Alternative activation of silicomanganese slag with olive biomass fly ash to produce one-part geopolymers for a circular economy.

P. Delgado-Plana[1,2], D. Eliche-Quesada[1,2], S. Bueno-Rodríguez[1,2], L. Pérez-Villarejo[2,3]

[1]Department of Chemical, Environmental, and Materials Engineering, Higher Polytechnic School of Jaén, University of Jaen, Campus Las Lagunillas s/n, 23071 Jaén, Spain
[2]Center for Advanced Studies in Earth Sciences, Energy and Environment (CEACTEMA), University of Jaén, Campus Las Lagunillas, s/n, 23071 Jaén, Spain
[1]Department of Chemical, Environmental, and Materials Engineering, Higher Polytechnic School of Linares, University of Jaen, Campus Científico-Tecnológico, Cinturón Sur s/n, 23700 Linares (Jaén), Spain
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Presenting author email: lperezvi@ujaen.es

Introduction

Circular economy is aimed at a new circular model that includes the use of wastes as new raw materials, decreasing by this way the impact of human development on environment. In this sense, the use of geopolymers or alkaline activated materials as a potential substitute of Portland cement in construction sector could be an strategic line to reduce the emissions of CO_2, allowing the utilization of a wide range of residues as a source of aluminosilicates in the manufacture of these environmental friendly materials.

The use of slags in the manufacture of geopolymers is one successful example of how alkali activation of different residues can lead to materials of adequate properties for their use in construction sector. However, most research is focus on the activation by addition of alkali solutions made from alkali hydroxides and, sometimes, silicates. These chemical activators imply the drawback of not being environmentally friendly or easy to hand. In other words, almost 80% of the footprint of alkali activated materials is due to the use of the activator (Ignatius Garces et al., 2021).

For that reason, this study is focus on the use of olive biomass fly ash (OBFA) as alternative solid activator in the activation via one-part of silicomanganese slag (SMS). Fly ash, due to its high content in K_2O has been previously used as activator with different slags obtaining promising results (Yousefi Oderji et al., 2019). So in this research it has been used with this barely studied kind of slags to evaluate the influence of the amount of K_2O added (by means of OBFA) on the activation process. In addition, the use of this solid activator allowed to work via one-part with the additional benefit on not to handle alkali solutions. On the contrary, the activation with OBFA has the disadvantage of the need of thermal curing for the first 24 hours, in accordance with other studies (Alonso et al., 2019).

Material and methods

To the purpose of this study, silicomanganese slag was ground in a ball mill and sieved under 0.100 mm and olive biomass fly ash was just mechanically activated in the same ball mill for 12 hours at 60 rpm. OBFA was added in dry to silicomanganese slag to obtain samples with 5, 10, 20 and 30 grams of K_2O per every 100 grams of precursor. Table 1 shows the composition of every batch of samples, normalized for 100 g of SMS. Samples were named according to "FA-x", where "x" is the amount of K_2O added.

Table 1. Composition of pastes.

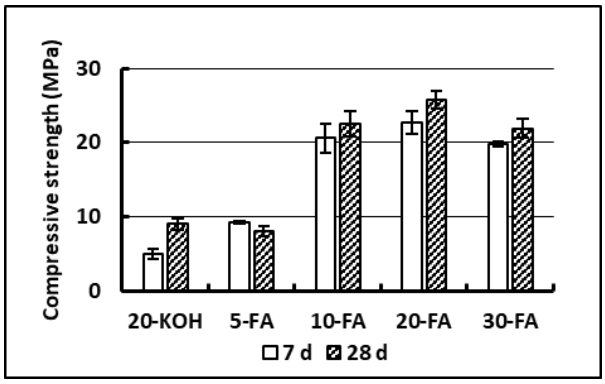
Sample	SMS (g)	BFA (g)	Water (g)	K_2O content (g/100 g)
FA-5	100	8.109	25.460	5
FA-10	100	16.218	26.919	10
FA-20	100	32.436	29.838	20
FA-30	100	48.654	32.758	30

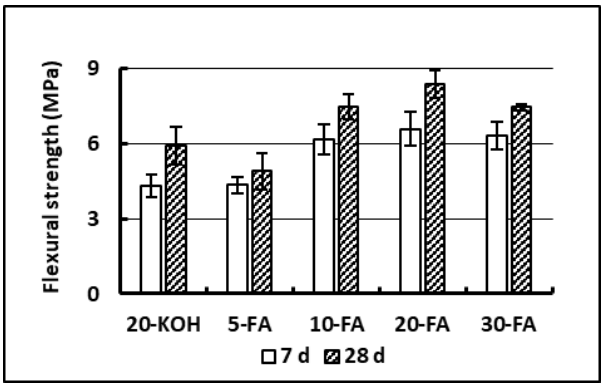
Samples were manufactured just by adding distilled water to the solids previously mentioned and homogenising in a planetary mixer for 120 s. Then, the paste was poured into moulds were stay for 24 hours at 80 ºC and preserved from evaporation. After that, samples were demoulded and kept at ambient temperature until the age of test (7 and 28 days).

Compressive and flexural strength of the prototypes were determined according to standard UNE-EN 1015-11:2020 and absorption and apparent density were measured according to UNE-EN 1936:2007.

Results and discussion

According to the results of mechanical tests (Image 1 and 2), OBFA seems to be an adequate solid activator when thermal curing for the first 24 hours is used.





In accordance with results of Images 1 and 2, sample 20-FA show the higher values of mechanical properties (flexural and compressive strength) and also showed the maximum apparent density (1995 kg/m^3 at 28 days) and the minimum water absorption percentage (7.11 % at 28 days).

Conclusions

The results of this study indicate that silicomanganese slag can be effectively activated via one-part, using as activator olive biomass fly ash with high K_2O content contributing to the utilization of both wastes in the line of current strategies of circular economy.

Geopolymers manufactured reached best properties when the addition of OBFA is equivalent to 20 grams of K_2O per every 100 grams of SMS.

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References

Alonso, M. M., Gascó, C., Morales, M. M., Suárez-Navarro, J. A., Zamorano, M., & Puertas, F. (2019). *Olive biomass ash as an alternative activator in geopolymer formation: A study of strength, radiology and leaching behaviour*. https://doi.org/10.1016/j.cemconcomp.2019.103384

Ignatius Garces, J. T., Jessemar Dollente, I., Beltran, A. B., Tan, R. R., & Angelo Promentilla, M. B. (2021). Life cycle assessment of self-healing geopolymer concrete. *Cleaner Engineering and Technology*, *4*, 100147. https://doi.org/10.1016/j.clet.2021.100147

Yousefi Oderji, S., Chen, B., Ahmad, M. R., & Shah, S. F. A. (2019). Fresh and hardened properties of one-part fly ash-based geopolymer binders cured at room temperature: Effect of slag and alkali activators. *Journal of Cleaner Production*, *225*, 1–10. https://doi.org/10.1016/J.JCLEPRO.2019.03.290