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Exploring the Dynamics of Natural Sodium Bicarbonate (Nahcolite), Sodium Carbonate (Soda Ash), and Black Ash Waste in Spray Dry SO_2 Capture.

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INTRODUCTION & AIM

Background: Spray drying devices are a subset of SO_2 mitigation methods proven to be as competitive as wet FGD units, surpassing 90% while producing dry by-products, eliminating the need for post-treatment procedures (Koech et al., 2021).

Hydrated lime ($Ca(OH)_2$) is primarily employed in spray dry absorption operations, given its excellent performance, however limited by high prices and low reagent conversion rates.

Aim: This study evaluated and compared the performance attributes of sodium-based sorbents (nahcolite, soda ash, and black ash) obtained from various sources using a laboratory spray-dry setup

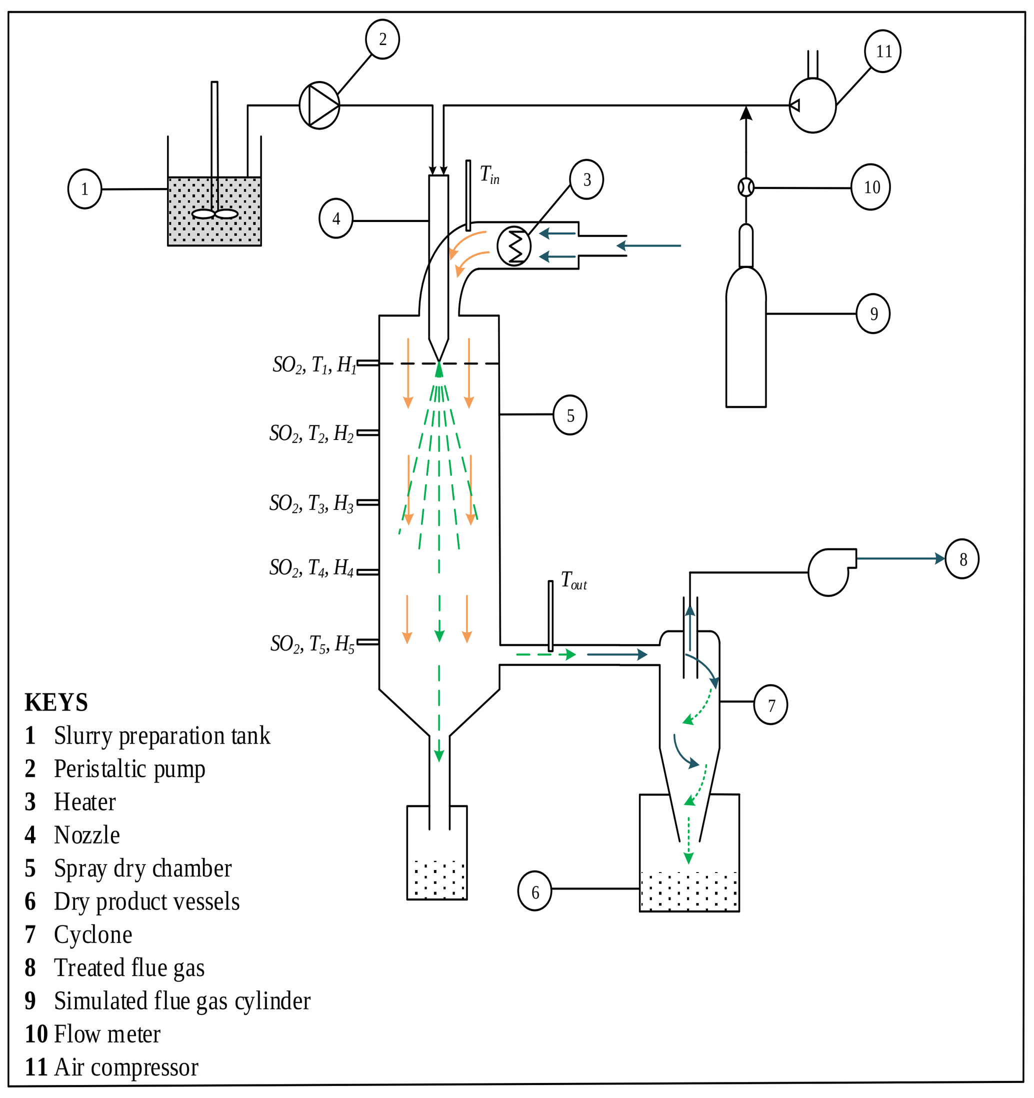

***Figure* 1**: The spray dry laboratory experimental setup.

METHOD

Materials.

- Sulphur dioxide gas (99.9%) was supplied by Afrox, South Africa.
- Nahcolite (93 wt.% $NaHCO_3$) and trona (87.1 wt.% Na_2CO_3) were obtained from Sua Pan mines, Botswana, while the black ash (62.9 wt.%:36.5 wt.% of Na_2CO_3:$NaHCO_3$) was sourced from paper and pulp manufacturing.

Absorption experiments.

***Table* 1:** Spray dry operating conditions.

Experimental variable	Range
Stoichiometric ratio	0.5-2
Flue gas flow rates (m³/h)	21-34
Sulphation temperature (°C)	120-180

Slurry flow rate of 0.8 kg/h, SO_2 concentration of 1000 ppm, fluid spray nozzle dimensions of tip diameter - 0.7 mm and a cap diameter - 1.4 mm.

RESULTS & DISCUSSION

1. **Effect of the stoichiometric ratio**

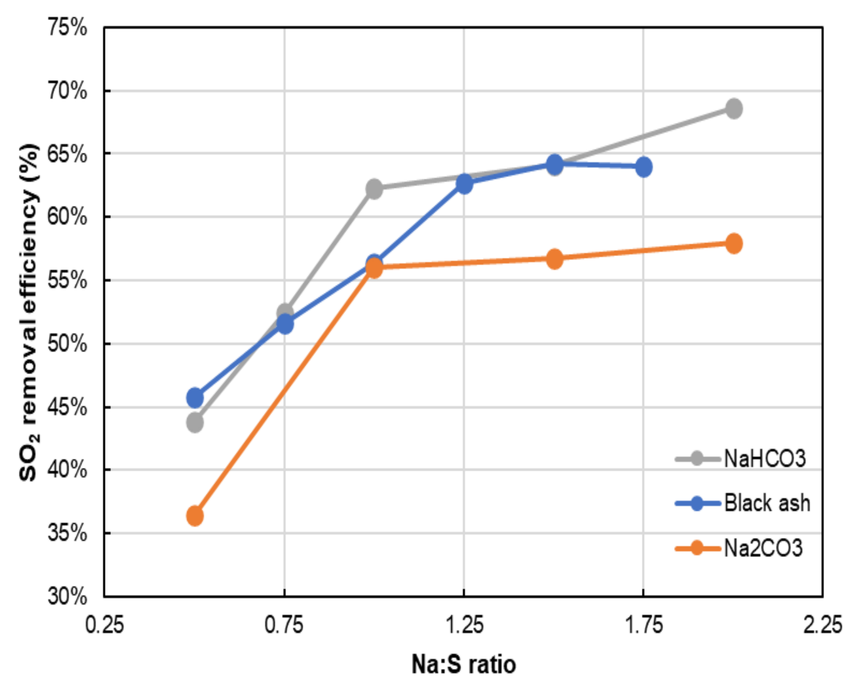

***Figure* 1**: Effect of stoichiometric molar ratios on SO_2 capture for sodium bicarbonate, sodium carbonate, and black ash sorbents (solid weight fraction, 10%; inlet SO_2 concentration, 1000ppm, sulphation temperature, 120 °C; flue gas flowrate, 27 m³/h; slurry flowrate 0.8 kg/h).

2. **Effect of flue gas flow rate**

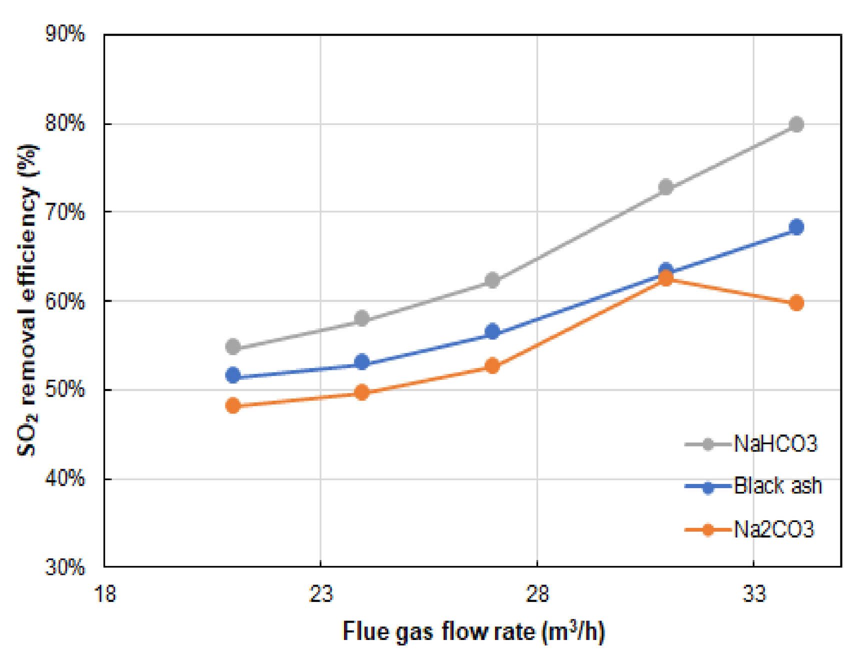

***Figure* 2**: Effect of flue gas flowrate on SO_2 capture for sodium bicarbonate, sodium carbonate, and black ash sorbents (solid weight fraction, 10%; stoichiometric molar ratios, 1.5; inlet SO_2 concentration, 1000ppm, sulphation temperature, 120 °C; slurry flowrate 0.8 kg/h)

3. **Effect of sulphation temperature.**

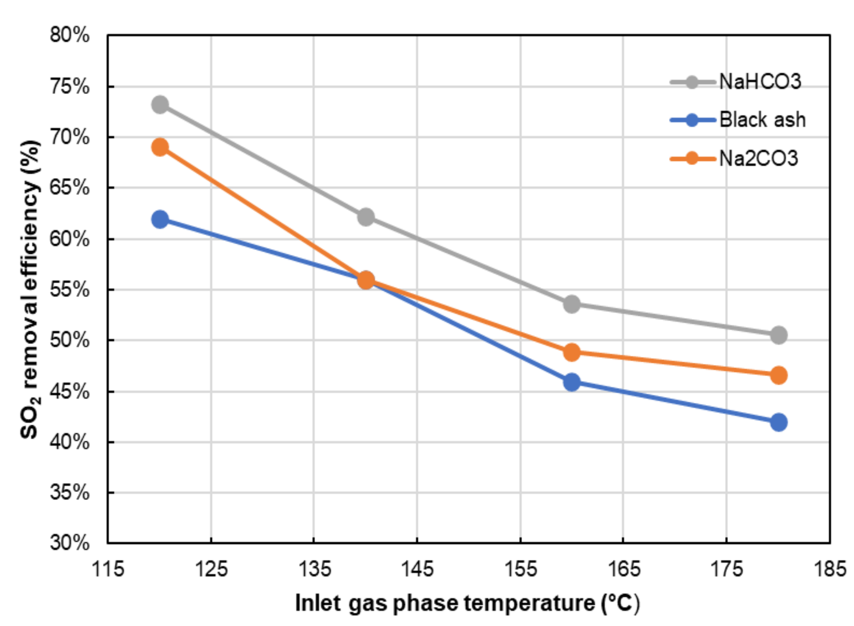

***Figure* 3**: Effect of sulphation temperature on SO_2 capture for sodium bicarbonate, sodium carbonate, and black ash sorbents (slurry weight fraction, 10%; stoichiometric molar ratios, 1.5; inlet SO_2 concentration, 1000ppm, flue gas flowrate, 27 m³/h; slurry flowrate 0.8 kg/h)

CONCLUSION

- Elevated SR improve the neutralization reactions for all sorbents.
- Augmenting the flue gas flow rate results in greater material blending, which improves desulfurization for all sorbents, but the performance of soda ash declines above a flow rate of 31 m³/h due to diminished gas contact.
- Nahcolite showed higher performance across all experimental conditions, with removal efficiency of 73%, compared to 69% for black ash and 62% for soda ash.

FUTURE WORK / REFERENCES

Koech, L.; Rutto, H.; Lerotholi, L.; Everson, R.C.; Neomagus, H.; Branken, D.; Moganelwa, A. Spray Drying Absorption for Desulphurization: A Review of Recent Developments. Clean Technol. Environ. Policy 2021, 23, 1665–1686, doi:10.1007/s10098-021-02066-3