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Fired ceramics 100% from lignite fly ash and waste glass cullet mixtures

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Abstract

In the present study, the development of new building ceramics is investigated, using 100% lignite fly ash (FA) and waste glass cullet (WGC) mixtures as secondary industrial raw materials towards circular economy. Thus, compacted and sintered (at 700 and 900^{o}C) ceramic bodies based on binary WGC/FA mixtures, with WGC loadings up to 15%, were fabricated. The utilization of WGC (amorphous) aimed at lowering the sintering temperature of the mixture, for energy reduction purposes, via a better heat flux regulation in the material. The successful consolidation/densification of the ceramic microstructures, mainly composed of different silica phases, was achieved upon synergistic sintering at 900^{o}C for 2h. Moreover, the successful consolidation/densification was confirmed by the SEM micrograph observation and the porosity evaluation from the SEM micrographs. The addition of WGC yielded to a drastic decrease in the porosity values (down to 12%) for the samples sintered at 900^{o}C for 2h. This porosity decrease favored, in turn, the substantial microhardness increase (up to 3833 HV) due to the pore sealing by the glassy phase of WGC. Moreover, an exponential relationship between microhardness and porosity was revealed. Finally, further investigation of the processing conditions is currently underway towards the optimization of the attained ceramic microstructures in order to meet the requirements of specific applications.

Keywords: building ceramics; lignite fly ash; glass cullet; firing; characterization.

1. INTRODUCTION

A recent trend in building engineering is the valorization of various waste materials into added-value building products. Specifically, novel ceramic materials, for building engineering applications, can be developed by properly formulating and processing mixtures of solid industrial byproducts. In principal, these byproducts contain valuable oxides such as silica (SiO_2) and alumina (Al_2O_3) that improve the mechanical and other properties of the ceramics. The main advantages of the valorization of industrial byproducts is the production cost reduction, resources conservation and environmental protection. In that sense, the usage of industrial byproducts is strongly encouraged according to the current environmental policies and circular economy [1-4].

Up to now, considerable research efforts have been reported regarding the investigation of the production process for the conversion of various silicate wastes into useful materials destined to building, construction and other technical applications [5-7]. Particularly, siliceous fly ash (FA), produced in massive quantities from power station coal-fed combustors, is considered an attractive starting material for the development of cost-effective ceramic and glass-ceramic products. These