Effect of NaOH concentration and temperature on the hydrothermal synthesis of zeolitic materials

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INTRODUCTION

Thepresent workfocuses onthemanufactureofnewzeolitized structural materials, building ona novelapproach previously developed by Moreno-Maroto and Alonso-Azcárate (2024).Sincemarine debris, and more specifically the so-called mixed plastic fraction (MPF), generates a significant environmental and socioeconomic impact, the incorporation of MPF in mixtures to obtain these new materials could be an interesting alternative. Moreno-Maroto et al. (2024)demonstratedthat the addition of this residue to kaolin in percentages no higher than 10 wt.% could lead tohigh performancezeolitic materials, obtained by hydrothermal treatment with NaOH 3M at 150ºC for 24 h.Thisstudy aims to understandhow temperature and NaOH concentration affect the characteristics of the final product.

MATERIALS AND METHODS

This study proposes the recycling of MPFas a technological component in thefabricationof a new generation of structural materials obtained by hydrothermal zeolitization. For this purpose, the combination of kaolin with 5wt. %ground MPF<1mm has been studied. Rounded pellets of 10 mm diameter wereshaped. Afterovendryingat 105° C,thespecimenswere fired at 600°C, facilitating the formation of porosity due to the combustion of the plastic. Based onprevious studies (Moreno-Maroto and Alonso-Azcárate, 2024; Moreno-Maroto et al., 2024),thematerial obtained (in the form of lightweight aggregates)washydrothermally treated for 24 h, using steel reactors with Teflon vessels, studying different NaOH concentrations (2, 3 and 4 mol/L) and temperatures (90, 120 and 150°C),and maintaining a liquid/solid ratio of 8 ml/g. Thesupernatant was removedfrom the reactorandthefinal zeolitized aggregates werewashed to neutral pH, dried in an oven and finally characterized,determiningtheirmineralogy(XRD-Rietveld),density, water absorptionandporosity(waterpycnometry), compressive strength(hydraulic press)and microstructure(SEM).

RESULTS AND DISCUSSION

The hydrothermal treatment has favored an important crystallization of zeolites and feldspathoids,which was particularly pronouncedwhenMPFwas added. The formation of zeolite A (32-44%)was notable,with its proportion decreasingas thetreatment temperature andNaOHmolarityincreased,in favor of other phases, such as cancrinite, hydrosodalite, sodalite, phillipsite, nepheline and analcime(Fig. 1).The growth of zeolites(more accentuated with increasing temperature and NaOH concentration)contributedtoa very significant reduction in porosity, resultinginlower water absorption capacity, but higher density and mechanical strength (Fig. 2).Although the structure is lightweight(particle density around 1.7 g/cm3), the mechanical strength hassubstantiallyincreased with hydrothermal treatment, from 0.1 MPa (non-hydrothermally treated sample) to 2.1-3.4 MPa after zeolitization.

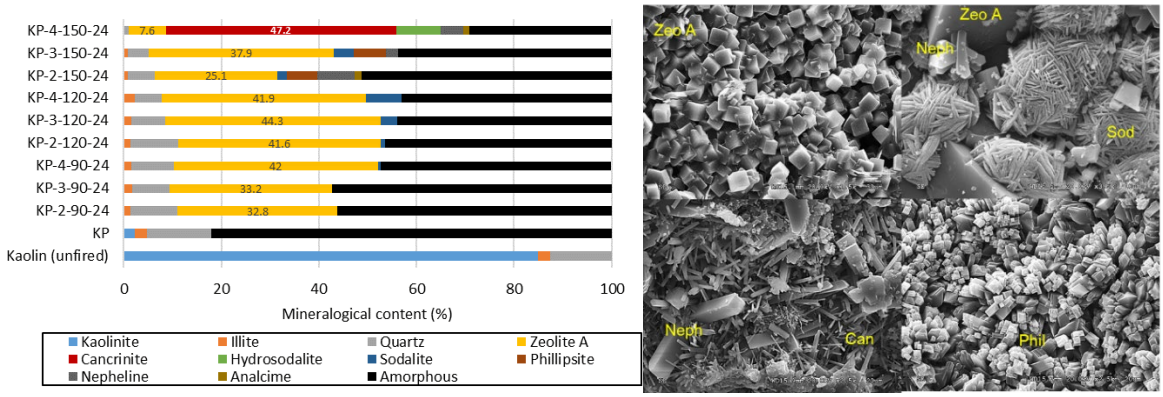

Fig 1. *Mineralogy: (a) Percentages of each mineral species obtained by XRD-Rietveld; (b) SEM images of some zeolite types formed.*

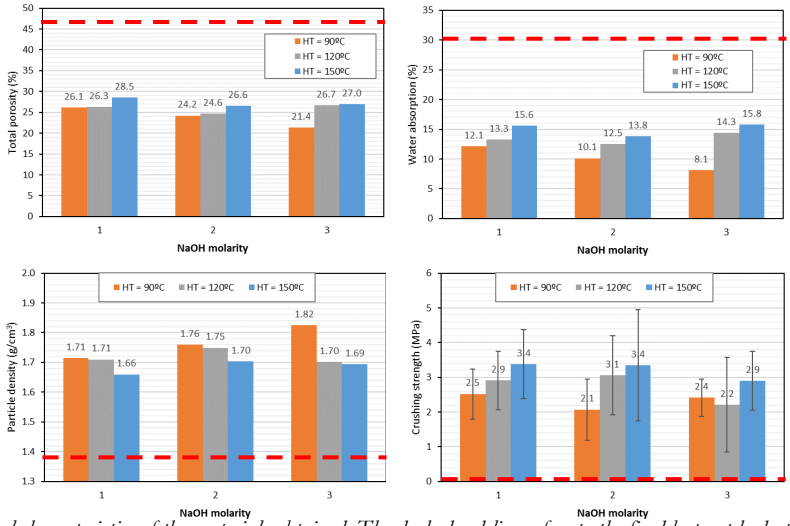

Fig 2. *Technological characteristics of the materials obtained. The dashed red line refers to the fired but not hydrothermally treated material.*

CONCLUSIONS

The results of this study show that the proposed hydrothermal synthesis method could be an alternative for the manufacturing of sustainable construction materials. It is demonstrated that the increase of both the treatment temperature and the NaOH concentration could favor the growth of zeolite in the structure, also affecting the zeolite type. In addition, the high zeolite content (especially zeolite A) could provide decontaminant capacity to the material, which is not common in conventional ceramics. It has also been shown that this new approach can accommodate highly problematic wastes, such as marine plastics, which can now act as technological components.

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