CO2 Reforming of Methane via the Low Temperature Plasmas
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1. Introduction
The electrical discharge reactor has been used for many years for the conversion of methane, abundant as natural resources on the earth and possible chemical feedstock in the future. In consequence some results have suggested that the plasma is useful media to convert methane to higher hydrocarbons and the synthesis gas. The reformation of methane by carbon dioxide has also been attracting considerable interest in both controlling the greenhouse gas and deducting the CO2 emission. For the reaction of methane and carbon dioxide in the plasma reactor, a cylindrical-type dielectric barrier discharge (DBD) reactor and a gliding arc discharge one were employed in investigating the basic reaction mechanism and finding the process design variables affecting the energy economics in plasma. Additionally chemical catalysts were introduced in a way to control the selectivity of a certain component out of the product mixture.

2. Experiment, Results and Discussions
The influence of the polarity of a pulse power supply on the conversions has been investigated using a unipolar and bipolar pulse power supply. The input voltage and the power frequency were used as operating variables. The energy efficiency of the bipolar pulse power was compared with that of the unipolar pulse power for the CO2 reformation of methane using DBD. Increasing the voltage and frequency resulted in an increase of the conversion of CH4 and CO2. The selectivity of CO and C2 was decreased, while the conversion of CH4 and CO2 increased with the electric power being increased. For the same amount of energy consumed, the bipolar pulse power was more effective than the unipolar pulse on the CH4 reformation of the CO2 reaction. The selectivity of the product was not affected by the pulse polarity.

Fig. 1. The effect of pulse polarity on the conversion.
A gliding arc plasma reactor under the atmospheric pressure was used to investigate the effects of the discharge on methane conversion as well as the product selectivity and the power consumed. With four different kinds of additive gases; He, Ar, N2, and CO2 the effect of the feed dilution was also examined to see the variation of the products and the selectivity change. The conversion was increased with the higher concentration of helium, argon, and nitrogen in the feed gas but decreased when that of CO2 increased. In this process, qualitatively, hydrogen and acetylene were the major products in gas but the products in liquid form were not detected.

Fig. 2. CH4+CO2 experiment in a gliding arc reactor.

The above experimental observations indicated that the plasma reactor had to be improved to be able to control the selectivity of a certain valuable product with moderate energy. The chemical catalysts were introduced into a plasma reactor to vary the selectivity of the output product. Out of many catalysts, the Ni/Al2O3 catalyst has shown a great effect on the CO selectivity and also on the CO2 conversion, that is, in a DBD reactor, the CO selectivity was increased to 60.9% from 49.17% without catalyst and the CO2 conversion up about 3%. Even though the Ni/Al2O3 catalyst was helpful to improve the CO selectivity in this particular case, the fundamental mechanism of the reaction and the characterization of catalysts are still unknown. There are still many obstacles to be overcome in order for the plasma reactor to be useful in the industrial arena.

References