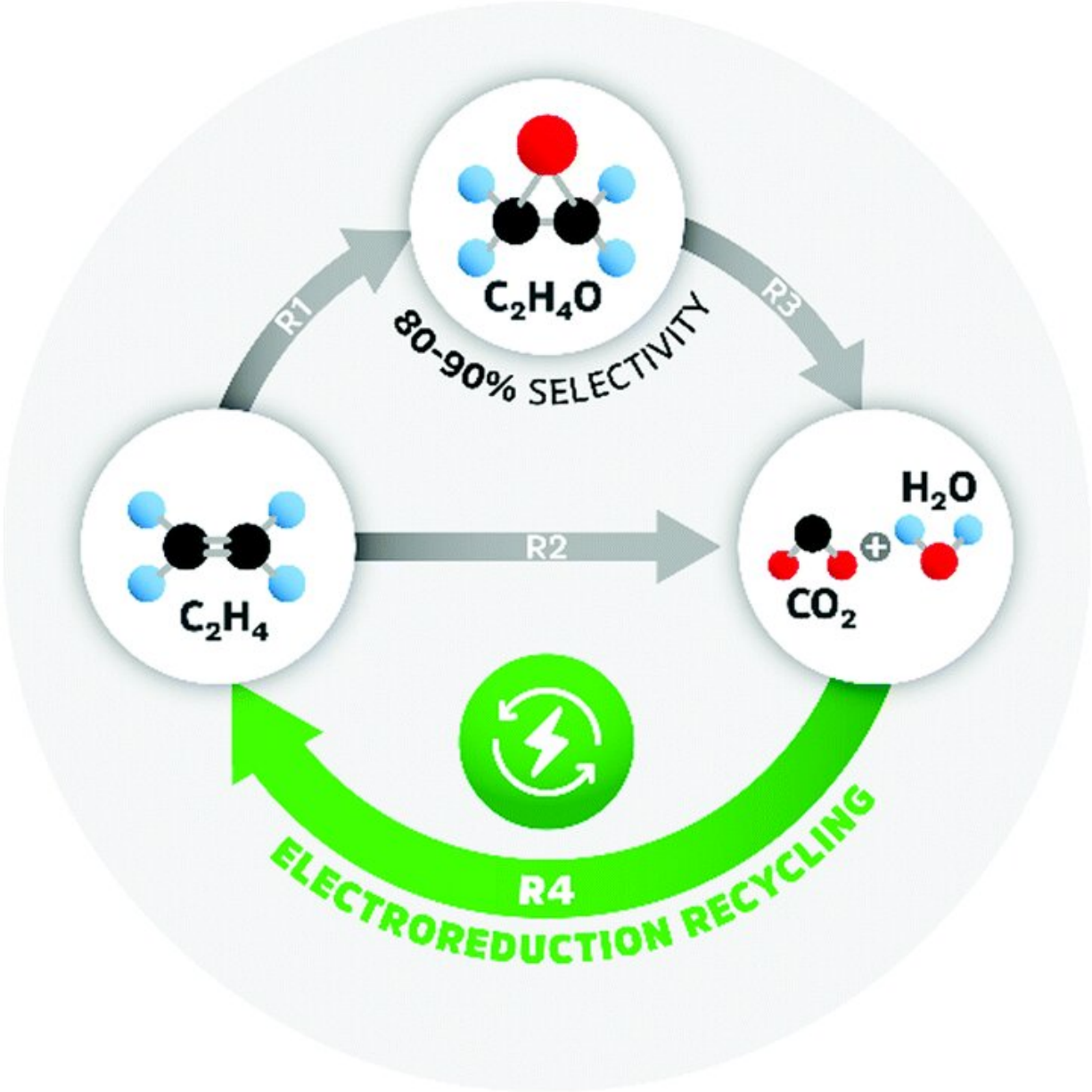
Closing the loop on carbon emissions from chemical plants

March 19 2021, by Louise Renwick



Proposed pathway for CO2 recycling (R4) within EO manufacture (R1)–(R3). Credit: Magda Barecka

To avoid environmentally and economically devastating climate breakdown, quick action to reduce greenhouse gas emissions that contribute to global heating is essential. However, the dependence of the world economy on products derived from fossil fuels is a major obstacle, hindering our progress towards an emissions-free future.

At present, the chemical industry is responsible for around 15% of industrial carbon dioxide (CO_2) emissions. For as long as economies continue to depend on fossil fuels, these emissions will remain a harmful by-product. As we wait for renewable energy technologies to become adopted more widely, what if we could make use of these emissions instead of allowing them to continue polluting the atmosphere?

Researchers from the Cambridge Centre for Advanced Research and Education in Singapore (CARES) have proposed a new, onsite CO_2 recycling technology that could take the waste CO_2 from chemical production processes and turn it into other chemicals that go straight back in to the production unit. Furthermore, this technology does not require new plants and factories to be built—it can be retrofitted into existing chemical plants, thus not competing with mature methods for bulk chemicals production.

The recycling concept is based on the use of an electroreduction reactor, where CO_2 is converted to useful chemicals, e.g. ethylene. Although this technology can be applied to any plant that produces CO_2, using concentrated CO_2 streams is most economically viable so that costly procedures are not required to separate CO_2 out from flue gas streams. For this reason, the researchers have chosen a chemical production

process where such a concentrated CO_2 stream is already available: ethylene oxide (EO) manufacturing. Currently, EO plants frequently vent this pollutant stream to the atmosphere, and the proposed technology enables conversion to ethylene instead. This bulk chemical is used as raw material for production of ethylene oxide, meaning that the products of CO_2 electrolysis can be used directly at the same plant, minimizing both the direct CO_2 emissions and the requirement for petrochemical feedstocks.

As a key raw material for ethylene glycol manufacturing, as well as a common disinfectant, EO is widely used and always in demand, making EO production an excellent market to showcase the benefits of CO_2 recycling.

In order for such a technology to be viable for a chemical company, it must meet three criteria: a significant reduction of CO_2 emissions, a short payback time and no change in the production scale of the chemical. CO_2 recycling using electroreduction fulfills these requirements, with low operational costs and minimal disruption to existing manufacturing processes.

Singapore's Jurong Islando Credit: Louise Renwick

Running the recycling process on renewable energy, such as wind or solar, would lead to significant emissions reduction. Operating entirely with a waste stream product, CO_2 recycling has the flexibility to run while intermittent renewable energy is available, with small-scale storage solutions in place. If the renewable energy is only partially integrated into the grid mix, the process can still make a significant impact on CO_2 emissions and reduce the need for non-renewable feedstocks.

This work has positive implications for Singapore as it aims to meet its Paris Agreement pledge of reducing its emissions by 36% from 2005 levels by 2030. Singapore's chemical industry is a vital part of its

economy, employing over 25,000 people and ensuring Singapore's place in the top 10 chemical exporters worldwide.[1]

The paper's authors Dr. Magda Barecka, Professor Joel Ager and Professor Alexei Lapkin are part of CARES' eCO_2EP project, which aims to develop ways to transform CO_2 emitted as part of the industrial process into compounds that are useful in the chemical industry supply chain. eCO_2EP is one of several projects hosted by CARES.

Dr. Barecka, lead author on the paper, said "This technology is exciting due to the huge impact it can make at a very low cost and with a simple retrofit for existing chemical plants. Furthermore, if renewable energy is used, we could reduce direct CO_2 emissions by up to 80% in each plant. There is so much potential for emissions reduction across the board and we are looking forward to seeing the technology start to make a difference."

More information: Magda H. Barecka et al. Economically viable CO_2 electroreduction embedded within ethylene oxide manufacturing, *Energy & Environmental Science* (2021). DOI: 10.1039/D0EE03310C

[1] www.edb.gov.sg/en/our-industri … y-and-chemicals.html. Data from 2015.

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