

Investigating a pilot-scale process sustainability integrating CO₂ capture with its bioconversion for carbon footprint decrease of lignite-based power plants

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Abstract In this study, we investigated the sustainability of a process combining the use of carbon dioxide capture methods with the non-photosynthetic CO₂ bioconversion into biofuels and chemicals/biologicals from extremophilic bacteria, which possess the capability to use CO₂ as the main carbon source. The study integrates cutting-edge engineering technologies about CO₂ capture and use into valuable chemicals, respectively, which have been traditionally optimized separately, while also representing two traditionally more distant engineering science domains. However, there is a high need to examine whether they can be successfully combined into a sustainable and efficient workflow at the laboratory and pilot-scale, having subsequently the possibility for further development to a more mature product. To this end, mathematical modeling of the specific sections of the integrated process individually and in combination was applied in order to predict the response and the boundaries of the system, taking into consideration the specifics of each module. We will present the modeling of a pilot-scale process, in which we took into consideration realistic input and output types and rates at the various parts of the process, using data from high CO₂ emitting lignite-based power plants in Greece and the theoretically optimal conditions of CO₂ capture technologies along with reported and experimentally produced data about the CO₂ bioconversion from the strict anaerobe model-acetogen *Moorella thermoacetica*. Data about CO₂ absorption and desorption conditions were provided by the involved collaborating groups. For the bioconversion, we considered mixotrophic (with glucose) microbial cultures at the conditions previously optimized for continuous cultures to decrease the needs for hydrogen availability. No previous investigation of the particular bioprocesses in sync with CO₂ absorption/desorption units has been carried out to-date. Our data support the sustainability of such process, with the initial establishment cost appearing as the major expense. The study has been funded by NSRF 2014-2020 BIOMEK” (T1EΔK-00279) and HFRI Greece 2.0 CO2BION (#016103) projects.

Keywords: Bioreactor modeling, extremophile metabolic modeling, CO₂ capture, anaerobic CO₂ bioconversion, pilot-scale process sustainability