Development of Combined Carbon Capture and Conversion (quad-C) Systems for the Utilization of Atmospheric CO_2

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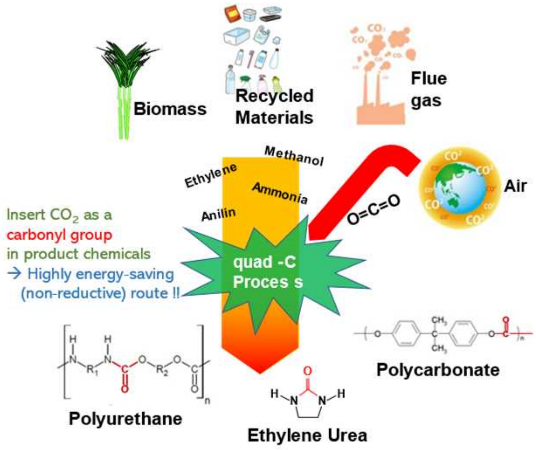
Summary

Many of the chemical products around us contain carbon. For a carbon-neutral future, a shift is required in chemical production so that this carbon should be sourced predominantly from three recycling routes: from biomass, carbon fixation and end-of-life (EoL) products. In this project we develop a new CO_2 utilization process that will allow carbon to be introduced into chemical production through an energy-saving conversion route which is suitable for use with the above three carbon sources.

Strategy 1 - Taking an energy-saving conversion route: Many chemical substances contain a structure called carbonyl. There are many good examples of carbonyl-containing products around us, in resins, such as polycarbonate, polyurethane, and urea, in lithium-ion battery materials, etc. The advantage of employing a route that allows CO_2 to be used as a carbonyl source is that, by use of an appropriate catalyst, CO_2 can be incorporated into the chemical structure without the need for a carbon reduction process. This amounts to a high energy saving.



Strategy 2 – Streamlining the conversion process using DFMs: To obtain CO_2, which exists in the atmosphere at a concentration of only ~ 0.04%, a huge amount of air needs to be blown into the converter. A high recovery rate of CO_2 from the introduced air is the key to save energy, which will be carbon-free while being extremely limited in the future. We approach this challenge by upgrading membrane separation technology that was originally developed for space applications. In addition, we eliminate energy requirement for CO_2 recovery from absorbents by using a new process configuration termed *Combined Carbon Capture and Conversion* (quad-C) realized by Dual Function Materials (DFMs).

Our first target is to produce a urea derivative by bringing the ethylene diamine that chemically absorbed CO_2 into contact with the catalyst (CeO_2). The knowledge on sorption and the reaction of various DFMs and CO_2 obtained in this work, together with the new simulation and evaluation techniques we develop, will expand the range of carbonyl compounds that can be produced from CO_2 with biomass and recycled EoL products.

KPI

FY2022	FY2024	FY2029
[Confirmation of Strategy 1] Using existing pilot plant for Direct Air Capture and storage as the benchmark, we will demonstrate that an energy saving greater than 40% is attainable, by process simulation based on our original experimental data.	[Confirmation of Strategy 2] Using a hypothetical process that utilizes high concentration CO2 supplied by existing Direct Air Capture pilot process for producing urea derivatives as the benchmark, we will demonstrate a twofold CO2 emission reduction by process simulation based on our original experimental data.	[Pilot demonstration] A pilot plant will be established for the quad-C process using diamine to produce urea derivatives, confirming abovementioned key performance indicators.

Implementation

Tohoku University, Osaka Metropolitan University, Renaissance Energy Research Corporation