

## 液膜被覆ガス供給カソード電極を用いた排ガス中希薄 CO<sub>2</sub> の直接電気化学還元

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Gas-fed liquid-covered cathode electrodes used for direct electrochemical reduction of dilute CO<sub>2</sub> in a flue gas

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We are developing highly efficient large-sized artificial photosynthetic cells that reduce CO<sub>2</sub> to organic valuables. The newly designed 1 m<sup>2</sup>-sized cell consisting of an electrochemical reactor and crystalline silicon solar cells converted CO<sub>2</sub> of 100% concentration to formate with a high conversion efficiency of 10.5%<sup>1,2)</sup>. Thus, the next challenges are long-term durability<sup>3)</sup> and direct conversion of CO<sub>2</sub> in a flue gas<sup>4)</sup>. As for the latter, a low CO<sub>2</sub> concentration and a high O<sub>2</sub> concentration degrade the performance. Although a gas-diffusion electrode secures sufficient CO<sub>2</sub> supply even at a low concentration, O<sub>2</sub> affects fatally. By contrast, an electrode immersed in an electrolyte suffers from CO<sub>2</sub> depletion, whereas a low O<sub>2</sub> solubility mitigates the detriment. To exploit both advantages of these configurations, we developed a cathode electrode covered with a thin electrolyte layer, which is fed with a reaction gas (Fig. 1). In addition, monoethanolamine that is often used for CO<sub>2</sub> capture was added in the electrolyte for more CO<sub>2</sub> supply. Thus, we achieved Faradaic efficiencies of formate production as high as around 70% even under direct feeding of a simulated flue gas (15% CO<sub>2</sub>, 4% O<sub>2</sub>, N<sub>2</sub> 81% (v/v)).  
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CO<sub>2</sub> を還元して有価物に変換する人工光合成セルの高効率化と大型化の両立に取り組んでいる。電気化学リアクターと結晶シリコン太陽電池を組み合わせた最新の 1 m<sup>2</sup> サイズのセルは、濃度 100% の CO<sub>2</sub> を 10.5% の高い効率でギ酸に変換した<sup>1,2)</sup>。次の課題は、耐久性の向上と<sup>3)</sup>、排ガス中の CO<sub>2</sub> の直接変換である<sup>4)</sup>。後者については、低濃度の CO<sub>2</sub> と高濃度の O<sub>2</sub> が高効率化を妨げる。ガス拡散電極は低濃度であっても十分な CO<sub>2</sub> 供給量を確保するものの、O<sub>2</sub> の悪影響が致命的となる。逆に、電解液に浸漬された電極は溶解度が低い O<sub>2</sub> の悪影響を受けにくい、CO<sub>2</sub> の供給不足となる。これらの構成の両方の長所を組み合わせた、薄い電解液層にて覆われた触媒層に反応ガスが供給される構成を考案した (Fig. 1)<sup>4)</sup>。CO<sub>2</sub> 供給を更に促進するため、CO<sub>2</sub> 回収に用いられるモノエタノールアミンを電解液に添加した。これらの結果、疑似排ガス (15% CO<sub>2</sub>, 4% O<sub>2</sub>, N<sub>2</sub> 81% (v/v)) 供給であっても、約 70% の高いギ酸生成ファラデー効率を実現した。

- 1) N. Kato, et al., *Joule* **2021**, 5, 687. 2) N. Kato, et al., *ACS Sustain. Chem. Eng.* **2021**, 9, 16031.
- 3) M. Shiozawa, et al., *Electrocatalysis* **2022**, 13, 30.
- 4) Y. Takeda, et al., submitted.

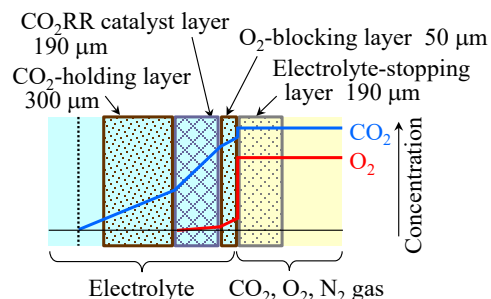


Fig. 1 Multilayered structure of gas-fed liquid-covered cathode electrode, and CO<sub>2</sub> and O<sub>2</sub> concentrations in and around the electrode.