Mass spectrometry and plasma chemistry of atmospheric pressure plasma jets

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Atmospheric pressure non-equilibrium plasmas are effective source of large densities of reactive radicals, metastables and ions and also high fluxes of photons with wavelengths down to the vacuum UV range. The resulting high reactivity of these APPs can be used in many surface treatment applications such as activation of polymer surfaces, treatment of living tissues (decontamination, acceleration of wound healing) or in deposition of thin films or nanostructured materials. However, the complexity of plasma-chemical processes in the discharge requires combined experimental and theoretical approach in plasma analysis, where quantitative and qualitative plasma diagnostics are compared with theoretical plasma simulations. In this contribution, molecular beam mass spectrometry (MBMS) for detection of neutral reactive and stable species and positive and negative ions will be introduced and discussed in detail. The advantage of mass spectrometry is that it measures the directly at the surface, the place of interest for any surface treatment, and it is not limited by existence of accessible optical transitions. Additionally, mass spectrometry provides absolute densities of the measured species when properly designed and carefully calibrated. It can even provide information about vibrational excitation of the detected species or about electronically excited metastables. The ion mass spectrometry can provides information about the formation of positive and negative ions (and ion clusters) in the effluent and provides supporting information about the influence of variety of species (including impurities) on plasma chemistry. These experimental results serve for validation of plasma-chemistry models and rate-equation calculations, which can provide deep insight into the whole plasma and plasma-surface interaction. Several examples of investigation of plasma chemistry processes in gas mixtures and at the surface relevant for plasma medicine applications and growth of thin films will be discussed.