Measurement of CO densities by IR absorption spectroscopy in a CO_2/O_2 and CO_2/N_2 dielectric barrier discharge

C. Douat[1*], O. Guaitella[1,2], S. Ponduri[1], T. Boumans[1], S. Welzel[1,3], R. Engeln[1]

[1] *Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands*
[2] *LPP, Ecole Polytechnique, UPMC, Université Paris Sud XI, CNRS, Palaiseau, France*
[3] *FOM Institute DIFFER, P.O. Box 6336, 5600 HH Eindhoven, The Netherlands*
*c.a.douat@tue.nl

The continued and increasing use of fossil fuels, owing to its limited availability, poses a major energy supply and environmental problem. An alternative to this issue is the use of renewable energies. To counterbalance their intermittency, one possible solution is to store the excess energy in a chemical form by reforming CO_2 into a fuel. The most energy-consuming step in this process is the dissociation of CO_2 into CO. A promising route to achieve high conversion, while keeping investment and running costs low, is to use plasma-assisted dissociation [1].

The aim of this work is focused on the fundamental study of CO_2 splitting by a dielectric barrier discharge (DBD) operated at elevated pressure (400 – 700 mbar). Today, the majority of studies on the CO_2 dissociation in DBD have been performed in pure CO_2 [2], while no investigation on the effect of the addition of molecular gases such as O_2 or N_2 in CO_2 DBD at high pressure have been reported, even though it is known that oxygen and nitrogen can influence the CO_2 dissociation [3]. In this study, we will present the influence of the addition of O_2 and N_2 in the gas mixture in a DBD.

The experiments were carried out in a discharge consisting of two pin electrodes covered with glass. The plasma was powered with a sinusoidal high voltage (15 – 22 kV peak to peak) at a frequency of 22 kHz. The electrodes were mounted inside a cylindrical glass cell to maintain reproducible gas conditions. A gas flow at a flow rate in the range of 400-700 standard cm^3 per minute (sccm) was established in the cell, while using a vacuum pump at the exhaust. The experiments were performed in pure CO_2 and in different gas mixtures: oxygen/CO_2 and nitrogen/CO_2.

The CO density in the effluent of the DBD was measured *ex-situ* by IR absorption spectroscopy using a pulsed quantum cascade laser, in the range 2212 – 2216 cm^{-1}. The exhaust of the gas was directed into an external cell through which the laser beam passes twice. The total optical path length was 948 mm. The intensity of the transmitted laser light was measured by a fast IR detector and recorded by an oscilloscope.

Influence of O_2/N_2 on conversion efficiency of CO_2 is studied using three different gas compositions. The results are shown in *Figure 1* for different gas flows (square: 400 sccm, circle: 700 sccm) and pressures (square: 400 mbar, circle: 700 mbar). Addition of N_2 increases conversion efficiency while addition of O_2 shows only a dilution effect, acting like an inert spectator.

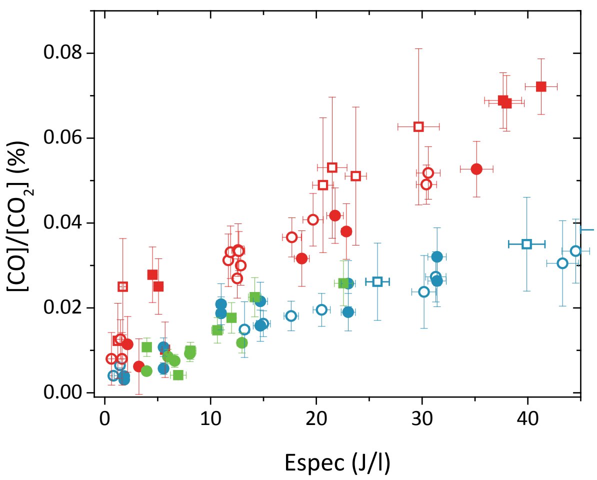

Figure 1: Conversion efficiency in different gas mixtures (blue: 100% CO_2, red 50/50 CO_2/N_2 and green 50/50 CO_2/O_2), pressures (open: 400 mbar, full: 700 mbar) and gas flows (square: 400sccm, circle: 700 sccm) as a function of the specific energy (E_{spec}).

1.References

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