proceedings

Abstract

Sustainable CO_2 Capture and Bio-Fixation Using Functionalized Deep Eutectic Solvents and Microalgae †

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† Presented at the 19th International Symposium "Priorities of Chemistry for a Sustainable Development", Bucharest, Romania, 11–13 October 2023.

Keywords: CO_2; microalgae; experimental model; high throughput screening

Citation: Brettfeld, E.-G.; Popa, D.G.; Moga, C.; Dobre, T.; Constantinescu-Aruxandei, D.; Oancea, F. Sustainable CO_2 Capture and Bio-Fixation Using Functionalized Deep Eutectic Solvents and Microalgae. *Proceedings* **2023**, *90*, 35. https://doi.org/10.3390/proceedings2023090035

Academic Editors: Mihaela Doni and Radu Claudiu Fierăscu

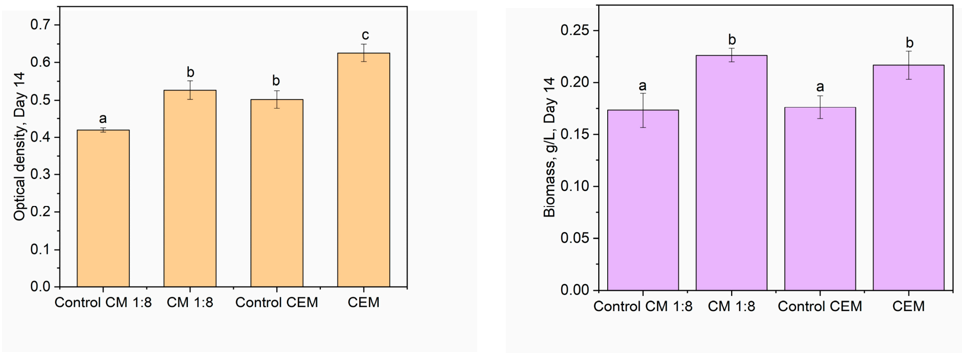
Published: 18 December 2023

The urgent need to mitigate anthropogenic CO_2 emissions has spurred innovative approaches for CO_2 capture and utilization. In this study, we explore a novel method involving the capture of CO_2 using a functionalized deep eutectic solvents (DESs) [1,2] and subsequent bio-fixation through microalgae cultivation [3]. The study focuses on the development of an integrated system that efficiently captures CO_2 and harnesses the photosynthetic capabilities of microalgae for sustainable CO_2 reduction.

Two DESs were compared: a binary DES, ChCl:MEA 1:8 (CM) and a ternary DES, ChCl:EG:MEA (CEM) 1:2:1 molar ratio. Choline chloride (ChCl) is a hydrogen bond acceptor, while ethylene glycol (EG) and monoethanolamine (MEA) are hydrogen bond donors. The CO_2 capture took place in a glass bubbler with ceramic diffuser. The desorption process involved immersing the DES in a stainless-steel container, subjecting it to a controlled temperature of 80 °C, and agitating at 12 RCF (Relative Centrifugal Force) within a full vacuum, ensuring effective desorption of CO_2 from the DES. The CO_2-enriched gas was introduced into a microalgae bioreactor series, where it served as a carbon source for photosynthesis [4]. The microalgae culture, *Chlorella* sp. NIVA-CHL137, was cultivated under controlled environmental conditions, including a day/night photoperiod (13/11 h) and BG-11 cultivation medium. The optical density (OD) and biomass yield were used to evaluate the microalgae development.

The microalgae cultivation in the bioreactor showed CO_2 fixation capabilities, resulting in a significant increase in the microalgal biomass and a corresponding reduction in CO_2 concentration within the system. Using the binary DES (CM) resulted in a significant 26% increase in OD of *Chlorella* sp. compared to control and the bio-sequestration of 53 mg of carbon per liter, equivalent to an elevation of 194 mg CO_2 per liter of culture. The ternary DES (CEM), on the other hand, exhibited slightly higher CO_2 concentration removal than CM (+1.4%), leading to higher OD and biomass augmentation, compared to the control culture. Additionally, CO_2 desorbed from CEM positively influenced the biomass growth of *Chlorella* sp. compared to control, with OD surging by 12% during the initial 7 days and

a sustained 24.7% increase until day 14, surpassing the performance of the control group (Figure 1).



(**a**) (**b**)

Figure 1. Comparison between *Chlorella* sp. microalgal cultures grown in the presence of CO_2 desorbed from ChCl:MEA 1:8 (CM) and ChCl:EG:MEA 1:2:1 (CEM) in comparison to controls; (**a**) Optical Density (OD), (**b**) Biomass. The bars represent standard errors. Columns labeled with different letters are significantly different for $p > 0.05$.

Our study presents an approach for CO_2 capture and bio-fixation using functionalized DES and microalgae cultivation. The CO_2 desorption process, coupled with the prolific growth of microalgae, highlights the viability of this integrated system as an environmentally friendly and sustainable strategy for mitigating CO_2 emissions. This innovative method has the potential to contribute significantly to the global efforts aimed at addressing climate change and advancing the utilization of captured CO_2 in various applications, including biofuels and bioproducts.

Author Contributions: Conceptualization, F.O.; methodology, E.-G.B. and D.G.P.; validation, E.-G.B., D.G.P., D.C.-A. and C.M.; formal analysis, D.C.-A. and T.D.; investigation, E.-G.B. and D.G.P.; resources, C.M.; data curation, D.C.-A.; writing—original draft preparation, E.-G.B.; writing—review and editing, F.O.; visualization, E.-G.B.; supervision, F.O. and T.D.; project administration, F.O and E.-G.B.; funding acquisition F.O. All authors have read and agreed to the published version of the manuscript.

Funding: The research leading to these results has received funding from European Regional Development Fund (ERDF), the Competitiveness Operational Programme (POC), Axis 1, project POC-A1-A1.2.3-G-2015-P_40_352, My_SMIS 105684, "Sequential processes of closing the side streams from bioeconomy and innovative (bio)products resulting from it—SECVENT", subsidiary project 1882/2020—AquaSTIM.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data is contained within the article.

Conflicts of Interest: The authors declare no conflict of interest and DFR Systems SRL has no conflict of interest.

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