CO_2 and CO vibrational excitation in Townsend and filamentary DBD at atmospheric pressure: in situ FTIR measurements.

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In the last few years, study on CO_2 have gained interest. One of the current goals is to find a way to convert CO_2 into value-added products. Several technologies are already used for this purpose [1]. Plasma discharges allow to induce chemistry in gases at reduced energy cost, and thus constitute an interesting way to dissociate CO_2 molecules. Studies in microwave discharges reported a conversion factor of up to 90%. On the other hand, atmospheric pressure dielectric barrier discharges (DBDs) reach a lower percentage of conversion (a few per cent) and energy efficiency. However, these discharges are easy to set up and couple with catalytic materials, scalable and may consist of different driving mechanisms. As a result, DBDs are investigated to understand in detail the resulting plasma-chemical processes. At atmospheric pressure DBDs generally work in the classical filamentary regime. Under certain conditions, a Townsend breakdown could occur, allowing the discharge to work in a diffuse regime. This was observed for DBDs in a few gas compositions, such as N_2 [2], N_2 with oxygen admixture [3] or Air [4]. More recently, we also observed this regime in pure CO_2 for a DBD at atmospheric pressure [5]. This regime constitutes an interesting way to study the discharge mechanisms involved in CO_2 plasmas because of the easy determination of the reduced electric field. Indeed, for a Townsend discharge, the electric field in the gas gap is almost constant and can be easily determined thanks to electrical measurements.

Fourier transform infrared spectroscopy (FTIR) is used to measure concentrations of CO_2 and CO molecules and evaluated the vibrational temperatures. Recent works propose to use this method in atmospheric pressure RF jets [6][7]. Our contribution will present the first results obtained with *in situ* FTIR measurements in CO_2 DBDs at atmospheric pressure. We will compare the classical filamentary regime to a Townsend regime. For this purpose, conversion factor α is defined by equation 1. Where [CO] is the measured concentration of CO and $[CO_2]$ is the measured CO_2 concentration. It is known that dissociation by electron impact is the main dissociation mechanism in atmospheric pressure DBDs [8]. The large difference of the reduced electric E/N field between both filamentary and Townsend regimes leads to a difference in the conversion ratio α, as it is visible in Figure 1. It appears that CO concentration is higher in the case of filamentary discharge due to higher dissociation rate.

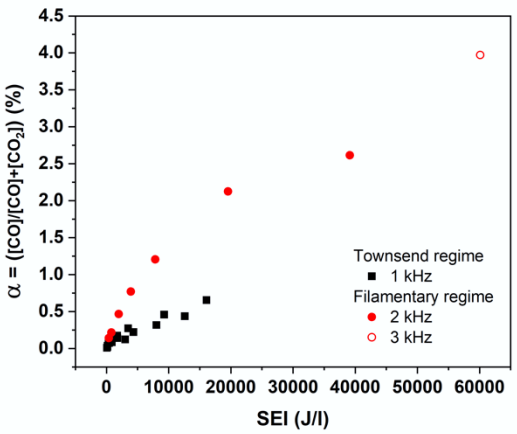

Fig. 1: Evolution of the conversion factor α as a function of the specific energy input (SEI).

$$\alpha = \frac{[CO]}{[CO] + [CO_2]} \quad (1)$$

The Figure 2 shows the rotational temperature (T_{rot}), the vibrational temperatures of CO_2 in the symmetric-bending mode (T_{12}), asymmetric mode (T_3), and the vibrational temperature of CO (T_{CO}). Despite problems in the determination of some points for certain conditions, the rotational and vibrational temperatures of CO_2 and CO were correctly evaluated. There is a non-equilibrium between T_{12} and T_3, while T_{12} remains close to T_{rot}. T_{CO} is still higher than the other temperatures and decline with the increase of the SEI. This evolution is consistent with results obtained in the literature for different discharge configurations. Our results will be discussed in detail during the presentation.

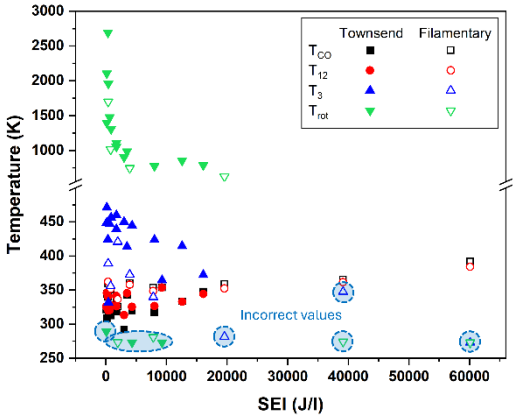

Fig. 2: Evolution of the vibrational temperatures of CO_2 and CO as a function of the specific energy input (SEI).

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