ABSTRACT - ORAL

Synthesis of cordierite – geopolymer composites: Green materials for high-temperatures applications

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Abstract

Advanced ceramics exhibit outstanding properties but require high-purity powders and sintering technologies with high energy consumption. Silicate ceramics offer lower properties but can be an advantageous alternative to advanced ceramics for many applications. For example, cordierite ($2MgO\ 2Al_2O_3\ 5SiO_2$) shows a low coefficient of thermal expansion ($2 – 3\ 10^{-6}$/K) and good mechanical properties that makes it widely used as a substrate for catalytic converters within the automotive industry. The large production of catalytic converters leads to significant volumes of end-of-life waste. Studies are carried out on the recovery of precious metals, but also on the substrate itself [1]. However, cordierite cannot be reintroduced into the primary production process, which relies on the reactive sintering of kaolin, talc, and alumina. On the opposite, the thermal consolidation of green parts made from recycled cordierite is based on solid-state sintering requiring high temperatures and a fine particle size distribution to enhance the diffusion mechanisms.

The ECOMAT-UMONS project aims to develop a low-energy and low greenhouse gas emission route. The project explores the possibility of a consolidation of recycled cordierite below 100 °C by using a geopolymer binder. The cordierite–geopolymer composite, potentially shaped by additive manufacturing, is intended for applications in catalysis and filtration, withstanding temperatures of up to 1000 °C. Industrial cordierite production wastes, corresponding to non-compliant sintered substrates without catalytic coating are used as raw material.

This study investigates a composite composed of cordierite bonded by metakaolin-potassium silicate geopolymer. The focus is on the influence of the K/Al ratio related to the geopolymer and the cordierite fraction in the composite on the dimensional stability and mechanical properties. Heat treatment at 1000 °C is applied to simulate the first use in temperature of the composite. High-temperature XRD (HT-XRD) analyses evidence that cordierite acts as a crystallization inhibitor and prevents the crystallization of the geopolymer in leucite. Moreover, while K/Al = 2.3, there is the insertion of potassium in the cordierite structure. These crystallographic transformations impact the sintering and final properties of the composite (porosity, shrinkage, Young's modulus, and coefficient of thermal expansion).

Keywords: Cordierite, Geopolymer, High-temperature, HT-XRD

References:

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