

Physical and mechanical properties after acid and thermal resistance tests in a blast furnace slag based geopolymer

A. Pérez-García¹, Y. Luna-Galiano^{*1}, M.P. Ariza², C. Fernández-Pereira¹
¹ Chemical and Environmental Engineering Department, University of Seville, Seville, Spain.
² Continuum Mechanics and Structure Department, University of Seville, Seville, Spain.
yluna@us.es, Phone: 34-954481180

INTRODUCTION

Many studies were carried out to investigate the effect of blast furnace slag (BFS) in fly ash based geopolymers. The study shows that the addition of BFS did not yield significant changes in the microstructure, appearing a well-developed matrix [1] with lower porosities and higher compressive strength. The presence of slag mainly results in the formation of calcium aluminium silicate hydrate gel [2] which can fill out the pores appearing among the different hydrated phases and the unreacted particles, resulting in a denser and more homogeneous matrix [3]. The durability aspects of these materials are an important issue, in order to evaluate the material safety in construction. In the current work, a blast furnace slag based geopolymer has been manufactured in order to study its physical and mechanical properties, and their evolution after two durability tests, an acid attack test with H₂SO₄ and a thermal test at different temperatures, i.e., 105, 300, 500 and 700 °C. [1] Luna-Galiano et al (2016) Mater. Construcc, 66(324), e098. [2] Palomo et al., (2014) Mater. Construcc, 64(315), e022. [3] S. Puligilla, P. Mondal (2013) Cem. Concr. Res, 43 (2013) 70-80.

MATERIALS and METHODS

Aluminosilicate chemical composition

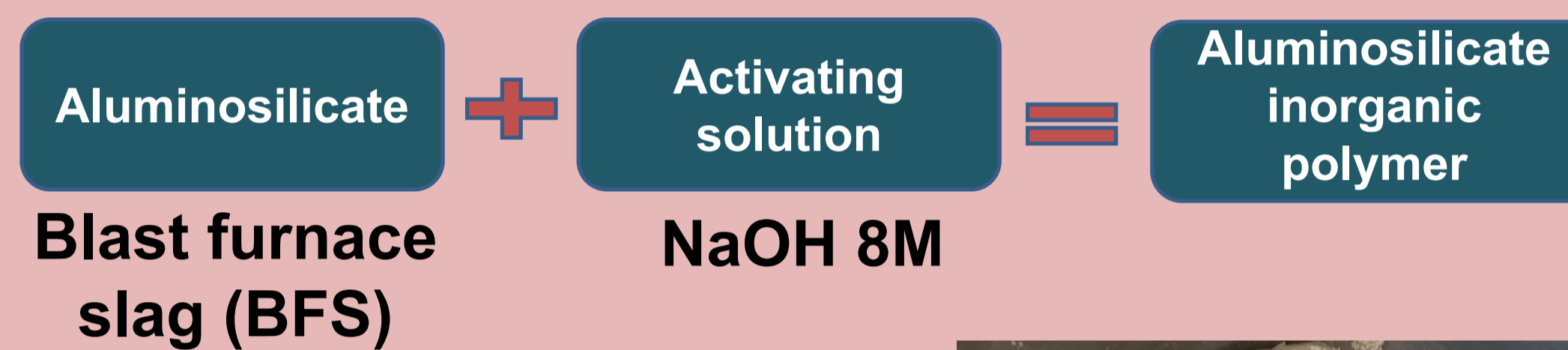
Main oxides (w%)						
Fe ₂ O ₃	CaO	MgO	SiO ₂	Al ₂ O ₃	Na ₂ O	K ₂ O
0.44	45.8	6.49	21.9	10.3	0.26	0.56

BFS: D₁₀₀ = 80 µm

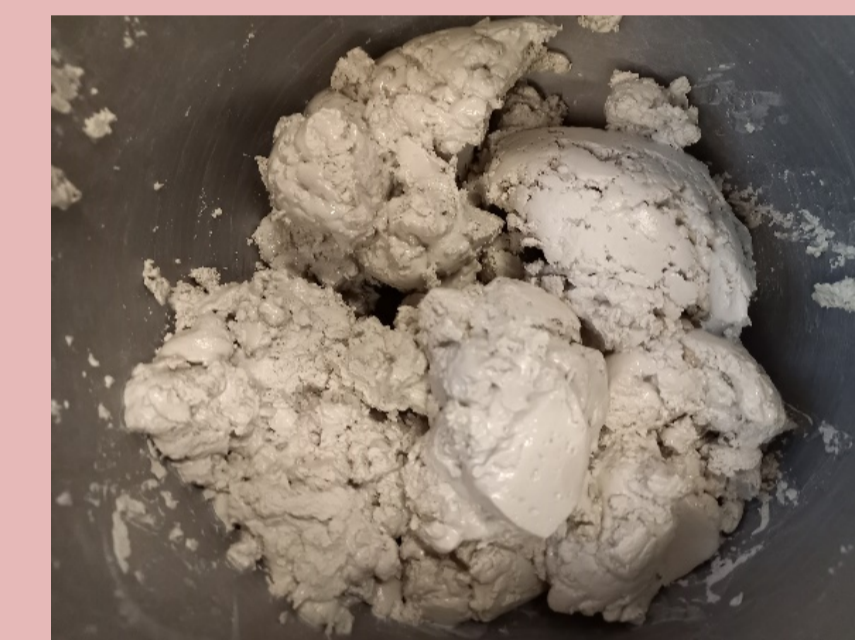
Activating solution

NaOH 8 M Density = 1.216 g/mL

Geopolymer composition



BFS/Activating solution w/w ratio = 4.11



Properties

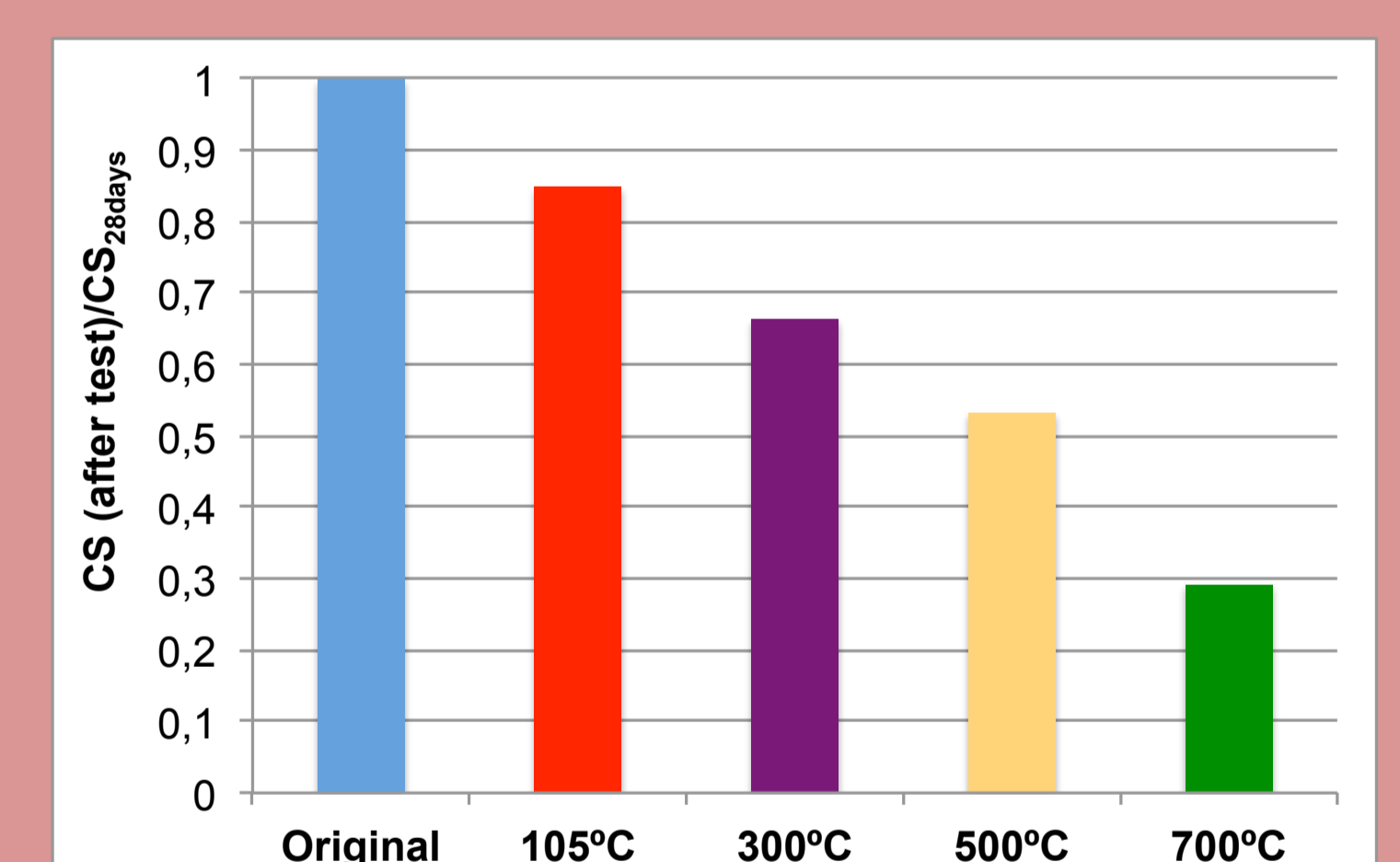
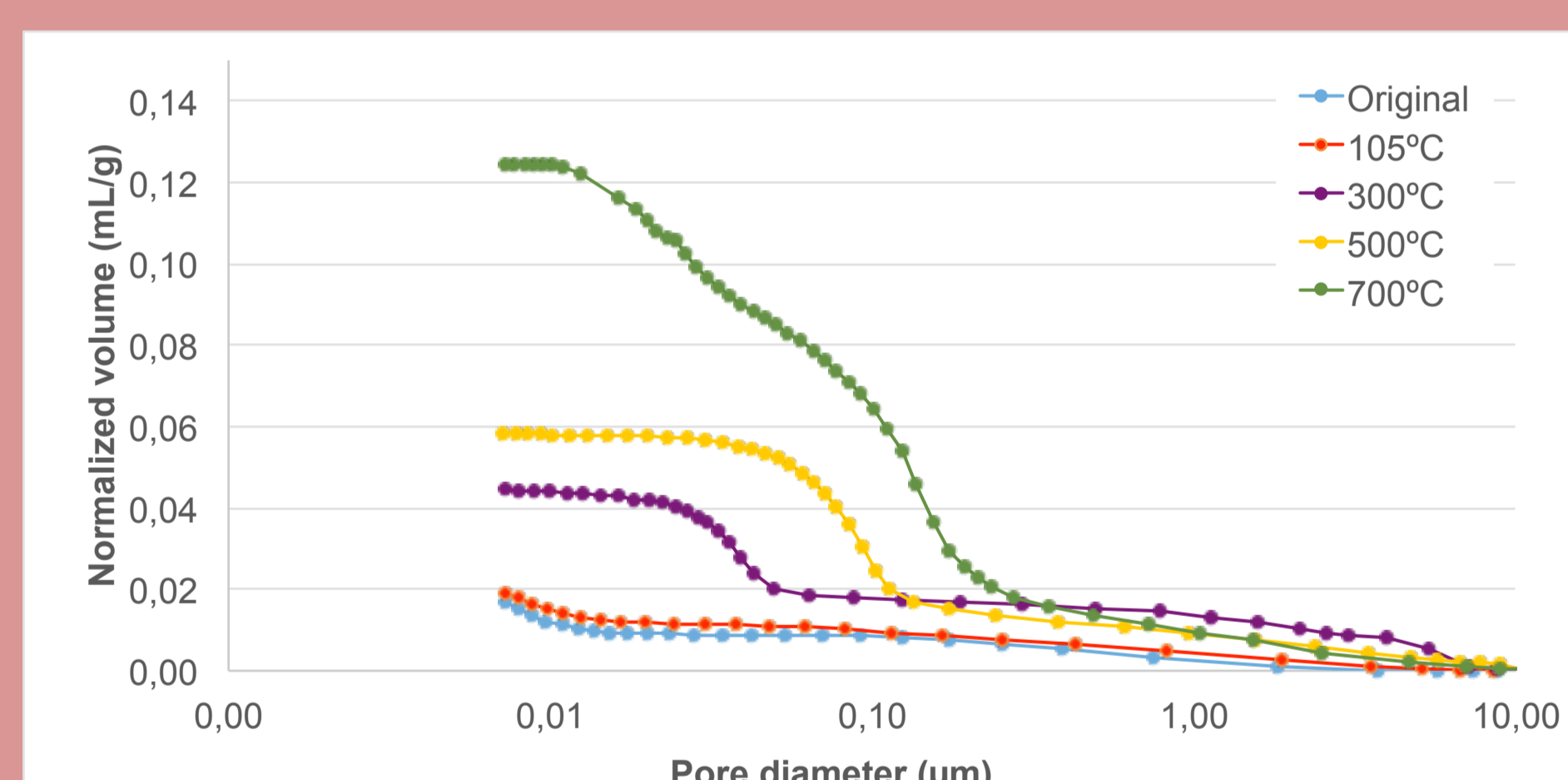
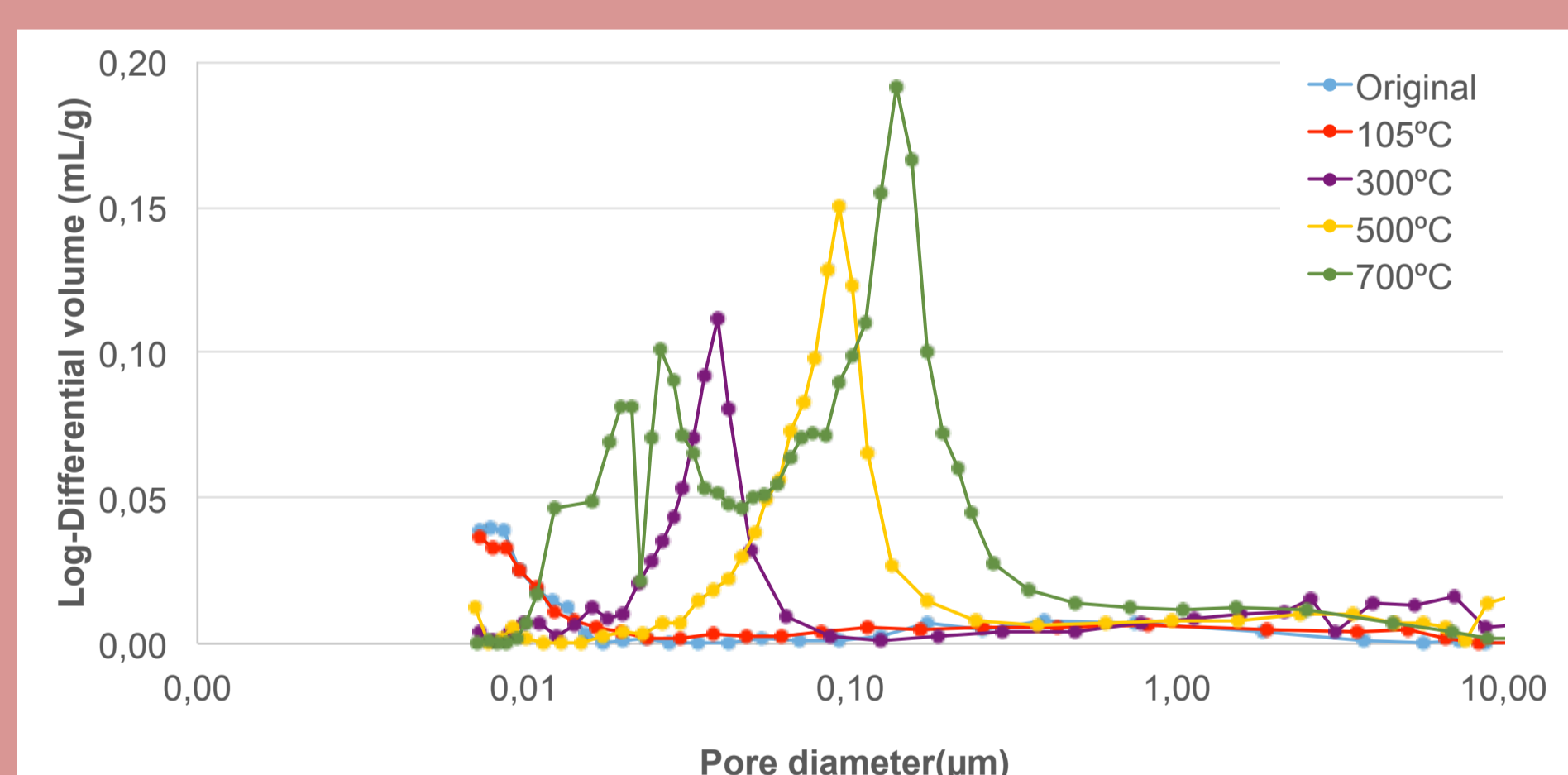
- BET surface
- Pore size distribution (Mercury intrusion porosity)
- Porosity (MIP)
- Bulk density
- Mechanical properties
- Durability tests:
 - Acid attack resistance
 - Thermal resistance

RESULTS and DISCUSSION

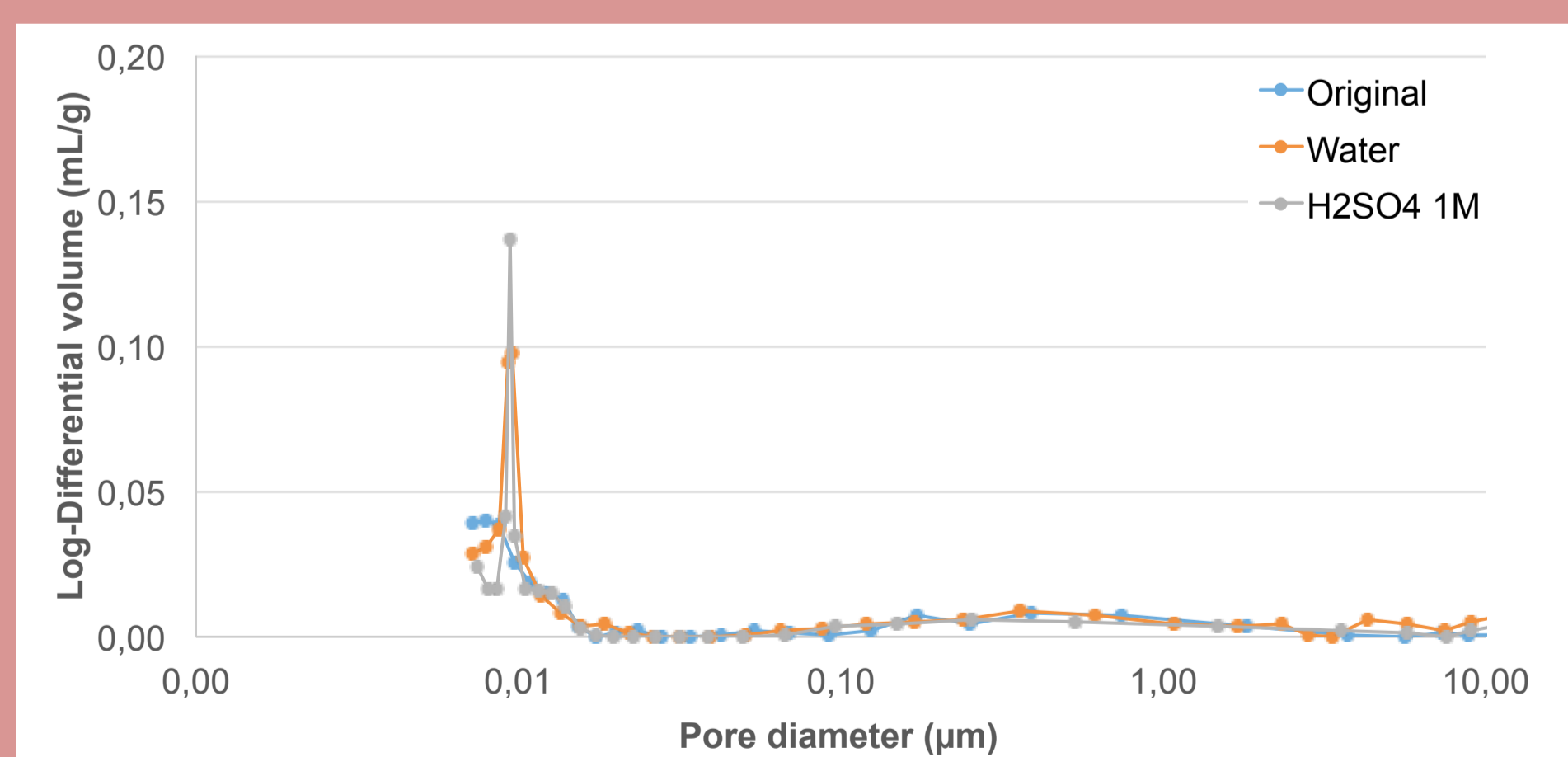
PROPERTIES at 28 days of curing in environmental conditions					
BET surface (m ² /g)	Total pore volume (mL/g) MIP	Total pore area (m ² /g) MIP	Density (g/cm ³)	Compressive strength (MPa)	Flexural strength (kN)
1.82	0.0174	3.7358	2	70	5.32



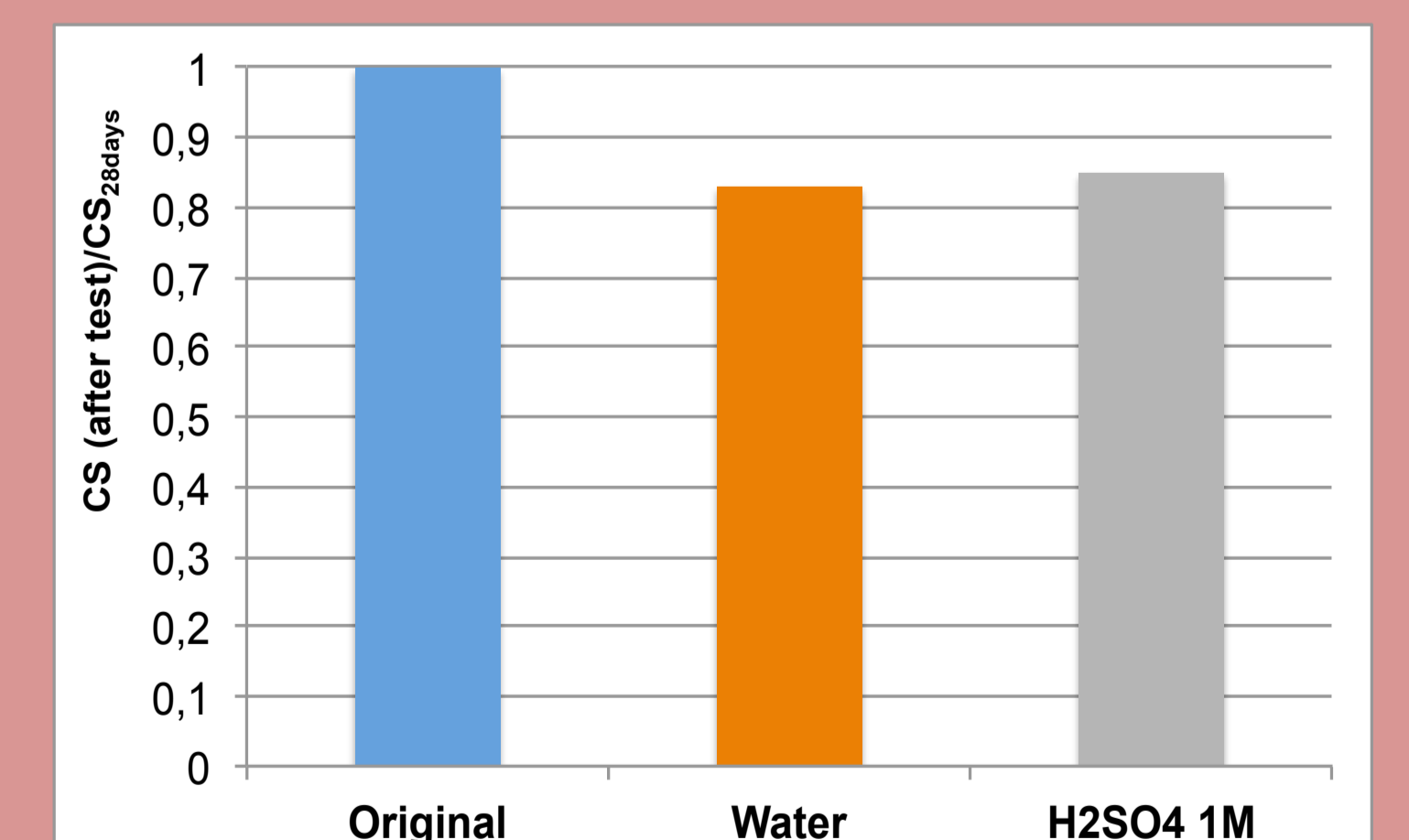
THERMAL RESISTANCE TEST Geopolymer samples were submitted at temperatures of 105, 300, 500 and 700°C for 3 hours. Porosity, pore size distribution and compressive strength (CS) are evaluated.



ACID ATTACK RESISTANCE TEST Geopolymer samples were submerged in 1M H₂SO₄ for 14 days. For comparison purposes, other geopolymer samples were immersed in water for 14 days. Porosity, pore size distribution and compressive strength (CS) are evaluated.



After acid test	Total pore area (m ² /g)	Total pore volume (mL/g)
Water	3,40	0,0200
H ₂ SO ₄ 1M	3,63	0,0198



The geopolymer manufactured by the activation of the BFS with NaOH 8M shows a very high value of compressive strength after 28 days cured at ambient temperature (70 MPa). It is a high dense material (2 g/cm³) with a low porosity (0,017 mL/g).

After acid/water attack, porosities undergo a slight increment, possibly due to the deterioration of the matrix after immersion of samples in 1M H₂SO₄ and in water. Both pore size distributions are similar to the original one, although a slight increment of pore volume in pore sizes of 0.01 µm is observed. In addition, a decrement of pore volume in pores less than 0.01 µm is also noticed after H₂SO₄ attack, possibly due to the formation of some type of precipitates (calcium sulphate) that fill these pores. Therefore, a decrement of compressive strength (CS) after the test is observed, which is lower after acid immersion than in water immersion.

As a result of the thermal resistance attack, the mass of the geopolymer decreases with increasing temperature due to the damage of the material, and consequently the compressive strength drops off. In addition, the porosity increases with the temperature; specifically, it has been observed that the pore volume rises with the temperature for pore sizes less than 0.35 µm. The log-differential volume curves show the appearance of one peak at 300°C (in a pore size of 0.038 µm), which shifts to greater pore sizes as temperature increase to 500°C (0.093 µm) and 700°C (0.137 µm).