Abstract

In the thesis, an Atmospheric Pressure Field Effect (APFE) ionisation source and its application in the field of Ion Mobility Spectrometry (IMS) is presented. The new ionisation source operates for both negative and positive polarity. The APFE ion source is of a point to plane geometry configuration, consisting of a 10 μm Pt point electrode and a stainless steel plate electrode with 12 mm gap between the electrodes, and ultra-high resistor (20 GΩ) current limiters. The formation of the negative and positive ions in synthetic air was studied and compared with an Atmospheric Pressure Corona Discharge (APCD) ionisation source. In the negative polarity, the ion source was able to generate Reactant Ions RI $O_2^-(H_2O)_n$ and $O_2^-CO_2$ in two different gas flow regimes of the IMS. In the positive polarity stable production of $H^+(H_2O)_n$ RI was achieved. RI formed in APFE in both polarities made it a reliable ion source for Atmospheric Pressure Chemical Ionisation (APCI). Identification of the ions generated in APFE was performed using an Ion Mobility Spectrometry orthogonal acceleration Time of Flight Mass Spectrometer (IMS-oa-TOF-MS). In the negative polarity, APCI of halogenated hydrocarbons (CCl_4, $CHCl_3$, CH_2Br_2, $C_7H_6Cl_2O$, and $C_7H_4Cl_4O$) was demonstrated, resulting in the formation of Cl^- and Br^- in both flow regimes. In positive polarity, the chemical ionisation of 2,6-di-tert-butyl-pyridine was demonstrated for the APFE ionisation source. Supporting studies of field emission of electrons were carried out in vacuum and at atmospheric pressure, for different materials and geometries of the electrodes.

The computer-aided simulations have been carried out for the drift gas flow and static electric field in the IMS drift tube. Additionally, dynamic pressure, total pressure, and fluid density of gas flow have been simulated. The simulations confirmed homogenous electric field and homogenous gas glow in the drift tube. Based on the simulation, the design of the drift tube was optimized.