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Abstract

Valorization of Bauxite Residue in Ceramic Pastes †

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Bauxite residue or red mud (RM) is an industrial hazardous waste generated from alumina production using the Bayer Process. At present, it is one of the most abundant industrial wastes. Currently, 300 million tons of RM are generated per year worldwide, and already there are about 3 billion tons stored in ponds or dried mounds. Consequently, is of the utmost importance to tackle this problem and change this paradigm.

This work aims to valorize red mud by using it as a coloring agent in stoneware ceramic pastes. For this purpose, RM in several different proportions (0–10 wt.%) was added to ceramic paste. RM was firstly dried (at 120 °C) and, afterwards, used as received and calcined at 600 °C—for a heating rate of 10 °C/min and a dwell time of 30 min. To prepare the ceramic suspensions, the stoneware paste and RM were mixed with water and Dolapix using a turbo diluter to obtain a density of ≈1720 g/cm^3 and a viscosity of ≈30 s (Ford cup with 4 mm diameter), which are industrial values. The slip was sieved at 425 µm and cast in gypsum molds to obtain parallelepedic samples (of approximately 12 × 2 × 1 cm^3) and cups (height = 7.3 cm and diameter = 7.2 cm). After drying, the cups were industrially glazed with a bright opaque white glaze. The specimens and cups were sintered in a laboratory furnace with air ventilation. Through chemical characterization, the RM was found to be, as expected, mainly composed of iron oxide (48 wt.%) and alumina (19 wt.%), and presented a loss of 11 wt.% on ignition. The properties of the obtained products were analyzed. The developed stoneware products with RM exhibited a reddish color and the increase in the RM content increased the color difference value. Furthermore, all the technical characteristics (firing shrinkage, weight loss, water absorption, density and flexural strength) of all the prepared specimens were within the industrial limits. Leaching tests were performed with cups prepared industrially and all the obtained values were found to be below the maximum permitted values for iron, cadmium, and lead. Lastly, a life cycle assessment was performed that involved replacing the pigment used with RM. It was concluded that, if the RM was used as received, the carbon footprint of the system would decrease by 18% when the RM was incorporated in the stoneware paste. Therefore, this work provides a viable alternative for the management of this waste and reduces the environmental issues associated with RM disposal and carbon footprint associated with the ceramic production process. Moreover, these results prove that the bauxite residue, a hazardous waste, can be valorized in stoneware products as a coloring agent, promoting the concept of the circular economy.

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