Effect of environmental condition for atmospheric pressure plasma reactor on CO_2 reforming of CH_4 to syngas

Duc Ba Nguyen and Won Gyu Lee*

Department of Chemical Engineering,
Kangwon National University
Chuncheon, Kangwon, 200-701, Korea

CO_2 reforming of CH_4 to produce syngas by dry reforming has received attention because the reforming reaction has advantages to produce more valuable chemicals. Until now, several methods have been suggested for the CO_2 reforming of CH_4, including catalyst method, plasma method and a combination of catalyst and plasma methods.

On disadvantage of reaction using conventional catalytic methods is that they are very costly because reaction consumes a great amount of energy due to endothermic reaction. In addition, carbon deposition and subsequent deactivation of the catalyst are fatal problems of the method. Several plasma methods have been employed for the reaction of CO_2 and CH_4 to syngas, such as thermal plasma, corona discharge, arc discharge and dielectric barrier discharge (DBD). Regarding the plasma and catalyst methods, reaction by plasma can obtain higher conversion of reactants and higher selectivity of products than the catalyst method under the same conditions with relatively low process temperature, and without concern about carbon deposition. The DBD with one or more insulating layers in the current path between the metal electrodes has received attention for application in the synthesis and treatment of materials.

It seems that CO_2 reforming of CH_4 by a conventional DBD reactor has been mostly carried out under ambient conditions with an air ambient or gas. The power delivered to the coaxial dielectric barrier discharge system is used to ignite and sustain glow discharge. It is also partly dissipated to heat up the plasma reactor system, which is usually composed of electrodes and dielectric materials. Heating of the plasma system due to power dissipation would be beneficial to yield a high reactivity because CO_2 reforming of CH_4 is a strong endothermic reaction with a higher conversion at a higher temperature. However, rapid heating would be harmful to sustain dielectric materials such as quartz. To prevent the abnormal heating of the reactor system, we suggested the immersion of a DBD reactor system in an electrical insulating oil.

In this study, CO_2 reforming of CH_4 to syngas was performed in a coaxial dielectric barrier discharge reactor. The location of the reactor system was the main focus of this report. The reference condition was location of the reactor in an air ambient, and the comparative condition was immersion of the reactor in an electrical insulating oil. The effects of the ambient condition with several parameters such as applied voltage, total flow rate of feed gas, and the CH_4/CO_2 ratio of the feed gases were investigated in relation to the conversion of reactants, selectivity of products, H_2/CO ratio of outlet gases, and energy efficiency.