NOVEL CERAMIC PRODUCTS BASED ON INDUSTRIAL WASTES

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ABSTRACT

This contribution reports the valorization of distinct industrial wastes as raw materials in different ceramic products. Metal-rich sludges generated from plating and galvanizing processes (e.g. steel wiredrawing, Cr-galvanizing, Al-anodizing), fines or sludge from ores extraction/treatment (red mud or bauxite residue, marble-sawing/cutting sludge), sludge from the recovery circuit of chemical reagents and from the wastewater treatment, as well as fly ash from the cogeneration of energy, all them generated by the cellulose industry. Three distinct valorization ways were explored, namely production of ceramic pigments, Portland and belite-based clinkers, and geopolymers. In such way we explore massive but inexpensive products, as well as technical/advanced solutions as targets for wastes recycling.

Keywords: industrial wastes, recycling, ceramic products.

INTRODUCTION

Currently the final destination of industrial wastes is a critical matter, and it is desirable to achieve a perfect symbiosis between economic and environmental aspects. Thus, the waste producers are encouraged to seek for more sustainable solutions and alternatives that involve the waste valorization through their use as raw materials for other industrial and technological sectors (Fischer, 2012).

In Portugal the production of paper pulp by chemical digestion is a good example of an industrial sector that generates a large volume of solid wastes, deriving from the internal chemicals recovery circuit, from the production of energy in biomass boilers, and from the wastewater treatment process (Modolo, 2011). Metal plating activities are still very expressive, and potential hazardous sludges are commonly generated (Magalhães, 2005). At a global level, the production of alumina from bauxite in the Bayer process generates huge amount of red mud. This residue is highly alkaline (pH>11) and is normally confined in huge tailing dams (Power, 2011). Recent studies and semi-industrial trials were directed to the incorporation of such wastes in distinct construction materials (Liu, 2011; Pacheco-Torgal, 2013). In fact, the construction industry is an ideal target for the wastes recycling due to the huge consumed volume of non-renewable raw materials, as well as due to its great flexibility/range of products that are available (cement, concrete, aggregates, ceramics, etc.) (Lee, 2005). More technical products, such as inorganic pigment, might also be explored for metal-rich wastes (Hajjaji, 2012).

RESULTS AND CONCLUSIONS

Concerning the pigments two different systems/colours were explored: (i) black spinel; (ii) novel blue hibonite-based formulation. The black pigment was prepared by mixing Cr/Ni-rich and Fe-rich galvanizing sludges and is based on the (Ni,Fe)(Fe,Cr)₂O₄ spinel. Optimal colour
development on glazes and ceramic tiles was achieved for mixtures in which the amount of Cr/Ni-rich sludge varied between 50 and 75%. The colouring properties were similar to those imparted by a commercial black pigment. In the hibonite structure, cobalt and nickel ions, in the co-presence of titanium, were separately added, in an attempt to get strong blue (with Co) and turquoise (with Ni) hues. Once applied in glazes, colour was found pretty stable against temperature and oxygen partial pressure admissible changes.

Distinct clinker formulations (Portland and belitic types) were produced by using red mud or the cellulose wastes. Belitic clinkers with balanced amounts of cementitious phases were produced at 1,350 °C. In the case of Portland clinker, a reduction of the processing temperature was also achieved, resulting from the presence of mineralizing impurities in some of the wastes, with procedural and economic benefits. The addition of red mud in the mortars tends to improve the technological properties, due to filler and pozzolanic effects.

Finally, geopolymers were produced from cellulose wastes and red mud (added to metakaolin). Despite the risks of producing materials showing properties that are far from ideal, namely in terms of mechanical strength, the selected processing conditions were kept as simple as possible. For example, the solid components were used essentially in the as-received condition, while samples cure was performed at 40°C. In general processed materials show modest mechanical resistance, but the simple sieving of fly ash and the exclusive use of the finer fraction might improve the strength. Simultaneously, the low relative density of the samples is consistent with their thermal insulation characteristics. Also of interest is the lead retention capacity shown by the monoliths, envisaging possible uses in environmental decontamination, as is common with zeolites.

REFERENCES


