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Gliding arc plasmatron for CO_2 splitting: A chemical kinetics modelling perspective

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Experiments show that the gliding arc plasmatron (GAP) has significant potential to split CO_2 in an energy efficient way. However, a detailed description of the most important chemical pathways in this type of reactor has not been elucidated yet. We therefore present a detailed chemical kinetics model for CO_2 in a GAP. The model results, such as CO_2 conversion and the resulting energy efficiency, are in very good agreement with experimental data, for different values of specific energy input. Both the model and experiments show that the obtained energy efficiency is quite promising (>20%) due to energy efficient vibration induced dissociation.

1. Introduction

Plasma technologies for converting CO_2 into value-added chemicals in an energy efficient way and at atmospheric pressure are highly wanted. The gliding arc discharge is one of these possible candidates[1]. A 0D kinetic model for the conventional gliding arc for pure CO_2 has therefore already been developed[2]. A significant amount of gas, however, passes the plasma without any conversion in the conventional configuration and the high current density causes strong electrode degradation[3]. To tackle these issues, reverse vortex flow stabilization was introduced[1],[3]. To the authors' knowledge, a full kinetic study of the GAP for pure CO_2 has not yet been conducted, which is thus presented here.

2. Methodology

We used a 0D chemical kinetics model, called ZDPlaskin[4] with the built-in Boltzmann solver, BOLSIG+[5]. The chemistry set is based on the original work of Kozak et al.[6] in which vibrational excitation till the dissociation limit of CO_2 is taken into account, and was recently updated by Koelman et al[7]. The dissociation cross section used in this study is the one proposed by Phelps, with 7eV threshold, suggested by Bogaerts et al. [8].

3. Results

In Figure 1, we show the calculated CO_2 conversion and energy efficiency. They are in very good agreement with the experimental results obtained by Ramakers et al. [9]. Both in the model and experiments, energy efficiencies greater than or equal to 23% were obtained. This is attributed to the large contribution of vibration induced dissociation (> 70%), followed by electron impact dissociation.

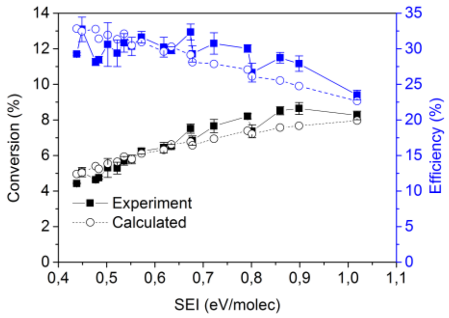

Figure 1: Calculated and measured CO_2 conversion (left y-axis) and energy efficiency (right y-axis) as a function of the specific energy input (SEI).

3. References

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