

ALKALI-ACTIVATION OF VITRIFIED BAUXITE RESIDUE: THE EFFECT OF MgO

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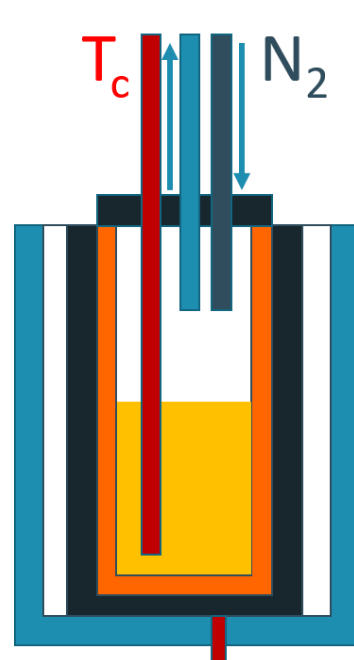


ABSTRACT

Bauxite residue (BR) is generated from the alumina industry, during the digestion of bauxite ore in the Bayer cycle, and is produced at a rate of 150 Mt/y. The estimated amount of landfilled BR is above 3 billion ton worldwide.¹ However, BR can be transformed into a reactive precursor for Inorganic Polymers after a high temperature treatment with descent strength properties. To increase it's durability MgO can be added in order to increase it's carbonation resistance due to to the formation of layered double hydroxide.² **This work shows that compressive strength up to 80 MPa can be reached with a good carbonation resistance, but MgO negatively influences performance.**

METHODS AND MATERIALS

The BR was dried at 105 °C for 24 h and 10 wt% SiO₂ and 2 wt% C were added. In total, four different glasses were synthesized by adding **0, 1, 3 and 5 wt% of MgO** to the mix, named as **TBR(0, 1, 3 or 5)MgO**. After melting and quenching, the treated bauxite residue (TBR), was milled until a Blaine specific surface area of 4400 ± 200 cm²/g. After milling, paste samples were prepared by mixing the TBR with an alkali activating solution (H₂O = 65 wt%, SiO₂/Na₂O = 2.0 molar ratio) with a L/S of 0.4. Samples were left 28 days for curing, afterwards these were tested for compressive strength and put in a carbonation chamber (1% CO₂, 65% humidity) for 3 months. In addition, dissolution tests were performed on the milled samples in 6M NaOH for 24hrs, filtrated and measured with ICP-OES.



RESULTS

The used BR was characterized by a **high Fe₂O₃** and **low SiO₂** content (Table 1). The **SiO₂ was increased to increase the amount of melt.**

Table 1: Chemical composition of the BR and TBR using different additions of MgO (estimated relative error is 10%).

	Fe ₂ O ₃	SiO ₂	Al ₂ O ₃	TiO ₂	Na ₂ O	CaO	MgO	Other
BR	48.3	9.8	17.1	8.6	8.2	6.0	0.1	1.8

By **increasing** the amount of **Mg** in the TBR, a **higher quantity of spinel** ((Fe,Mg)(Fe,Al)₂O₄) was formed. A significantly lower amount of amorphous phase is visible for TBR5MgO (Figure 1).

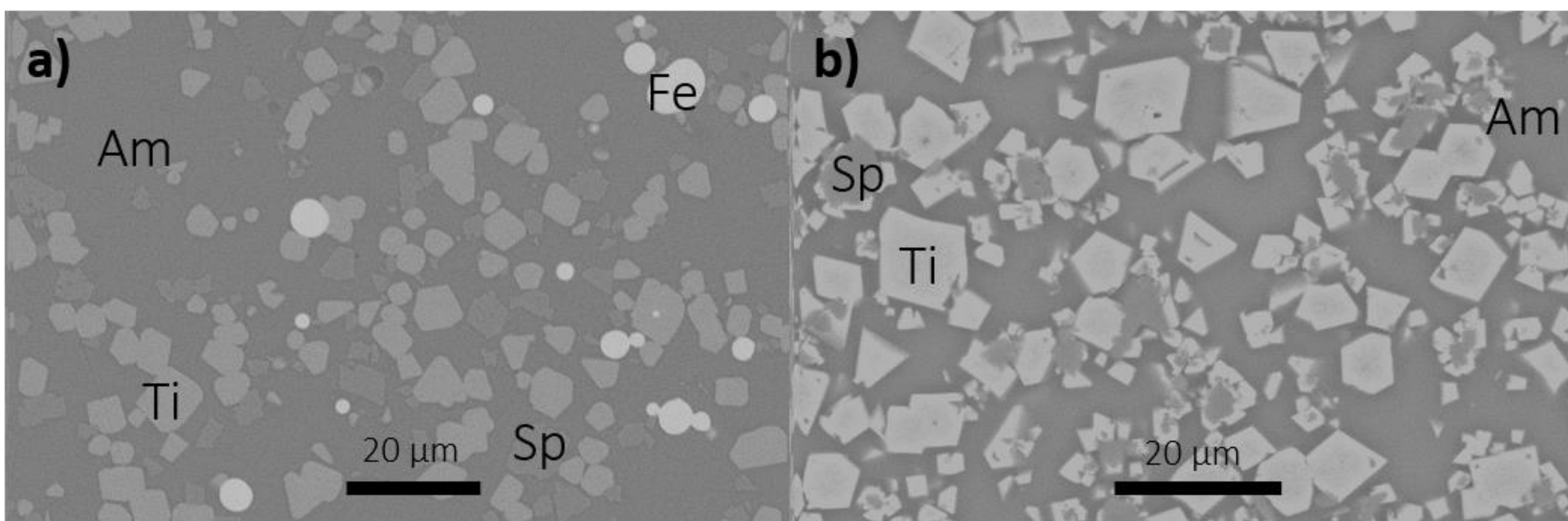


Figure 1: Microstructure of TBR using BSE imaging for a) TBR0MgO and b) TBR5MgO. Am: amorphous, Fe: iron, Ti: titanomagnetite, Sp: spinel.

In 6M NaOH, the release of Si increases and Al decreases, with increasing MgO due to the presence of more spinels (Figure 2a). **28 d compressive strength up to 80 MPa** was measured for the Inorganic polymers (Figure 2b). The **lowest compressive strength** was measured for TBR5MgO and can be **linked to a decrease of amorphous phase** and a **decrease of Al in the glass**, affecting the final binder chemistry.

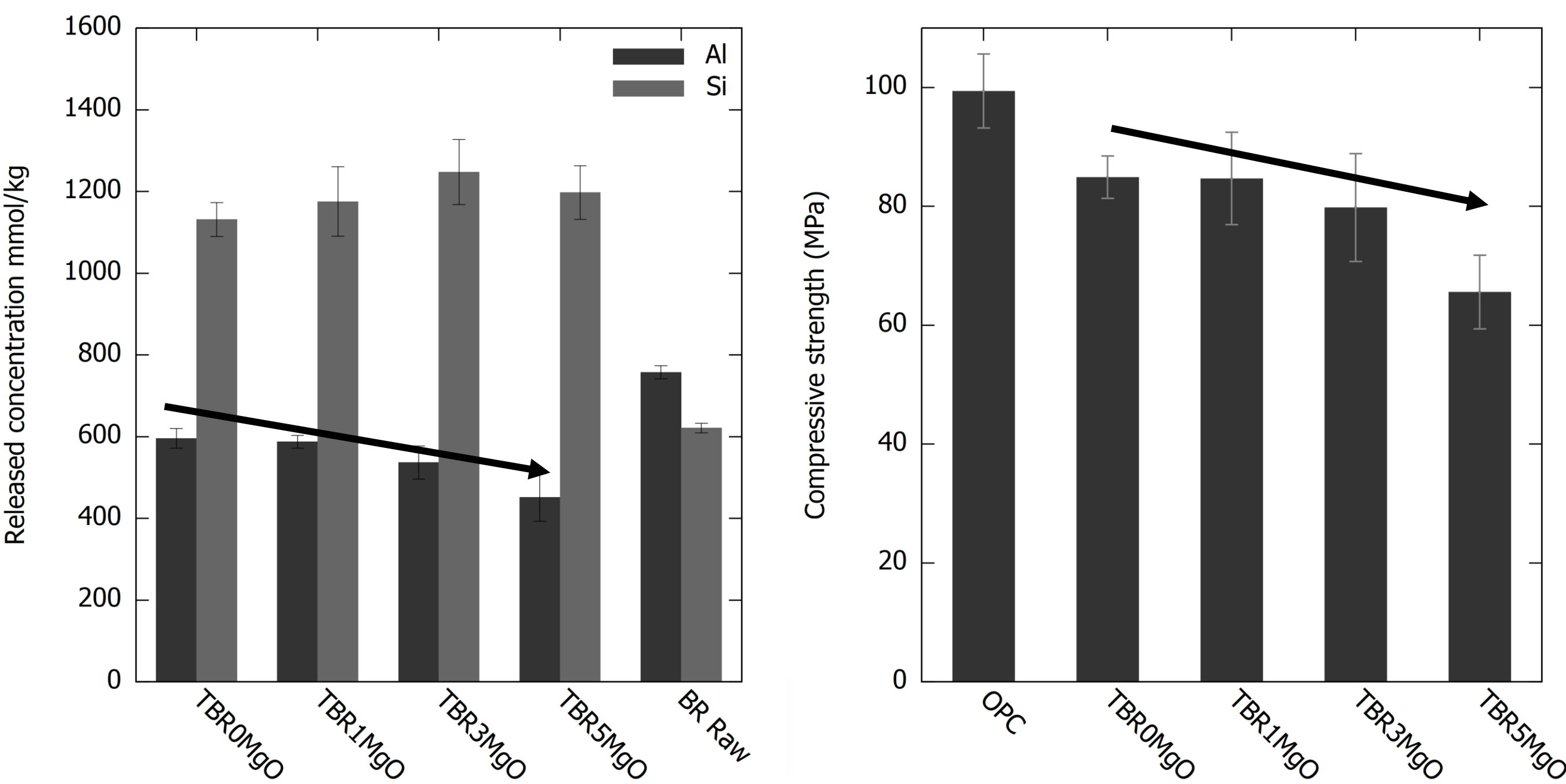


Figure 2: a) dissolution data in 6M NaOH b) 28d compressive strength data.

Carbonation tests showed that the degree of **efflorescence increased with increasing MgO content**. The phenolphthalein indicator showed no carbonated regions for all the samples after 3 months (Figure 3).

OPC	TBR0MgO	TBR1MgO	TBR3MgO	TBR5MgO

Figure 3: Samples after 3 months of carbonation in 1 % CO₂ and 65 % H₂O. A specific procedure to measure the degree of carbonation of Inorganic Polymers was followed.³

CONCLUSIONS

- ✓ Compressive strength up to 80 MPa can be achieved
- ✓ Mg increase the amount of spinels ((Fe,Mg)(Fe,Al)₂O₄)
- ✓ Reactivity decreases with increasing MgO content
- ✓ Reactivity decreases due to lower Al release in alkaline solutions.
- ✓ No carbonation front was observed after 3 months

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