1. Introduction

**UCG (Underground Coal Gasification)**

Underground Coal Gasification (UCG) is a process to convert coal in an underground coal seam into gaseous products by the in-situ combustion of the coal.\(^1\)

![Image: Diagram of UCG process]

Since the gas produced by the UCG (hereafter called UCG gas) contains \(\text{H}_2\), \(\text{CH}_4\), \(\text{CO}\), etc., the UCG gas can be used as fuel and raw material of chemical products. The UCG gas contains hydrocarbons, so that the UCG gas is potentially used as a raw material.

For the effective usage of the UCG gas, it is important to reform the UCG gas, because the UCG gas contains contaminants such as \(\text{H}_2\text{S}\), tar, etc.

**Requirement of reforming the UCG gas**

In this work, we use discharge plasma to reform the UCG gas. Plasma reforming of gases has been reported,\(^2\) but the reforming characteristics of the UCG gas by discharge have not been clarified.

**Objective**

To investigate reforming characteristics of the UCG gas by a packed-bed dielectric barrier discharge (PB-DBD).

- We generate an artificial UCG gas by heating of the crushed coal, and reform the UCG gas using the PB-DBD.

2. Experimental apparatus and conditions

- **Discharge reactor**
  - The PB-DBD reactor consists of a glass tube filled with glass balls, a rod electrode, and a metal electrode.
  - The glass balls have a specific dielectric constant of 7.3. The rod electrode is inserted into the glass tube: The mesh electrode is wrapped around the glass tube, and earthed.

- **UCG gas generator**
  - UCG gas is generated by heating finely crushed coal. 70% of the crushed coal are put into a chromatographic-tube.
  - An electric heater is wound around the chromatographic-tube, and inner air is introduced from an air pump into the chromatographic-tube. Then, the coal is heated up to about 420°C, the UCG gas is generated.

- **UCG gas flow**
  - The UCG gas is introduced into the PB-DBD reactor at a flow rate of approximately 0.1 L/min.

- **High voltage application**
  - An AC high voltage of 11 kV is applied between the electrodes, generating the PB-DBD. Input power to the PB-DBD reactor is approximately 30 W. The PB-DBD is switched ON and OFF every 2 minutes.

- **Measurement of sampling gas**
  - Samples are taken from the PB-DBD reactor every 2 minutes and analysed by Gas Chromatograph (GC; Shimadzu, GC-2014C, column: SHICARBON ST, and Hitachi, 263-50, column: Sunpak-S) equipped with a thermal conductivity detector.

3. Results

**Measurement of coal temperature**

- CO\(_2\), CH\(_4\), H\(_2\)S, and H\(_2\) are detected in the UCG gas.

- The temperature when the temperature of the coal reaches at 420°C is set as the origin of measurement.

**Concentration variations of CO\(_2\), CH\(_4\), H\(_2\)S and H\(_2\)**

The concentrations of CH\(_4\), H\(_2\)S and H\(_2\) vary with time.

- No significant difference is observed in CO\(_2\) concentration.
- The concentration of CH\(_4\) slightly decreases with discharge plasma.
- The concentration of H\(_2\)S with discharge tends to be lower than that without discharge.
- Plasma desulfurization is found to be taken place.
- The maximum decomposition rate of H\(_2\)S is about 85%.

- The concentration of H\(_2\) increases with discharge plasma.
- This indicates the conversion from CH\(_4\) and/or hydrocarbons to H\(_2\).
- Production of H\(_2\) increases by 30%.

4. Conclusions

An artificial UCG gas is generated by heating of the crushed coal, and reformed the UCG gas using the PB-DBD.

- H\(_2\), H\(_2\)S, CO\(_2\), and CH\(_4\) are obtained in the UCG gas, and that the UCG gas can be desulfurized by the PB-DBD.
- The maximum decomposition rate of H\(_2\)S is about 85%.
- CH\(_4\) will be converted into H\(_2\) in the PB-DBD.
- Production of H\(_2\) increases by 30%.