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同軸型水素プラズマシャワー法を用いた二酸化炭素還元によるメタンの生成
Production of Methane by Carbon Dioxide Reduction Using a Coaxial Hydrogen Plasma Shower Method

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1. Introduction

Today, emissions of carbon dioxide into the environment have been regarded as a serious cause of the global warming. For this reason, various studies for carbon dioxide reduction have been conducted all over the world. The purpose of this study is to reduce the carbon dioxide efficiently by using a hydrogen plasma to convert it to methane as a reusable organic compound. Here, potential energies of H* (10.20eV) and H_2* (11.75eV) are so high that they can overcome potential energies of CO_2 (8.28eV) and CO (11.09eV) in their reduction reactions.

Our group have studied fundamental properties of the conversion of carbon dioxide to methane by using a hydrogen plasma [1]. In this report, the experiment is conducted by changing the discharge electrode configuration with magnets, discharge current, and input gases flow rate.

2. Experimental Apparatus and Methods

In this study, the apparatus is radially divided into two (discharge and non-discharge) regions by orifices which make also a pressure difference. Though we use two kinds of gases (hydrogen and carbon dioxide), the discharge takes place only for hydrogen to prevent re-decomposition of the product of methane. H* and H_2*, generated in the discharge region, flow into the non-discharged region like a shower to react with carbon dioxide introduced into the non-discharge region. The power supply provides a square-pulse voltage with repetition frequency of 25 kHz. Cylindrical samarium cobalt magnets are placed at both ends of the discharge region to confine hydrogen plasma. All produced gases are sampled and analyzed by FTIR, and finally evacuated by a scroll pump.

3. Experimental Results

In the experiments, the following four items are defined to evaluate the results. Decomposition ratio of CO_2; α (%), CH_4 selectivity; β (%), CH_4 yield; $\alpha\times\beta/100$ (%), and energy efficiency for CH_4 production; γ (L/kWh).

Through the experiment, the gases mainly produced were found to be CO and CH_4. Dependences of CH_4 yield and γ on input gas flow rate ratio H_2/CO_2 are shown in Figs.1 (a) and (b), respectively, with CO_2 flow rate as a parameter. Here, the distance between electrodes was 4.5 mm and the discharge current was fixed at 0.7mA.

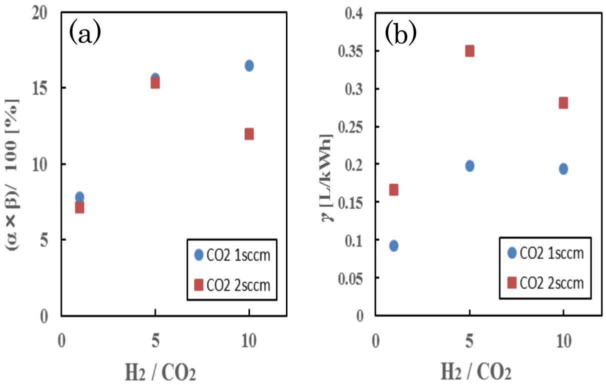

Fig.1 Input gas flow rate ratio dependence of (a) α×β/100 [%] and (b) γ [L/kWh].

In the case of H_2/CO_2 = 5, the value of $\alpha\times\beta$ is nearly constant (about 15%), but γ increases by about 1.75 times when CO_2 flow rate is changed from 1 sccm to 2 sccm. From this result, it is thought that the discharge with large CO_2 flow rate is effective for generating CH_4 with less electricity consumption.

4. Summary

Production of methane is investigated by carbon dioxide reduction using a hydrogen plasma. Gases produced were CO and CH_4. From the results of input gases flow rate dependence, not only hydrogen flow rate but also total flow rate is a key parameter to increase the energy efficiency for the CH_4 production.

Reference

[1] K. Arita, et al., 31th ICPIG, P1-104-pp.1-4(2013).