Synthesis and sintering of cordierite ceramic for catalytic decomposition of NO\textsubscript{x}

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Abstract

Thermal reactions of kaolin with magnesium hydroxide and kaolin with magnesium carbonate mixtures were studied to produce cordierite ceramic without additives. The compositions were determined based on the molecular formula of cordierite (2MgO \cdot 2Al\textsubscript{2}O\textsubscript{3} \cdot 5SiO\textsubscript{2}). The firing of the mixed materials at mole ratios of this formula was expected to produce amorphous cordierite at temperature of 900°C due to thermal decompositions and reactions. The amorphous cordierite was then crystallized at temperature around 950°C, and was gradually transformed into α-cordierite. This study was conducted by pressing the mixtures of raw materials to form test specimens which were then fired to obtain α-cordierite ceramic at 1300 °C and 1350 °C. Cordierite of 80.41-86.62 % purity was resulted from the mixture of kaolin with magnesium carbonate and metakaolin with magnesium carbonate at the firing temperature of 1300°C and 1350 °C. The catalytic activity of cordierite to decompose NO was tested, in which 44.17% of NO could be decomposed to reactive species at 400°C.

Keywords: cordierite, kaolinite, thermal decomposition, sintering, NO\textsubscript{x} decomposition

Introduction

Cordierite (Mg\textsubscript{2}Al\textsubscript{4}Si\textsubscript{5}O\textsubscript{18}) is a ceramic material that has a lot of usefulness. In industry, cordierite is used as support material in the field of refractories such as furnaces, heat-resistant table, electrical insulators, and tableware. In the eighties cordierite ceramics was developed with thin wall structures that are used for the regenerator, recuperator, radiator, catalyst carrier (Suzuki et al., 1984) and filters. However, cordierite is relatively difficult to be sintered because it has a short sintering temperature range, which is between 1300-1400°C.

Cordierite ceramics can generally be synthesized by using kaolin material. The development of ceramics industry led to increased demand for kaolin as the main raw materials and auxiliary raw materials. The potential of the abundant kaolin in Indonesia provide good prospects for the development of cordierite ceramics. Processing of kaolin as raw material for ceramics which commonly done in Indonesia aims primarily at obtaining fine granules and a high degree of whiteness. The process is highly dependent on the amount and type of minerals of its impurities and its specifications use (Nakahara et al., 1995). As raw material for the manufacture of cordierite, kaolin of high purity is required. High levels of calcium, potassium and sodium will reduce the performance of cordierite especially its thermal expansion.

Based on research that has been reported, kaolinite material has not been successfully used as raw material for making dense ceramics consisting of α-cordierite. In previous studies, it was found that α-cordierite ceramics can be made by firing at 1300°C, using a mixture of magnesium and calcined kaolin and milled until fine particles were obtained (Suzuki et al., 1988). However, in this process impurities can not be avoided because of the long time of milling. In another study, dense cordierite ceramics and cordierite / mullite composites with high mechanical strength have been prepared by the sol-gel method using Si and Al alkoxides (Sumi et al., 1998). Although dense cordierite ceramics have been successfully prepared from alkoxides at low temperatures, the raw materials used are very expensive and the manufacturing process is very complicated. In this study the formation of cordierite was conducted at temperatures of 1300°C and 1350°C, with soaking time of 1 at each temperature. Observations on the growth of cordierite crystals were carried out by using XRD.

Cordierite produced will be tested for its catalytic activity by allowing NO\textsubscript{x} gas to flow in a glass reactor filled with catalyst cordierite at temperatures of 100-500°C.

Materials and Methods

Materials and Equipment

Equipment used in the experiments is the ball mill, mold with a diameter of 3 cm, hydraulic press machines, electric furnaces 1500°C, Philip X-Ray Diffractometer, DTA, UV-Vis spectrophotometer, drying oven, analytical balance, Gas flowrate meter and glassware.