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# A role of high power ATM Plasma for the environment

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The $CO_2$ capture and storage technology (CCS technology) needs immediate action, but does not have complete solutions yet due to the lack of efficient, and economical $CO_2$ conversion ideas. The governing fundamental quantities have been identified to obtain the maximum energy efficiency and capacity for $CO_2$ dissociation. Some of the $CO_2$ conversion ideas are introduced, describing the advantages and disadvantages of each conversion techniques.

The plasma reactor has been known as one of the most promising candidate for $CO_2$ dissociation. However, the problems on how to achieve high efficiency, stable discharge at atmospheric pressure, and reliability at high power density have been remained to be solved. $CO_2$ dissociation and $CH_4$ dry reforming, by high power inductively coupled plasma (ICP) torch at atmospheric pressure, have been studied. At a frequency of 400 KHz and power of up to 50kwatt, the ICP torch dissociates $CO_2$ gas directly, leading to $CH_4$ dry reforming. The resulting products are composed of syngas, $C_2H_6$, $C_2H_4$, and $C_2H_2$. As a result, the high CE of $CO_2$ and $CH_4$, the large amount of products, and the high selectivity of C2 hydrocarbons can be seen an important factors for achieving higher energy conversion efficiency in the $CH_4$ dry reforming process. The associated chemical reactions are simulated using CHEMKIN-PRO tool, and the results illustrate the tendency of CE to vary with variations in selected parameters, and syngas and C2 hydrocarbons production trends achieved in the simulation agree with experimental results. This shows conversion efficiencies (CE) for both $CO_2$ and $CH_4$ of 95%. In the $CH_4$ dry reforming process, the high CE of $CO_2$ and $CH_4$, the large amount of products, and the high selectivity of C2 hydrocarbons could be regarded as important factors for achieving higher energy conversion efficiency.

The conversion efficiencies of $CO_2$ and $CH_4$ increased when the applied power was increased, with syngas production estimated based on the same behavior. As the applied power increased, the power absorbed by the plasma also increased, and thus plasma density increased, causing more $CO_2$ dissociation. Increased $CO_2$ and $CH_4$ conversion efficiency, with increased power, has been confirmed by other research groups, using different plasma sources (DC corona, AC corona, DC arc, Microwave, etc ).

We have developed an electrically and structurally stable plasma continuous discharge, using a high power ICP torch, and used it in a research program in which the torch was applied to dissociate $CO_2$ gas directly, at atmospheric pressure, through a plasma discharge, with injected swirling gases. In addition, $CH_4$ dry reforming reactions, carried out under various experimental conditions in the ICP torch reactor, have been investigated. Under a certain condition, syngas (a mixture of CO and $H_2$ gases), and C2 hydrocarbons, such as $C_2H_6$, $C_2H_4$, and $C_2H_2$, are obtained, and these products are quantitatively analyzed with GC equipment.

As the $CH_4$ injection rate increases, the selectivity of the CO and $H_2$ decreases, and the selectivity of C2 hydrocarbons increases, and in that situation, energy conversion efficiency increases as a result.
The high power ICP torch source is able to dissociate directly a large amount of $CO_2$, at atmospheric pressure, Leading a $CH_4$ dry reforming reaction, to produce syngas and C2 hydrocarbons with high selectivity, chemical conversion efficiency, and energy conversion efficiency.

Other sources such as microwave, DBD (Dielectric barrier discharge), and DC would be compared. The associated chemical reactions are simulated using CHEMKIN-PRP tool, illustrating the tendency of CE to vary as selected parameters and syngas and C2 hydrocarbon production trends.

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