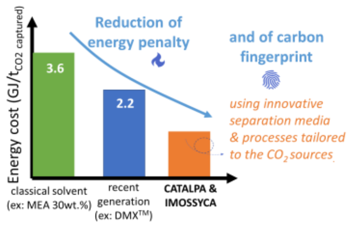
CATALPA: CO_2 cApTure At Low or decarbonized energy PenAlty



GENERAL CONTEXT

CO_2 capture is a key solution for the decarbonation of industries, esp. those with hard-to-abate and concentrated emissions. However, the costs, performance and energy penalty of CO_2 capture processes hinder their deployment. There is also a need to tailor the separating medium and the capture process to both the type and amount of gaseous effluents to be treated. CATALPA, together with IMOSSYCA (Intensified Modular SystemS for friendly CO_2 CApture), deals with efficient CO_2 capture from CO_2-rich gaseous effluents.

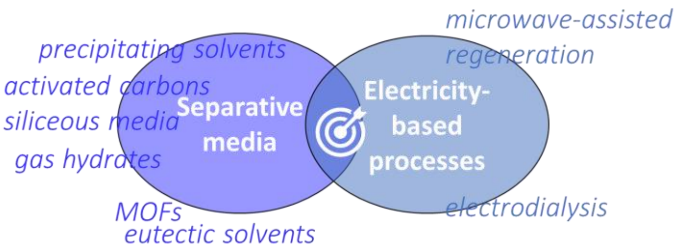
OBJECTIVES

When capturing CO_2-from CO_2-rich gaseous effluents, the main energy penalty is the regeneration of the CO_2-separating medium, whether a solid (adsorbent) or a liquid (absorbent). The energy penalty is often in the form of thermal energy (usually at T> 100°C) which implies a rise of produced CO_2. As this CO_2 is to be captured this raises the amount of CO_2 to be transported and stored, thus increasing the CO_2 avoidance cost. Two pathways are investigated to lower the energy and carbon footprints of CO_2 capture processes :

- The reduction of specific regeneration energy with **innovative separation media**, with a focus on temperature conditions below 100°C (activated carbons and siliceous materials, gas hydrates, MOFs, new solvents, either deep eutectic solvents or precipitating solvents): the challenge is to reach a balance between capacity, selectivity, and specific regeneration energy, while ensuring the proposed solution meet environmental criteria in terms of volatility, toxicity, and degradation products;

- **Integration of decarbonised energy (electricity)**, in the form of microwave energy or through electrodialysis, to assist and decrease the use of dedicated thermal energy: the challenge is to bring efficiently decarbonised energy to the separative medium to substitute, or to reduce, the use of high-T thermal energy. The goal is either to use less thermal energy or to lower the temperature of this thermal energy to an extent that makes it possible to use low quality (waste) heat, i.e., T <100°C, and thus decrease the energy cost.

METHODOLOGY



6 different laboratories, 6 PhDs, 6 postdocs, 31 researchers

EXPECTED RESULTS, IMPACTS

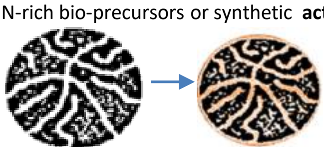
For each separative medium investigated, determine:

- the working capacity .. should be large
- the selectivity with respect to CO_2 .. should be large yet a low regeneration energy .. should be low

For given gaseous effluents (defined by their composition and flow rate), identify new promising unconventional capture processes.

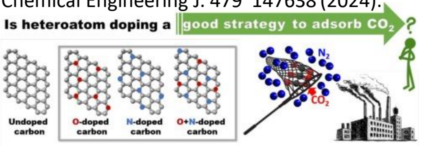
Some highlights

Doping with hetero-atoms (N, O), starting with N-rich bio-precursors or synthetic **activated carbons**

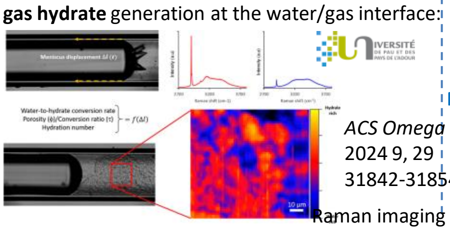


N-enriched activated carbon

Chemical Engineering J. 479 147638 (2024):



gas hydrate generation at the water/gas interface:



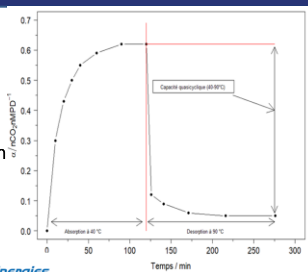
ACS Omega 2024 9, 29 31842-31854

Raman imaging

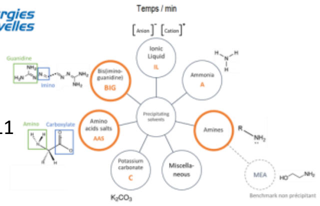
switchable eutectic solvents:

Institut de Chimie de Clermont-Ferrand

absorption/desorption cycle for a solution of oleic acid +lidocaine +N-methylpiperidine :



precipitating solvents:



doi.org\10.1016/jcej.2024.153111

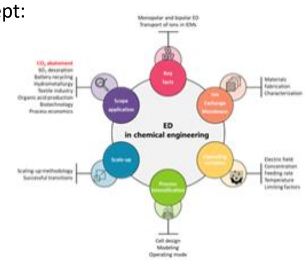
MOFs with microwave regeneration:

MOF CALF-20

CALF-20+ Graphene Oxide 5% (microwave-sensitive)

electrodialysis:

concept:



Techno-economical evaluation:

Common task to both CATALPA & IMOSSYCA :

defined as an optimum between claimed specifities and first cost estimates, based on thermo-physical properties, contactor type, application case, etc