The exhaust gas from a power plant can be recovered and used as a raw reaction material

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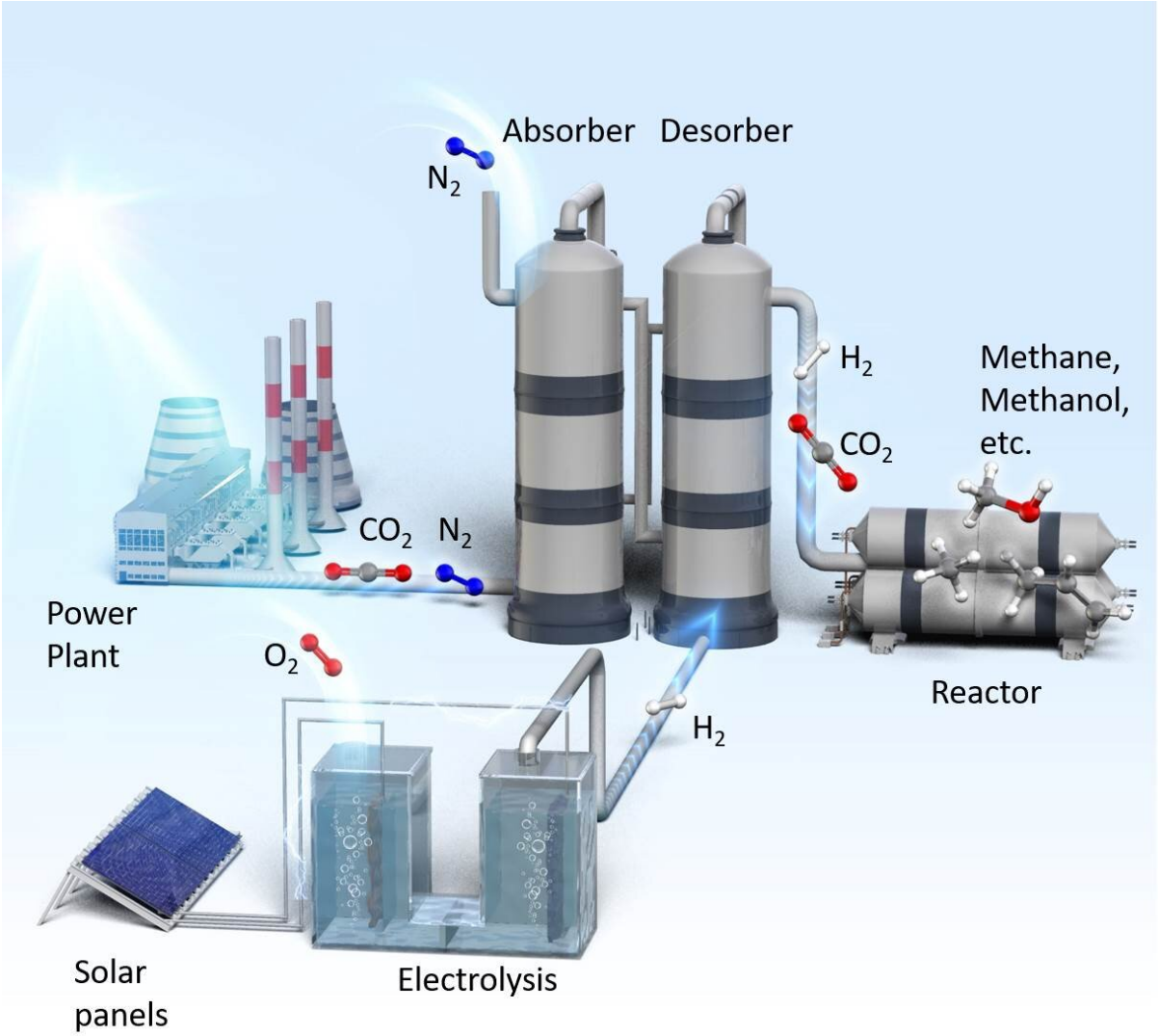

Fig. 1 Outline of process using “H2 stripping regeneration technology” CO2 partial pressure in the desorber is lowered by the H2 supplied to the bottom of the desorber and the mass transfer of CO2 from a liquid phase (i.e., amine solution absorbing CO2) to a gas phase is accelerated, making the desorber temperature lower. The mixture of CO2 and H2 gases collected from the head of the desorber can be used as material for the CO2 reduction reaction. As illustrated in the figure, the process to fabricate petroleum-independent fuel or chemicals is made feasible by making use of H2 electrolyzed by renewables (e.g., solar energy) and CO2 included in exhaust gas from facilities such as power plants. Credit: Nagoya University

A research group at Nagoya University has developed a new technology that can drastically conserve the energy used to capture carbon dioxide (CO_2), one of the greenhouse gases, from facilities such as thermal power plants. Conventionally, a significant amount of energy (3 to 4 GJ/ton-CO_2) or high temperatures exceeding 100 deg.C has been required to capture CO_2 from gases exhausted from a concentrated source, and there are expectations of the development of CO2capture technology that consumes less energy.

The research group led by Assistant Professor Hiroshi Machida has developed an unprecedented CO_2 capture technology, namely H_2 stripping regeneration technology1), in which hydrogen (H_2) gas is supplied to the regeneration tower (desorber)2). It is indicated in this research that, with the implementation of this new technology, combustion exhaust gas can be replaced by CO_2/H_2 gas at lower temperatures (85 deg.C) than those used in conventional technology. The further reduction of energy can be achieved when it is combined with technologies such as those involved in the promotion of exhaust heat utilization and recovery of reaction heat.

This new technology can exhibit the world's highest energy-saving

performance (i.e., separation and collection of energy required is less than 1 GJ/ton-CO_2 when a desorber temperature is 60 deg.C) when it is combined with the phase-separation solvent that this research group has also developed.

This technology is expected to be applicable to value-added material production such as the syntheses of methane, methanol, gasoline, etc., from CO_2 in the combustion exhaust gas and H_2 from renewable energy, and is expected to contribute to carbon recycling.

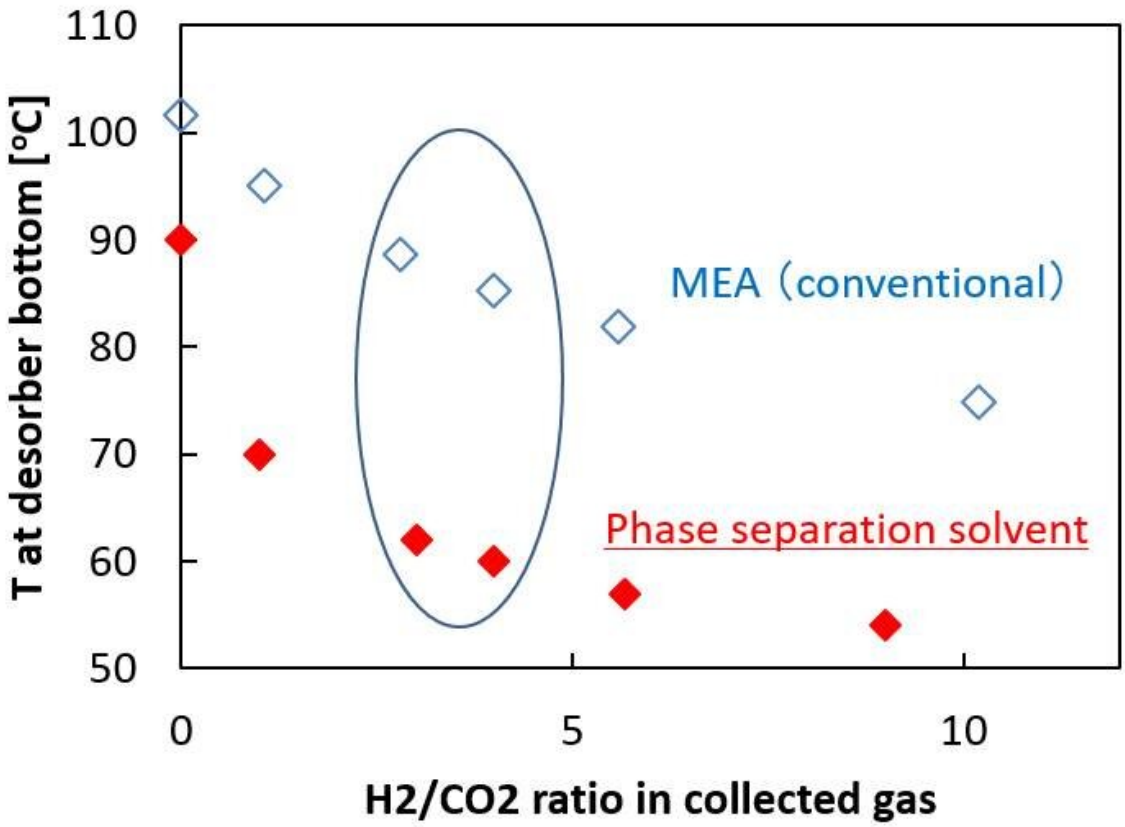

Fig 2. Comparison of H2/CO2 ratio in collected gas and temperature reduction in desorber As the H2/CO2 ratio increases, the temperature at the bottom of desorber will decrease. Stoichiometrically, the ideal H2/CO2 ratio is 4 for the

methane synthesis process and 3 for the methanol synthesis process (See area within ellipse in the figure). The phase-separation solvent is characterized by a low regeneration temperature, and the H2 stripping regeneration process can further lower the regeneration temperature. Credit: Nagoya University

(1) H_2 stripping regeneration technology

In the conventional process to synthesize fuel or chemicals from CO_2 and renewable H_2, pure CO_2 is collected and is then mixed with H_2 before being supplied to the reduction reactor. In the H_2 stripping regeneration technology, H_2 gas is supplied at the bottom of the desorber. As a result, CO_2 partial pressure in the desorber is lowered, which promotes regeneration and lowers the regeneration temperature. The mixture of CO_2 and H_2 gases collected from the head of the desorber is supplied directly to the synthesis reactor.

(2) Regeneration tower (Desorber)

In the amine absorption method, CO_2 absorption and regeneration towers (i.e., absorber and desorber) are used to separate and collect CO_2 in the exhaust gas mixture from facilities like power plants. Gases such as N2and O2, in addition to CO_2, are included in the combustion exhaust gas from these facilities and pure CO_2 gas is collected with this amine absorption method. Only the CO_2 gas is absorbed in the absorber by amine solution, and it is then heated in the desorber to regenerate pure CO_2 gas. In other words, only CO_2 gas can be extracted from the mixture of gases.

More information: Hiroshi Machida et al. Energy-Saving CO2 Capture by H2 Gas Stripping for Integrating CO2 Separation and Conversion Processes, *ACS Sustainable Chemistry & Engineering* (2020).

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