

**Carbon Capture, Utilisation and Storage:
Opportunities, challenges and pathways to Net Zero**
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Reversible CO₂ Capture by Zeolite Templated Carbon Nanostructures through Physisorption

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Carbon capture by physical adsorption is attracting increasing interest as a potentially energy-efficient option for the separation, temporary storage and subsequent utilization of CO₂ within carbon capture, utilization and storage (CCUS) strategies. Among porous solids Zeolite Templated Carbons (ZTCs), nano-ordered carbon-based materials synthesized by using a three-dimensional zeolite as a sacrificial template [1], are particularly promising because they combine a three-dimensional framework, high specific surface area, dominant microporosity and tunable surface properties. Intended as negative replica of the nano-structured zeolites structures, the ZTCs framework consists of ordered microporous sp² carbon with a specific surface area greater than 2000 m²/g and a large microporosity with a uniform pore structure [2]. In this work, ZTCs were synthesized via Chemical Vapour Depositions, using Beta zeolite as a scaffold and ethylene as a carbon source at 973K. In order to modify the nature of oxygenated groups, introduced in relatively high quantity by HF/HCl treatments to remove the zeolite scaffold [3], the external surface of ZTCs was modified using a combination chemical and thermal treatment. The effects of the treatments on the chemical-physical properties of the samples were studied by X-ray diffractions, N₂ adsorption and Scanning Electron Microscopy. Adsorption measurements performed at different temperatures and pressure, showed a high, reversible and strongly temperature dependent CO₂ uptake up to almost 86 wt% (19.5 mmol/g). The adsorption properties can be attributed to the different interaction between the sorbent and the adsorbent species at the ZTC surface, as well as to the high specific surface area (≈ 2400 m²/g) correlated to a mostly microporous porosity (≈ 65 -69% of the total pore volume). The adsorption enthalpy remained nearly constant with coverage and fell within the range expected for physical adsorption, supporting the absence of strong chemisorption. Overall, these results demonstrate that ZTCs are effective and regenerable adsorbents for medium/high-pressure CO₂ capture.

Keywords: *Zeolite templated carbon; CO₂ capture; Physisorption; Microporosity; Adsorption enthalpy*

References

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