Preparation and Characterization of Materials Obtained from Concrete and Paval Wastes

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INTRODUCTION

In recent years, waste from industrial activity and those generated in the construction and demolition have been intended for landfilling, creating a serious environmental problem due to contamination of soils and aquifers in uncontrolled landfills and to the landscape impact. Recycling is an economical and environmentally friendly way to handle some types of hazardous wastes, reducing or eliminating the amounts disposed in landfills. This is the case of aluminium and concrete residues (Shinzato & Hypolito, 2005, Tsakiridis, 2012).

The main objective of this study is the preparation and the chemical, mineralogical and microstructural characterization of green and sintered aggregates obtained from concrete and paval wastes, in order to investigate their possibilities of recycling.

MATERIALS AND METHODS

Green aggregates from paval (50%wt.) and concrete (50%wt.) mixtures were made for this study. Concrete is made from Portland cement CEM II / BV 32.5 R (Portland clinker + 65-79 % 21-35 % siliceous fly ash). Paval (also named non-metallic product, NMP), a waste of high aluminum oxide content, is produced in the recycling process of salt slag obtained in aluminum fusion. It was supplied by Befesa (Valladolid). Firstly, the process to produce aggregates involves crushing, grinding, and sieving raw materials to obtain fine size particles (<63 μm). These powders were then mixed with distilled water and rice starch as a binder, giving to green aggregates the necessary consistency for handling. Afterwards, cylindrical Teflon mold was filled with the mixture and brought to a drying oven to remove the mixing water and to consolidate the piece. Green aggregates were then sintered at 1300 ºC in a muffle furnace. Green and sintered aggregates (GA and SA, respectively) were weighed and measured in order to calculate their volume and density. A portion of each aggregate was finely ground to be analysed by X-ray diffraction using a Bruker D8-Advance diffractometer at University of Salamanca.

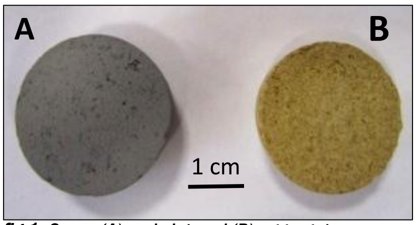

fig 1. Green (A) and sintered (B) aggregates.

Polished microslides of GA and SA were obtained and studied by polarizing microscopy (PM). Selected areas by PM were analysed using an electron probe microanalyzer (EMPA) JEOL SuperProbe JXA-8900M at the CNME (Madrid). The analysed elements were O, Mn, K, Si, Na, Fe, Ca, S, Mg, Al, P, F, Ti, Cu, Cr and Cl.

RESULTS AND DISCUSSION

Volume and density

The average values of volume and density were 7.97 cm^3 and 1.05 g/cm^3, respectively, for GA, and 5.93 cm^3 and 1.06 g/cm^3 for SA. The sintering process has involved not only a volume decrease, due to the removal of binder, but also changes in color and texture of the samples (Fig. 1).

X-ray diffraction

Identified crystalline phases in GA were (Fig. 2A): quartz, the most abundant, calcite, microcline, bayerite, gehlenite, corundum and spinel. In SA (Fig. 2B) a new crystalline phase appears, anorthite (generated by the reaction between silica, alumina and calcium

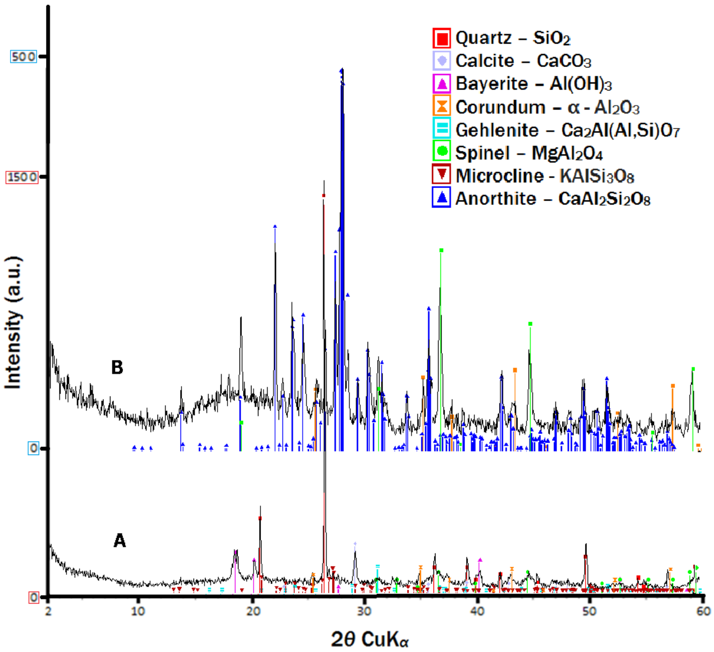

fig 2. X-ray diffraction patterns of green (A) and sintered (B) aggregates.

palabras clave: Muestras verde y sinterizada, Hormigón, Paval, Reciclaje

key words: Green and sintered samples, Concrete, Paval, Recycling

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compounds), along with spinel and corundum. The number of phases has decreased with the increasing temperature and their degree of crystallinity is higher. The background hump between 15º and 30º in the X-ray diffractogram provides additional evidence of the presence of an amorphous phase (probably SiO_2).

Polarizing microscopy

Quartz, calcite, feldspar, corundum and spinel were identified in GA but none phase were recognized in SA. In both samples some opaque phases were found.

Electron microprobe analysis

Backscattered electron images (BSE, Fig. 3) revealed that in GA particles are simply agglomerates, whereas in SA the microstructure has changed totally with a homogeneous distribution of phases due to the sintering process. The gases produced during this process have generated a high degree of porosity, mostly interconnected.

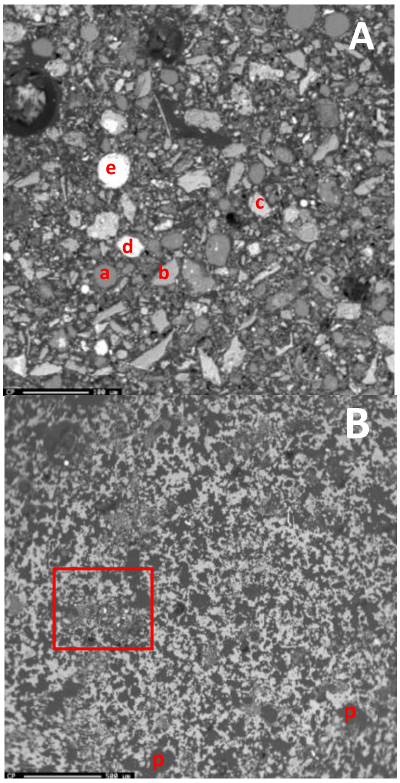

fig 3. BSE images of green (A) and sintered (B) aggregates. a: corundum, b: quartz, c: K-feldspar, d: calcium silicate, e: Si-Fe-Al-O phase; p: pore. Red zone in B is showed in fig 4.

Fifty microprobe punctual analyses carried out on different grains in GA revealed the presence of quartz, calcite, alite (C_3S), belite (C_2S), K and Na-feldspars, corundum, Al-Mg and Al-Si spinel phases and metallic phases of Al-Fe-Si (Fig. 3A). Twenty EMPA punctual analyses were carried out on different grey tonalities in SA, corresponding to corundum, anorthite phase of variable composition (CaO: 10-17%wt., SiO_2: 43-49%wt., Al_2O_3: 29-36%wt., Na_2O and K_2O up to 4 and 3%wt., and FeO and MgO up to 2 and 1%wt., respectively), Al-Si spinel phase, considered as a precursor of mullite (Chakraborty, 2005), Al-Mg and Al-Mg-Si-(Fe-Ca) spinel phases.

X-ray elemental distribution maps in sintered aggregates (Fig. 4) show the close association of Al-Si-(Ca)-(Mg)-O (anorthite and spinel phases) and Al-O (corundum). Metallic phases of Fe-Si-(Al) appear in minor amount. Zones with the highest Si contents seem to correspond to SiC used in microslide fabrication.

CONCLUSIONS

The sintered sample at 1300ºC based on concrete and paval, as reapplied waste material, could be a promising thermal-insulation and high temperature resistant material which could be used as refractory. Its constituent phases are quite resistant and corrosion inert, as well as very stable at high temperatures. The determination of its mechanical properties will allow to meet the potential uses. Moreover, the use of paval and concrete to produce new materials can reduce the amount of discarded wastes, contributing to environmental preservation.

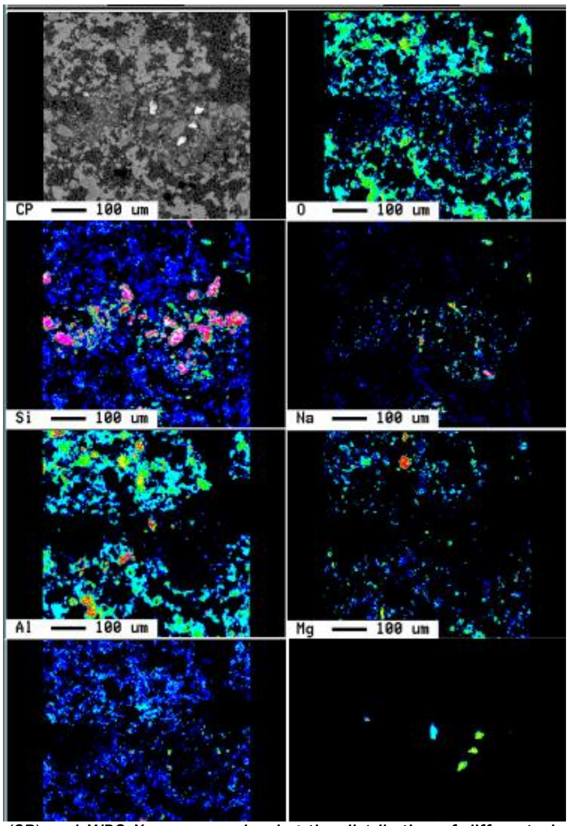

fig 4. BSE image (CP) and WDS X-ray maps showing the distribution of different elements. Color scale indicates the relative number of X-ray counts per pixel (low: blue, med: green-yellow, high: red-pink).

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