Ro-vibrational temperatures of CO(X) deduced from emission of third positive and angstrom system of CO in CO_2 glow discharge.

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Non-thermal plasmas (NTPs) offer a promising route for efficient CO_2 dissociation by inducing vibrational excitation in molecules. This process, driven primarily by electron temperature, selectively transfers energy to initiate chemical reactions like CO2 dissociation more efficiently than conventional methods. However, the non-equilibrium nature of NTPs complicates gas temperature determination, as electrons, ions, neutrals, and radicals are not in equilibrium. Additionally, different molecular degrees of freedom may be out of equilibrium, leading to varying characteristic temperatures. Various techniques, [6] such as Rayleigh and Raman scattering, Doppler broadening, thermocouples, absorption spectroscopy (FTIR or QCL), optical probes, IR cameras, and Optical Emission Spectroscopy (OES), are employed to measure gas temperature in non-equilibrium plasma. OES, offering a wide spectral range without disturbing the plasma, is particularly accessible and efficient. However, interpreting emission spectra requires caution, as emphasized in the literature.

We investigate on the possibility of using optical emission spectroscopy to quantify the degree of vibrational and rotational excitation of CO in CO_2 discharges. Experimental data is collected from glow discharges at pressures of 1-5 Torr and currents of 10-50 mA. We analyze CO vibrational and rotational excitation using optical emission spectroscopy of the 3rd positive and Angström systems, respectively spanning 250-360 nm and 400-570 nm. Those systems hold particular interest because they emit in an easily accessible spectral range, they do not overlap with other systems, and spectroscopic datas are available and multiples. Systematic comparison of those temperatures to those obtained from (i) infrared absorption spectroscopy in such discharges, (ii) the LisbOn KInetic (LOKI) simulation tool developed at IPFN [1] allow an estimation of the accuracy of the methods, as shown on figure 1.

Two methods are often used in plasma spectroscopy to deduce vibrational temperatures from molecular emission bands: 1) a "boltzmann plot", measuring the ratio of the peak intensity of vibrational transitions [8] 2) simulating the complete spectrum of the molecular band considered [9]. Both of these methods gives the vibrational temperature of the excited state that is responsible for the emission which is not representative of the vibrational temperature of the gas in the discharge [7]**.** A collisional-radiative model is needed to relate the obtained temperature of the emitting excited state to the vibrational distribution function of the ground state. In this study, we use a simplified method employing Frank-Condon factors without accounting for quenching.

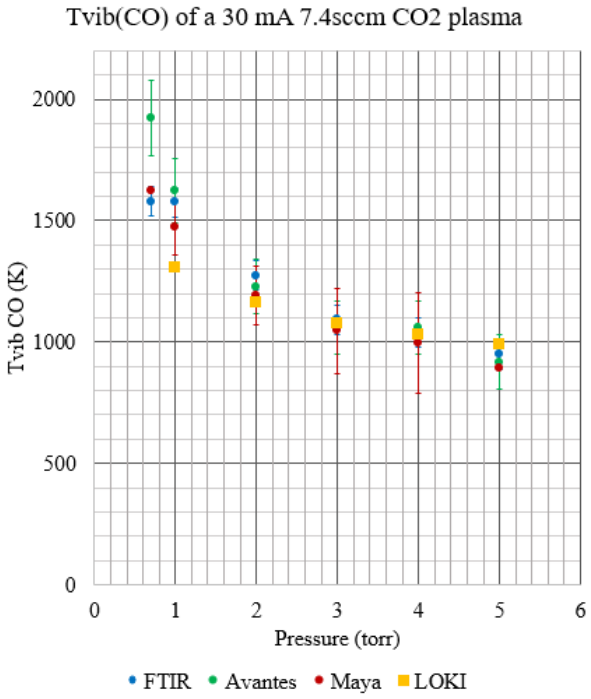

Figure 1 : Comparison of Tvib(CO) obtained through FTIR, OES and LOKI

The results of those methods depends strongly on the choice of the radiative parameters and spectroscopic constants. As a consequence this method can be use as a benchmark to validate important radiative parameters such as : Einstein coefficients of the b → a and B → A transitions which are given in the literature by [4] and [3]; Hönl London factors of the same transitions that are calculated using [10] and [5], Frank-Condon factors of b → a and B → a and X → b, either calculated using [2] or given by [4], and finally lifetimes of excited states given by [3].

This diagnostic is thus validated against FTIR measurements and can be used thanks to its spatial flexibility in order to measure vibrational and rotational temperature of CO in CO_2 containing plasmas with complex geometries.

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