

Supporting Information

Active Nanointerfaces Based on Enzyme Carbonic Anhydrase and Metal–Organic Framework for Carbon Dioxide Reduction

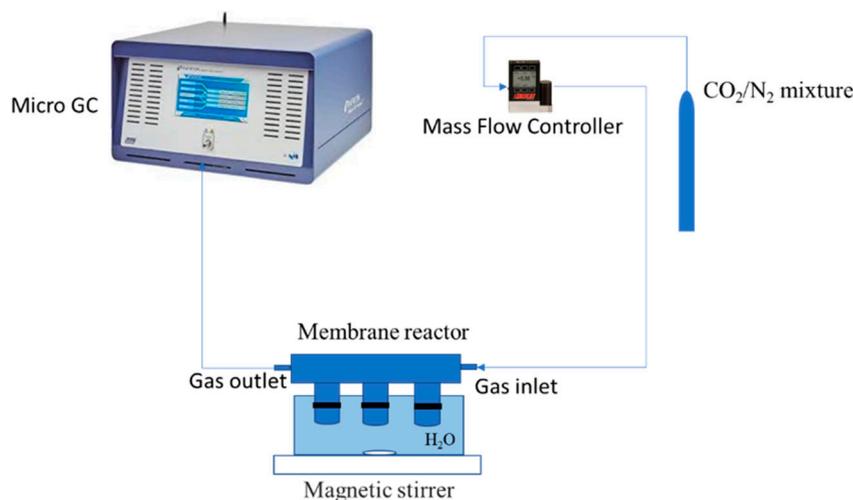
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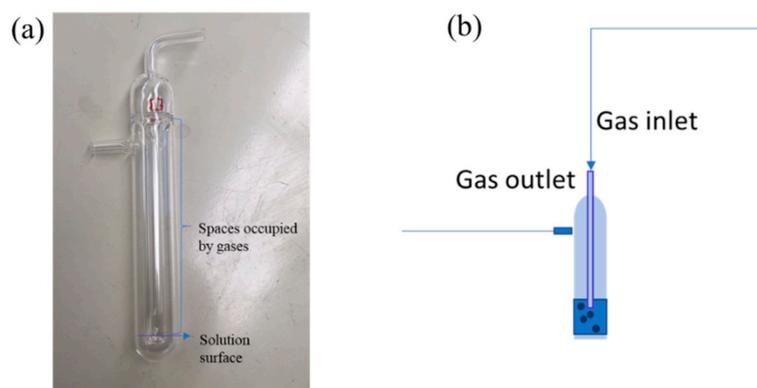
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Schemes, Figures and Tables

“*In house*” platform built to evaluate changes in the CO₂ concentration as resulted upon gas adsorption at the CA-membrane interface. The unit integrated a micro GC, a mass flow controller and a membrane module; the micro GC was used to monitor the concentration of CO₂ gas and any differences in the gas concentration in the inlet and outlet of the pipeline respectively. The mass flow reactor was used to control the gas flow, while the membrane module was used to store the CA-based interface where the CO₂ adsorption was to occur.



Scheme 1. Schematic illustration of “*in house*” platform used to evaluate changes in CO₂ concentration at the enzymatic membrane interface.



Scheme S2. Schematic illustration of the reactor used for monitoring changes in CO₂ concentration upon gas interaction with a solution containing free CA.

AFM in AC mode was used to evaluate changes in samples height profiles as resulted from sample functionalization. Results showed significant height changes upon FDCA binding onto the filter's surface.

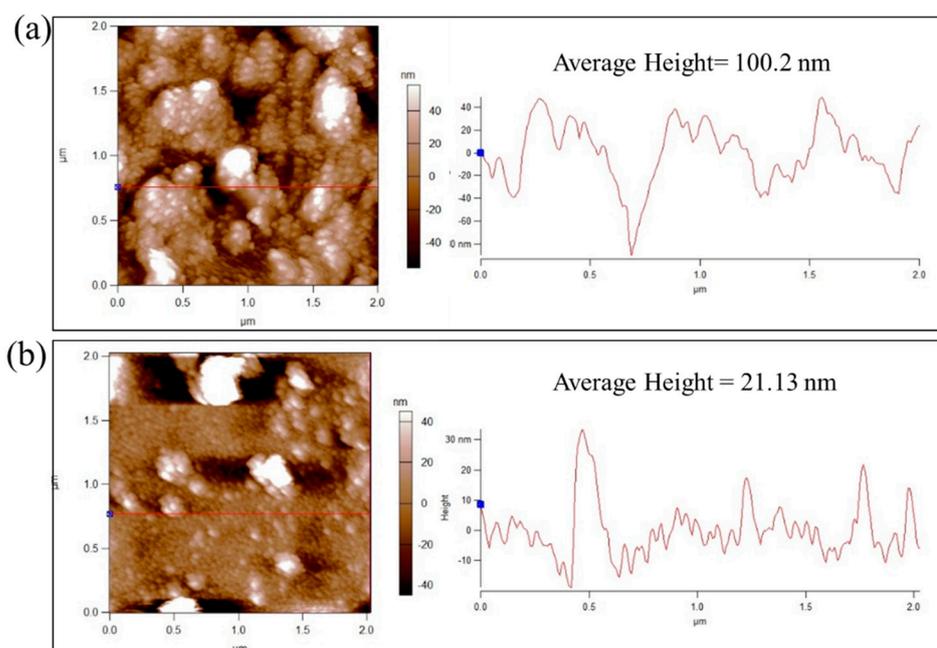


Figure S1. AFM images of FDCA/Al₂O₃ functionalized filter (a) and Al₂O₃ filter (b) with their corresponding average height profile.

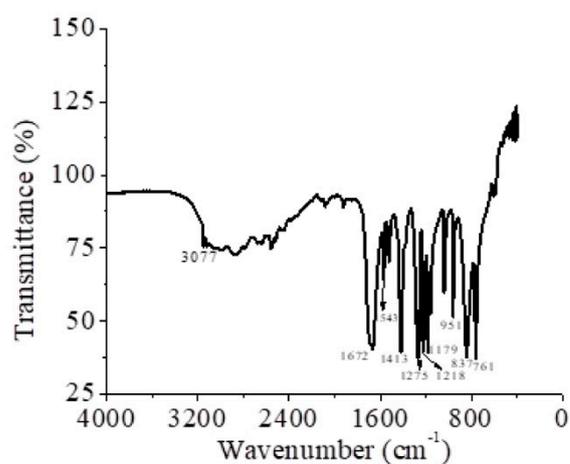


Figure S2. FTIR spectra of FDCA linker.

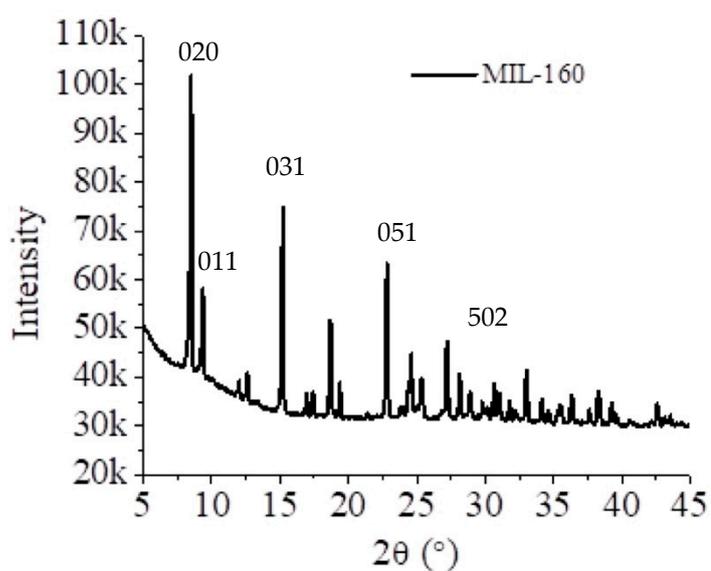


Figure 3. XRD spectra of the MOF.

Table 1. Elemental composition of control and FDCA/Al₂O₃ functionalized filter.

Sample	Element	Atomic concentration (%)
Al ₂ O ₃	C K	8.59 ± 0.36
	O K	37.48 ± 0.19
	Al K	53.93 ± 0.21
FDCA/Al ₂ O ₃	C K	12.45 ± 0.08
	O K	44.45 ± 0.11
	Al K	43.11 ± 0.09

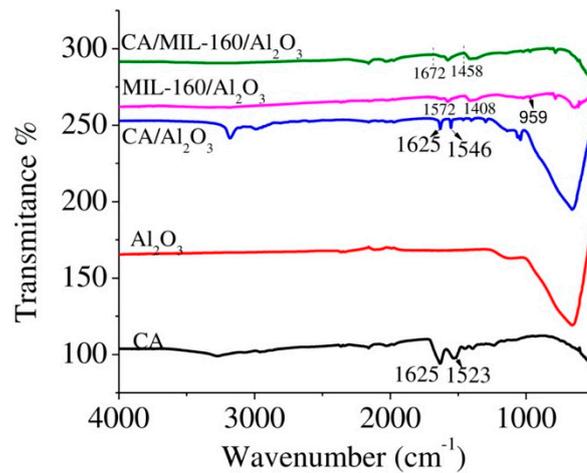


Figure 4. FTIR analysis of membranes and controls.

Equations S1–3 supporting previously established mechanism for CO₂ transformation by CA

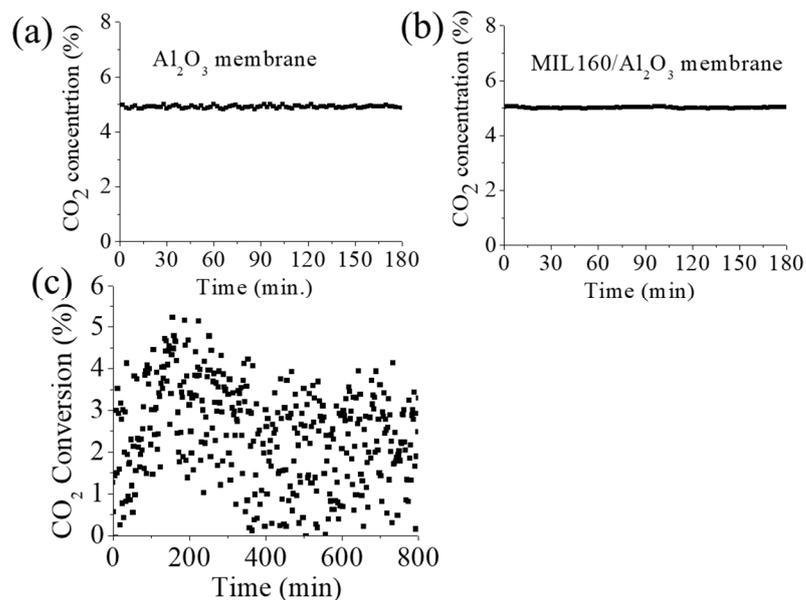


Figure 5. CO₂ adsorption at the Al₂O₃ filter (a), MIL-160/Al₂O₃ hybrid (b) and free CA in deionized water (c) interfaces.

Table S2. Comparison of the CO₂ hydration efficiency of the user synthesized CA/MIL-160/Al₂O₃ relative to other reports.

Membrane	CO ₂ hydration rate, mol s ⁻¹ m ⁻²	Effective Membrane area, m ²	Solvent	Reference
CA/MIL-160/Al ₂ O ₃	1.8×10^{-2}	1.2×10^{-4}	Water	This work
CA-FTCS-CNTs-PVDF flat sheet membrane	2.1×10^{-4}	-----	Water	3
CA-PDA-PEI-PVDF hollow fiber membrane	2.5×10^{-3}	6.4×10^{-4}	Water	4