One-part geopolymers from spent filtering earths using alternative activators from waste glass. An example of circular economy

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Introduction

New circular economy strategies aim to transform the current linear economy into a circular model to reduce consumption of finite material. In this sense, one of the most materials-consuming sectors is construction, where just the production of Portland cement is considered responsible for 5 % of CO_2 emissions at global scale (Andrew, 2018). Geopolymers or alkali activated materials are an environmental-friendly alternative with the potential to partially replace Portland cement contributing to decrease the emissions of CO_2 from construction sector and enhancing circular economy in many sectors, since their residues could be used as precursor of these alternative materials. However, geopolymers still need to face some drawbacks such as the use of moderate amounts of chemical products and the need of managing concentrated alkali solutions.

This study focuses on the valorization of spent filtering earths (SFE), a waste from the agri-food industry, as a precursor in the manufacture of geopolymers. At the same time, the drawbacks previously mentioned have been avoided by the use of alternative solid activators made from waste glass (WG), with the subsequent advantages of one-part type geopolymers (Ren et al., 2021). To accomplish the objective of this study, alternative solid activator was synthetized by mixing sodium hydroxide and waste glass to produce sodium silicate under different conditions. Then, activators were used in solid state to create geopolymers, avoiding the use of alkali solutions in this stage and reducing drastically the amount of chemicals used.

Material and methods

To the purpose of this study, SFE was collected, dried at 105 ºC and calcined at 700 ºC, according to the results of TGA-DTA analysis, in order to eliminate moisture and organic content. The residue was then ground in a ball mill and sieved under 0.100 mm. WG was collected from residues with different types of residential-use glass and ground and sieved under 0.063 mm. The activator was created by a thermochemical process according to existing research (Vinai & Soutsos, 2019), heating a mixture of NaOH and WG with a small amount of water in a furnace up to 300 ºC and maintaining the paste at that temperature for 3 hours. The resulting solid was reduced into powder in a ball mill and a sample of the powder was studied by X-ray Diffraction technique (XRD) to ensure its quality.

Geopolymers were manufactured just by adding distilled water to a mixture of precursor and activator previously prepared. Different additions of alternative activator were tested. The pastes were homogenized in a planetary mixer for 90 s, poured into moulds and subjected to 60 strokes in a punching table to achieve the settlement of the paste. After 24 h, samples were demoulded and kept at temperature ambient. The addition of the activator was calculated to achieve values of 10, 20 and 30 grams of Na_2O added per every 100 grams of precursor. A batch of samples activated with commercial sodium silicate and sodium hydroxide mixture was also created to compare with the best of alternatively activated prototypes. Compressive strength of the prototypes was determined at 28 days of curing according to standard UNE-EN 1015-11:2020.

Results and discussion

According to the results of XRD determination (Image 1), the activator manufactured is mainly composed of sodium silicate, with a small amount of sodium carbonate presumable owing to carbonation processes during synthesis or even XRD determination. The lack of deviation from the baseline indicates that alternative solid activator manufactured is mainly crystalline in contrast with the amorphous raw material used (waste glass).

According to compressive strength test results (image 2), the amount of solid activator added is an essential parameter to optimize. In this case, 20 g Na_2O addition per every 100 g of precursor was the recipe that led to higher compressive strength at 28 days (35.8 Mpa). In addition, the result obtained when commercial activators are used in the equivalent amount of Na_2O addition were widely lower (23.1 MPa).

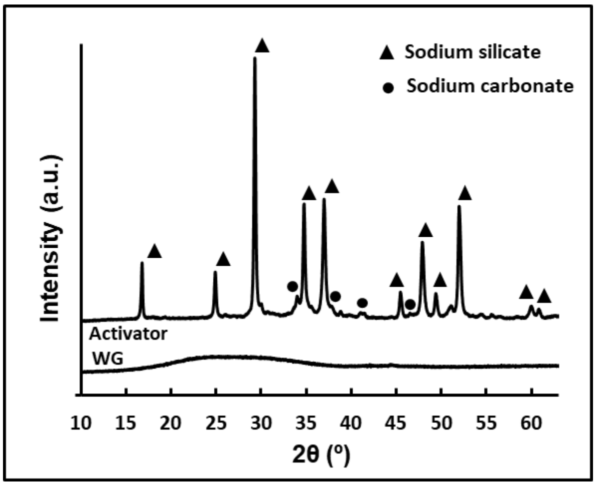

Image 2. XRD of waste glass and alternative solid activator

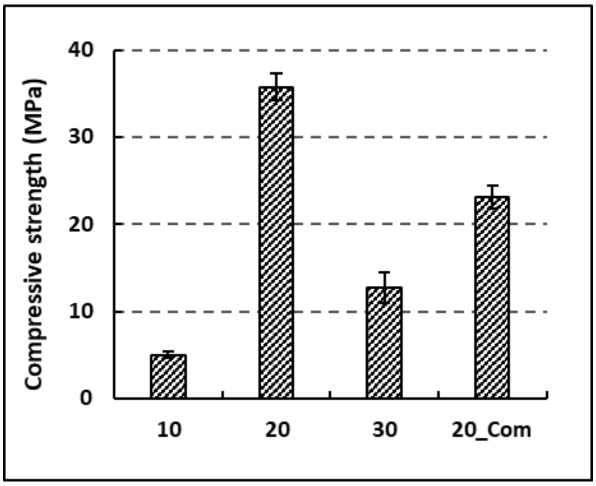

Image 1. Compressive strength test results

Conclusions

The results of this study indicate that one-part geopolymers can be manufactured using as aluminosilicate source spent filtering earths from agri-food industry just by adding distilled water and alternative solid activator made from waste glass and sodium hydroxide. In addition, the amount of Na_2O in the activator has an important influence on the mechanical properties, being 20 grams per every 100 grams of precursor the optimum amount to use. The use of residues to produce not only the precursor but also the activator opens the door to a bigger utilization of wastes in the line of the current strategies of circular economy with subsequent environmental and economic benefits.

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