CO_2 CAPTURE USING SODIUM SILICATES PREPARED WITH CONSTRUCTION AND DEMOLITION WASTE

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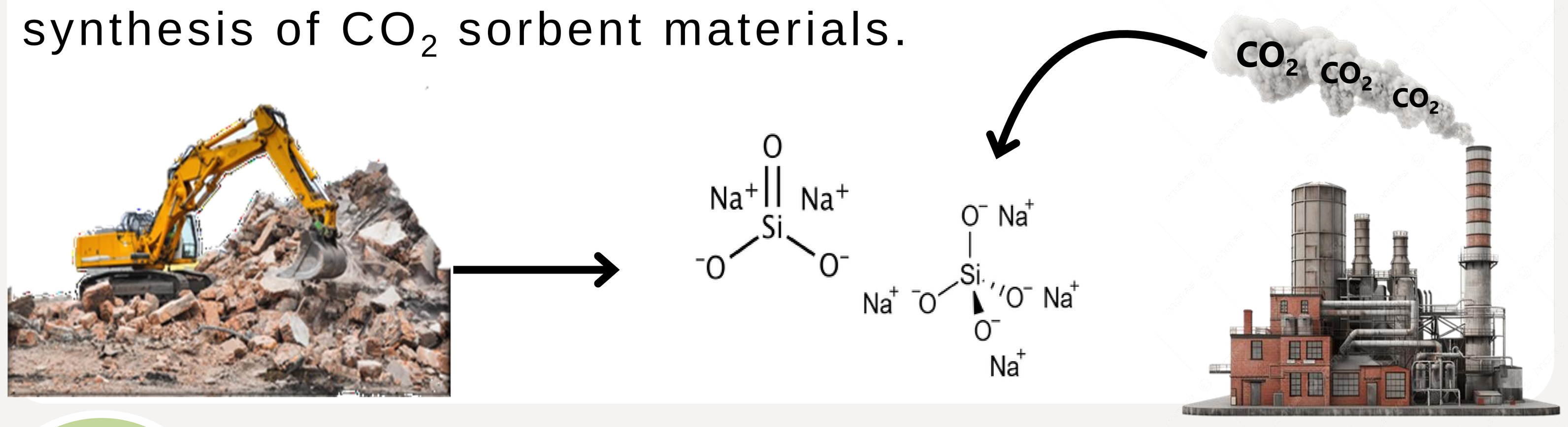
INTRODUCTION

The increase in atmospheric CO_2 (~420 ppm in 2023) represents one of the major global environmental problems. It is associated with population growth, urbanization, and industrial activity, which have also driven the generation of waste, particularly construction and demolition waste (CDW), with global generation estimated at ~11,000 Mt/year. In response, carbon capture, utilization, and storage (CCUS) technologies, together with the development of CO_2 capture materials derived from waste, have emerged as strategies within the circular economy framework.

In this context, sodium silicate is considered an accessible alternative to lithium silicates, although their application for CO_2 capture remains scarcely explored. Moreover, is growing interest in using CDW as a raw material for the synthesis of CO_2 sorbent materials.



MATERIALS AND METHODS

CDW characterization
- XRF
- N_2 adsorption-desorption

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Sodium silicate synthesis
NaOH+ silica source

$$SiO_2 + 4NaOH \rightarrow Na_4SiO_4 + 2H_2O \quad (1)$$
$$Na_2SiO_3 + 2NaOH \rightarrow Na_4SiO_4 + H_2O \quad (2)$$

CDW material
CDW as silica source
(Equation 1)

AG material
Na_2SiO_3 as silica source
(Equation 2)

↓

Thermal treatment
600 °C * 1 hour
Quenching

→ Sample characterization
- XRD
- N_2 adsorption-desorption

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CO_2 Capture
Dynamic and isothermal
15 vol.% CO_2

RESULTS

Table 1. X-ray fluorescence analysis of construction and demolition waste

Component	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	PxC
Weight %	48.67	0.74	13.83	4.95	0.08	2.36	13.09	2.29	1.25	0.23	12.4

The characterization of the CDW showed that its main components correspond to SiO_2, Al_2O_3, and CaO, with SiO_2 being the predominant phase. Additionally, it exhibited a surface area of 25.6 m²/g.

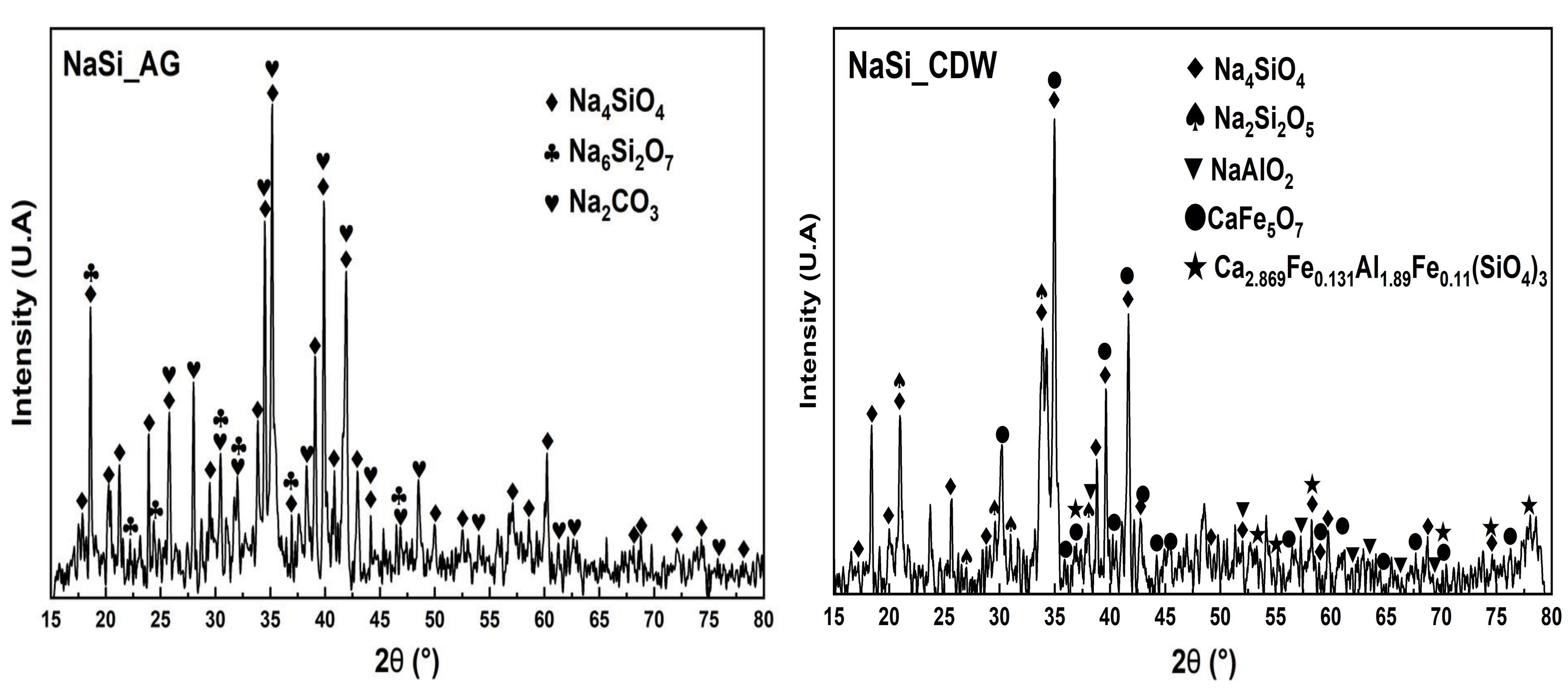

Figure 1. X-ray diffraction patterns for analytical-grade sodium silicate and sodium silicate prepared with CDW.

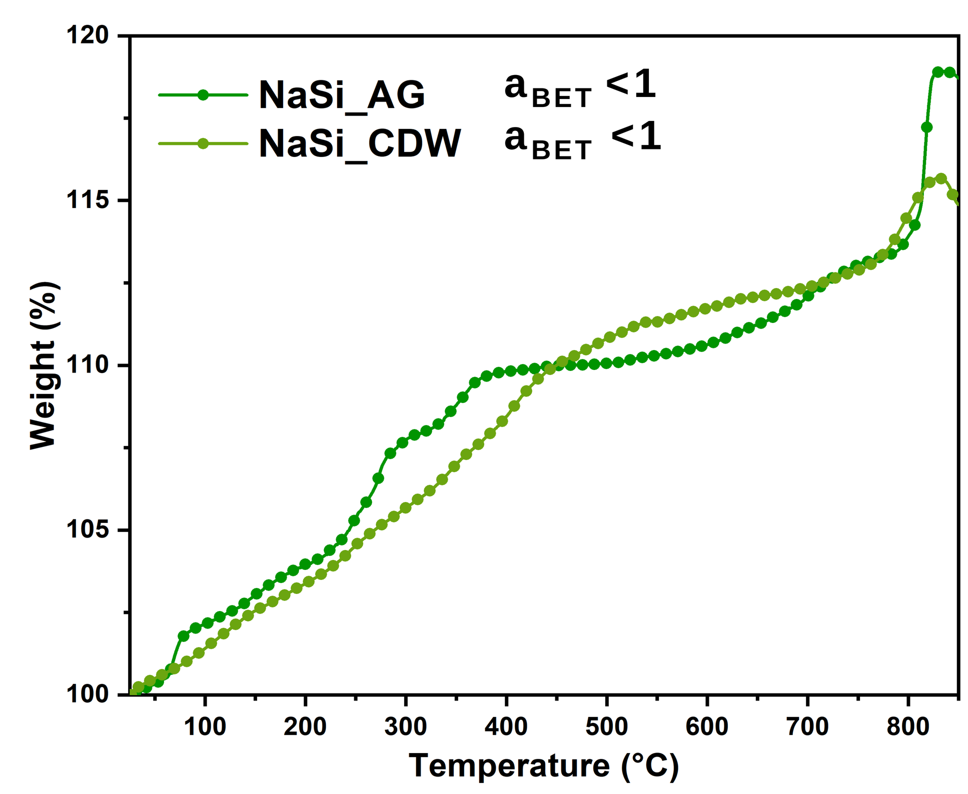

Figure 2. Dynamic thermogram for analytical-grade sodium silicate and sodium silicate prepared with CDW, using 15 vol.% CO_2

During the dynamic tests, NaSi_AG and NaSi_CDW reached experimental CO_2 capture capacities of 18.02 and 14.73 wt%, respectively, approaching the theoretical capacities of Na_4SiO_4 (23.9%) and $Na_6Si_2O_7$ (14.4%).

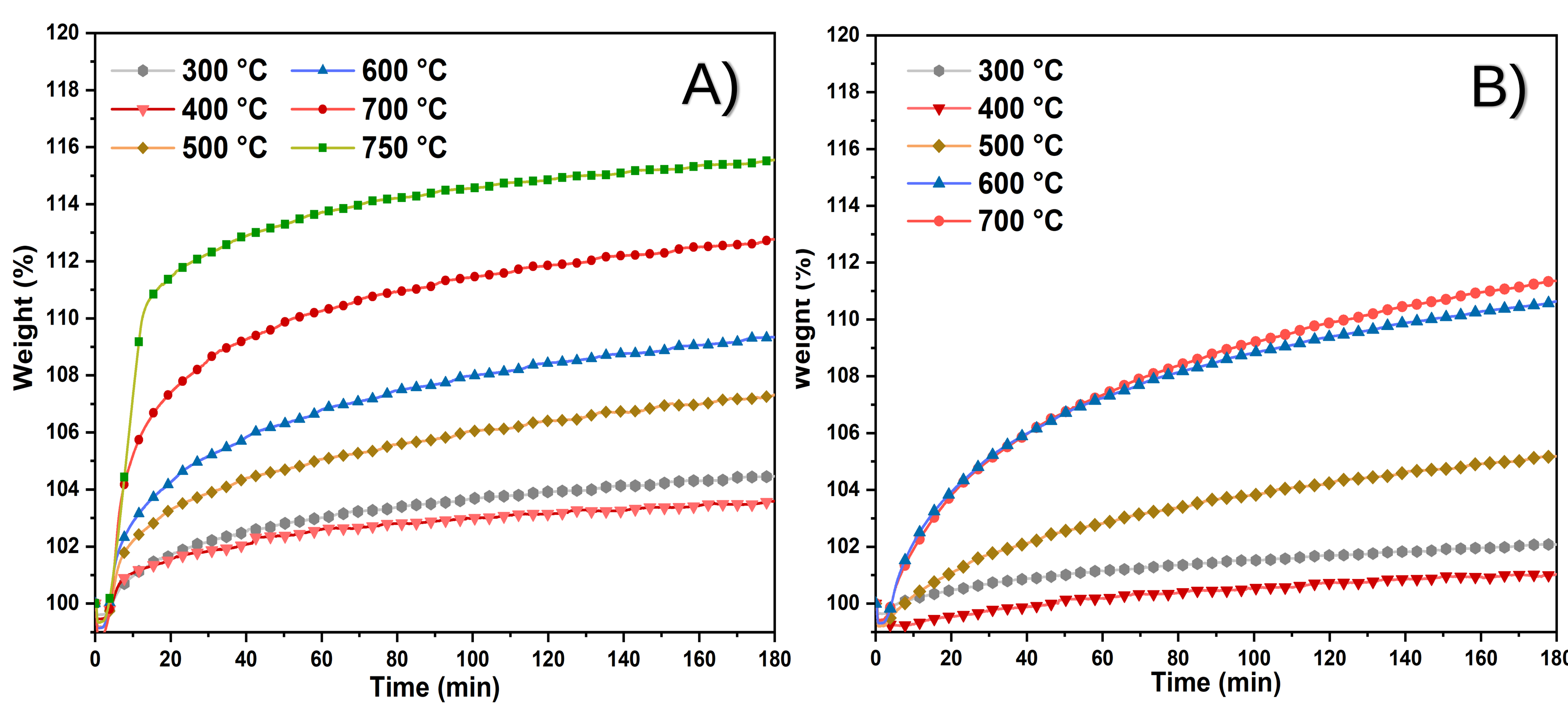

Figure 3. CO_2 sorption isotherms, using 15 vol.% CO_2 for A) sodium silicate prepared with CDW and B) analytical-grade sodium silicate.

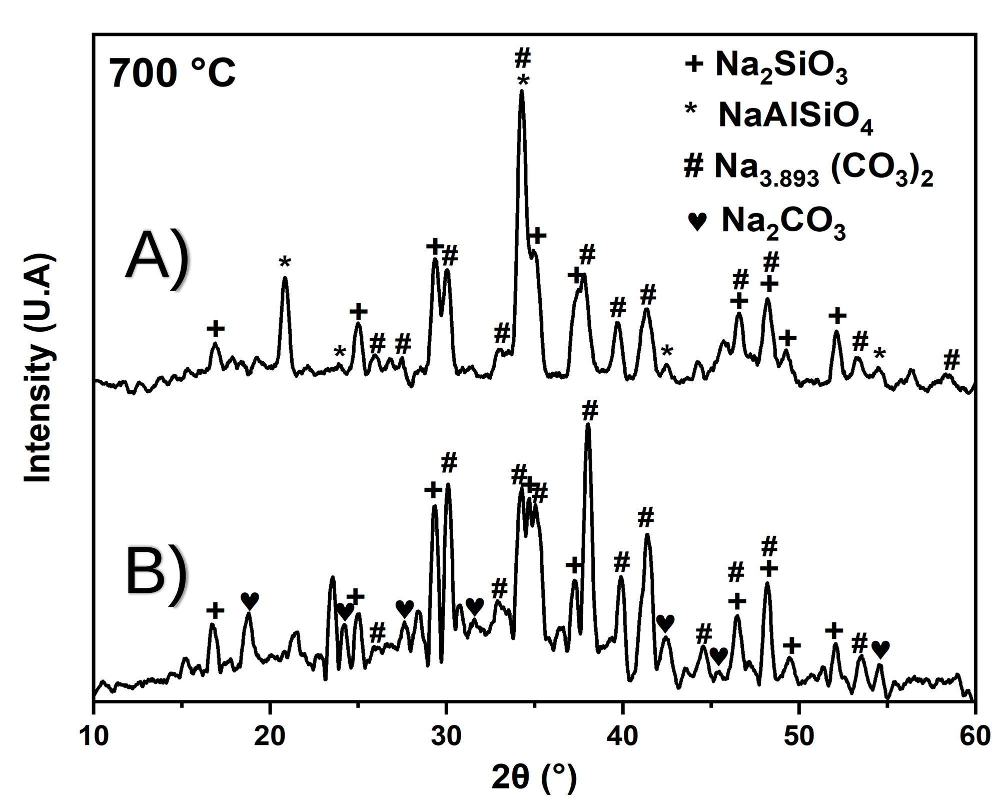

Figure 4. X-ray diffraction of the products obtained from the isotherms at 700 °C for (A) the sample prepared from CDW and (B) the analytical-grade sample.

The XRD patterns of CO_2 capture products, at 700 °C, show the formation of Na_2CO_3 and $Na_{3.893}(CO_3)_2$, together with Na_2SiO_3 in both samples, confirming the CO_2 capture reaction.

CONCLUSIONS

- Construction and demolition waste was used as a precursor for the synthesis of sodium silicate.
- The material prepared from CDW showed a higher CO_2 capture capacity compared to the analytical-grade material.
- A capacity of up to 155.5 $mgCO_2$/g was achieved at 750 °C with the material NaSi_CDW.

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