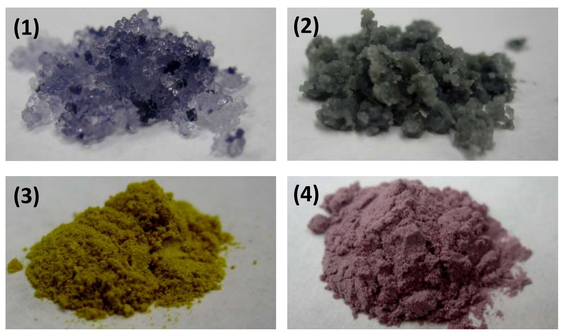

Figure 2: Images of powders at various steps:
(1) Initial powders
(2) Water evaporation
(3) Nitrate pyrolysis
(4) Cr reduction

Scanning Electron Microscope Images

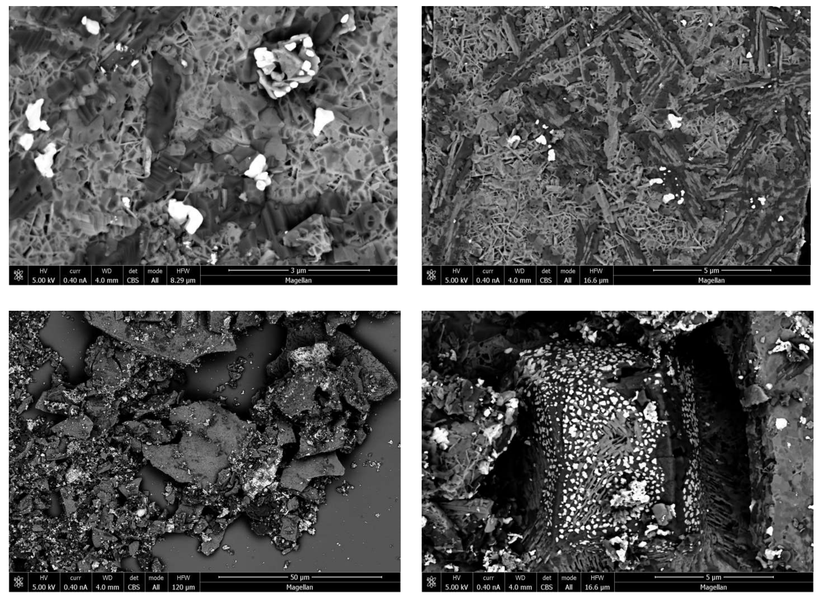

Figure 4: Scanning electron microscope images of powders reduced at 1400°C (see figure 2, image (4)).

Scanning electron microscope (SEM) imaging revealed three phases. From XRD analysis, it was determined that in addition to $LaCrAl_{11}O_{19}$, Al_2O_3 and possibly $LaCrO_3$ are present

Based on the densities of $LaMgAl_{11}O_{19}$, Al_2O_3, and $LaCrO_3$, it can be predicted that in the SEM images (white) is the $LaCrO_3$, (grey) is the $LaCrAl_{11}O_{19}$, and the darkest color is the Al_2O_3.

X-Ray Diffraction Data

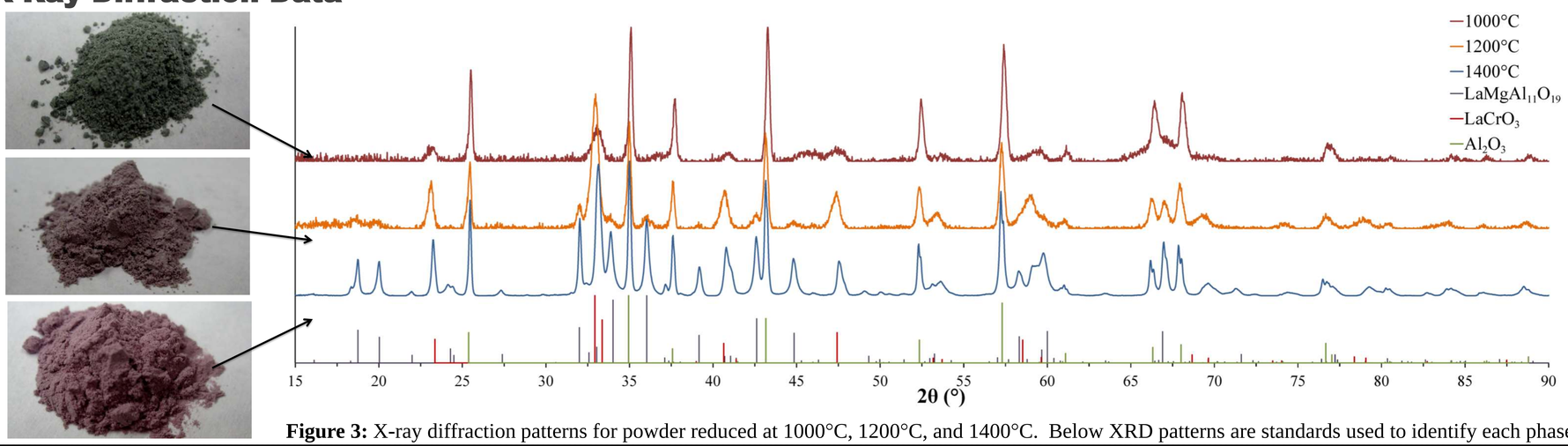

Figure 3: X-ray diffraction patterns for powder reduced at 1000°C, 1200°C, and 1400°C. Below XRD patterns are standards used to identify each phase.

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 $LaMgAl_{11}O_{19}$
- Material properties such as catalytic, magnetic, and luminescence need to be measured.

Acknowledgments

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