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Editorial: From CO_2 Emissions to Fuels and Chemicals: Current Development, Challenges and Perspectives

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Editorial on Research Topic

From CO_2 Emissions to Fuels and Chemicals: Current Development, Challenges and Perspectives

Carbon capture and utilization (CCU) is attracting considerable attention as a new way to reduce release of greenhouse gases to the atmosphere while valorising CO_2 through the production of fuels and green chemical intermediates [1].

Over the past decades, significant effort has been targeted at developing and demonstrating at large-scale CO_2 capture from power and industrial sources [2]. To accelerate deployment, further efforts are taking place to reduce energy penalties and costs of such a process, as well as scale-up promising solutions. However, one of the key hurdles for implementation remains the destination of these huge CO_2 streams. While CO_2 storage has been shown to be, by far, the main option to ensure permanent sequestration of the amount of CO_2 to be captured [3], integrating CO_2 capture and storage can be challenging, especially in the near term, due to the distances between sources and sinks, the time required to develop such geological sinks, scale mismatches, etc. While it is expected to play a smaller role than CO_2 storage, CO_2 utilization remains an interesting sink for captured CO_2 as it creates opportunities for new revenue streams. Furthermore, CO_2 utilization can also be considered for small capture flowrates which make it an interesting solution in the case of early deployment. There are many potential routes to convert CO_2 into useful and, hopefully, more sustainable chemicals and fuels. For example, converting CO_2 into polyols could enable the production of more sustainable elastomers, fibers, flexible foam, adhesives, sealants, inks, paints, and coatings. Another route that can be considered is the conversion of CO_2 in valuable energy carriers such as methane, methanol, etc., which could be an attractive CCU solution while simultaneously addressing global warming and storing of hydrogen energy or renewable energy in commonly used dense energy carriers [4–6]. However, for all the routes and targeted products, it is important to ensure that CCU pathways deliver the three following aspects: 1) sustainable cradle-to-grave solutions 2) economically viable solutions 3) scalable solutions.

In this Research Topic, we aimed to make a picture of the knowledge of the current progress in the area of CO_2 capture and conversion techniques.

In particular, Skoricova et al. proposed the techno-economic assessment of the sorption-enhanced dimethyl-ether (DME) synthesis process, as an innovative way for producing fuel-grade DME from carbon dioxide and green H_2. They found that the production cost for DME was ~€1.3 per kg for a relatively small-scale production plant of 23 kt/year. Although higher than the current market price for fossil-based DME, the results showed the potential of this route as more

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promising than other studies on DME production from CO_2 by conventional DME synthesis processes.

Biermann et al. discussed the effects of carbon allocation on the emission intensities of low-carbon products cogenerated in facilities that co-process biogenic and fossil feedstocks and apply the carbon capture utilization and storage technology. They considered an integrated steel mill that injects biomass into the blast furnace, captures CO_2 for storage, and ferments CO into ethanol from the blast furnace gas, obtaining an overall emissions saving up to 27 and 47% in the near-term and long-term future, respectively, and confirming that the choice of the allocation scheme greatly affects the emissions intensities of cogenerated products.

Fu et al. proposed an investigation of calcium looping capture for the Natural Gas Combined Cycle through a techno-economic study evaluating one simple and one advanced calcium looping processes for CO_2 capture. The analysis demonstrated that the calcium looping processes are not competitive with the reference MEA-based CO_2 capture process for this application, and would require significant improvements in terms of equipment capital cost, plant efficiency and sorbent annual cost.

Schellevis et al. investigated the CO_2 capture from the atmosphere *via* Direct Air Capture using solid supported-amine sorbents, evaluating the possibility of a continuous adsorption process in a radial flow contactor, using both batch and continuous modes of operation. A 15–25% lower capture efficiency was found for the continuous process, confirming that the batch process is preferred in most of the operating conditions.

The Research Topic ends with the study of Castel et al. who proposed interesting guidelines on the possibilities and limitations of the use of membrane technology for Direct Carbon Dioxide Capture from air. They found that a fundamental requirement to make this technology competitive is the use of highly selective membranes that can assure higher productivity levels, even if the specific energy requirement is globally higher than that of the adsorption and absorption processes.

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AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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