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EMISSION SPECTROSCOPY - ESSENTIAL DIAGNOSTICS TOOL OF ATMOSPHERIC PRESSURE PLASMAS FOR ENVIRONMENTAL, BIO-MEDICAL AND INDUSTRIAL APPLICATIONS

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Air and nitrogen plasmas at atmospheric pressure present considerable interest for a wide range of environmental, bio-medical and industrial applications, such as air pollution control, waste water cleaning, bio-chemical decontamination and sterilization, material and surface treatment, electromagnetic wave shielding, and element analysis. Besides electrical measurements, optical emission spectroscopy in UV-VIS represents an essential plasma diagnostics tool because it gives valuable information on excited atomic and molecular states, enables to determine the rotational and vibrational temperatures and thus the nonequilibrium in the plasma, gives insight in an ongoing plasma chemistry, and provides a measurement of the plasma active size.[1]

We present emission spectra of various DC electrical discharges generating non-thermal plasmas and of microwave torch plasma in atmospheric air and nitrogen. The spectra were obtained by a compact emission spectrometer Ocean Optics SD2000 (200 – 1100 nm, resolution 0.4 – 1.7 nm), and optionally by a 75-cm monochromator SPEX 750M (200 – 800 nm) fitted with a CCD camera for higher resolution (0.12 nm). Spectra of the N_2 2^{nd} positive system ($C^3\Pi_u - B^3\Pi_g$) are the most convenient for plasma diagnostics, since they enable to determine vibrational and rotational (i.e. gas) temperatures by fitting the experimental spectra with the simulated ones (we use Lifbase[2] and Specair[3] simulation programs). The emission of N_2 1^{st} positive system ($B^3\Pi_g - A^3\Sigma_u^+$) indicates the formation of $N_2(A^3\Sigma_u^+)$ metastable states that serve as reservoirs of energy promoting plasma chemical reactions leading to harmless products in air cleaning applications. Air plasmas also emit OH ($A^2\Sigma^+ - X^2\Pi_{3/2}$) and NO γ ($A^2\Sigma^+ - X^2\Pi_r$) systems. NO and OH radicals play crucial roles in biochemical decontamination, sterilization and water cleaning applications. Plasmas with high electron temperatures lead to the emission of N_2^+ 1^{st} negative system ($B^2\Sigma_u^+ - X^2\Sigma_g^+$), and atomic N, O and H lines, indicating a high level of nonequilibrium essential in air and water cleaning, and in bio-decontamination. Thermal microwave plasmas in nitrogen emit CN violet ($B^2\Sigma^+ - X^2\Sigma^+$) system, which can be used for the plasma temperature measurements as well. A very small admixture of oxygen or water vapor in nitrogen plasma dramatically changes the involved chemistry and thus the emitted spectra.

[1] C.O. Laux, T.G. Spence, C.H. Kruger, and R.N. Zare, Plasma Sources Sci. Technol. 12, 2003, 125-138

[2] J. Luque and D.R. Crosley, SRI Report MP 99-009, 1999, 1

[3] C.O. Laux, *Radiation and Nonequilibrium Collisional-Radiative Models*, von Karman Institute for Fluid Dynamics, Lecture Series 2002-07, Rhode Saint-Genese, Belgium, 2002

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