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A dielectric barrier discharge based ion source for a sensitive and versatile chemical ionization time of flight mass spectrometer instrument using the negative ion mode

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Chemical ionization mass spectrometry (CIMS) provides high sensitivity for ultra-sensitive trace gas measurements in the atmosphere. The presented ion source is used to replace radioactive Po ion sources. First in-field test runs have been done using an airborne instrument flown on the StratoClim campaign in Greece, Kalamata 2016. Especially stratospheric measurements at ambient pressures lower than 100 hPa require improved sensitivity. Therefore, a chemical ionization (CI) time-of-flight (TOF) instrument using a dielectric barrier discharge (DBD) ion source and a high-transmission transfer stage has been set-up and characterized. A new concept including the ion molecule reaction (IMR) zone inside an ion funnel is used.

The focus will be on the brilliant DBD ion source, which also can be used to generate ion precursors in the plasma. Thereby multiple reactants can be generated having a versatile ion source. To finally judge the brilliance of the DBD ion source it is compared to a 10 mCi Po ion source. These measurements are highlighting that even more ions are generated in the DBD ion source compared to a 10 mCi Po ion source. However, first measurements with good sensitivity have been made, employing the CIMS instrument described. The analyte gas is introduced into the first ion funnel and mixed with the ion source gas flow. It has been discovered that the mixing in the IMR funnel is critical in terms of sensitivity and was therefore optimized. The ion funnel achieves a transmission of 40% working at 50 hPa pressure and using a gas flow of 1 slm. The complete transfer stage achieves a high transmission of around 10 % for gas phase ions and therefore enables a high sensitivity combined with the brilliant DBD ion source. A detection limit better than 100 pptV was determined for SO_2 using CO_3^- ions. Further-on a fast exchange of the reactants is possible. NO_3^-, CO_3^-, I^- and SF_6^- have been successfully tested and can be generated in the DBD from low ppm or even ppb amounts of their precursor molecules. This allows a fast exchange of the reactant chemistry within minutes and gives a wide range of analytes for measurements using chemical ionization.