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# Application of bacterial thermostable carbonic anhydrases in amine scrubbing for highly efficient CO2 capture from biogenic emissions

## AUTHORS

IO ANTONOPOULOU / BIOCHEMICAL PROCESS ENGINEERING, DIVISION OF CHEMICAL ENGINEERING, LULEÅ UNIVERSITY OF TECHNOLOGY, PORSÖN CAMPUS, LULEÅ

ULRIKA ROVA / BIOCHEMICAL PROCESS ENGINEERING, DIVISION OF CHEMICAL ENGINEERING, LULEÅ UNIVERSITY OF TECHNOLOGY, PORSÖN CAMPUS, LULEÅ

PAUL CHRISTAKOPOULOS / BIOCHEMICAL PROCESS ENGINEERING, DIVISION OF CHEMICAL ENGINEERING, LULEÅ UNIVERSITY OF TECHNOLOGY, PORSÖN CAMPUS, LULEÅ

## PURPOSE OF THE ABSTRACT

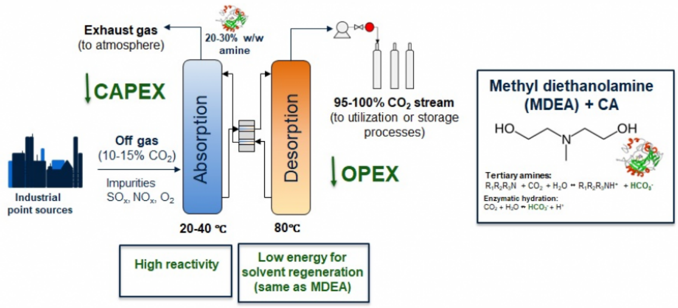
The recently released report by the Intergovernmental Panel on Climate Change (IPCC) leaves no doubt about the urgency to dramatically cut greenhouse gas emissions. In order to stay on track to limit earth's warming to 1.5°C, emissions need to be cut by 45% by 2030, compared to 2019 levels. To reach these goals, Bioenergy with Carbon Capture and Utilization and Storage (BECCUS) is now openly discussed as a solution to decrease net CO2 emissions, as well as a potential technology to move away from fossil carbon by using CO2 as an alternative feedstock for renewable chemicals and fuels.

A promising and novel alternative to the current state of the art for post-combustion CO2 capture is the use of the enzyme carbonic anhydrase (CA) (1). CA is one of the fastest enzymes in nature, catalyzing the hydration of CO2 to bicarbonate, which is the limiting step of CO2 absorption. CA is a biocatalyst that can be employed alone in aqueous media to capture CO2, or it can be used as additive in traditional chemical absorption processes, such scrubbing with amine or potassium carbonate solutions, or even the accelerated weathering of alkaline materials that can act as co-sequestrating agents.

Aim of this work is to evaluate the potential of novel carbonic anhydrases, such as an evolved CA from Desulfovibrio vulgaris (2,3), to act for improving the rate, efficiency and, in cases, the energy use in carbon capture. We screened five bacterial carbonic anhydrases for their performance as additive in amine-based CO2 capture using methyldiethanolamine (MDEA). The reaction conditions, such as the CO2 absorption temperature, MDEA concentration, enzyme load, effect of CO2 concentration in the gas and effect of inhibitors (NOx, SOx) concentration in the gas, were optimized, targeting to highest productivity and most economic process. The enzymes were also subjected to 10 consecutive absorption-desorption cycles to identify their capability of reuse in terms of stability towards desorption temperatures (80oC) and the highly alkaline amine environment.

By developing competitive routes for sequestrating CO2, a realistic pathway opens towards its storage or use as a renewable feedstock. Use includes the production of building block chemicals, such as organic acids via microbial processes, or use of sequestrated carbonates as a liming agent in agriculture. Circular use of materials and in particular CO2 that is of the main gases responsible for global warming, will aid towards a circular bioeconomy but also tackle the challenge of achieving a climate neutral society, aligning with other emerging solutions such as electrification and improving energy efficiency in industrial processes. This work is supported by the H2020 funded project VIVALDI (Grant agreement ID: 101000441).

## FIGURES




### FIGURE 1

Enzyme-assisted CO2 capture by amine scrubbing

Use of CA enhances the CO2 absorption step while maintaining the good desorption properties of MDEA

### FIGURE 2


## KEYWORDS

carbon capture | amine scrubbing | carbonic anhydrase | industrial emissions


## BIBLIOGRAPHY


1. De Oliveira Maciel, A., Rova, U., Christakopoulos, P., Antonopoulou I. (2022). Carbonic anhydrase to boost CO2 sequestration: Improving carbon capture utilization and storage (CCUS). Chemosphere, 299, 134419.
2. Alvizo, O., Nguyen, L.J., Savile, C.K. et al. (2014). Directed evolution of an ultrastable carbonic anhydrase for highly efficient carbon capture from flue gas. PNAS, 111(46), 16436-16441.
3. Sj�blom, M., Antonopoulou, I., Gim�nez, I.G., de Oliveira Maciel, A., Khokarale, S.G., Mikkola, J.-P., Rova, U., Christakopoulos, P. (2020). Enzyme-assisted CO2 absorption in aqueous amino acid ionic liquid amine blends. ACS Sustainable Chemistry & Engineering, 36(8), 13672-13682.