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Chemical composition of the semi-volatile grains of comet 67P/Churyumov-Gerasimenko

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The European Space Agency's Rosetta spacecraft (Glassmeier et al., 2007) has been in orbit of the comet 67P/Churyumov-Gerasimenko (67P/C-G) since August 2014. On board is the Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (ROSINA) instrument suite (Balsiger et al., 2007). ROSINA consists of two mass spectrometers, the Double Focusing Mass Spectrometer (DFMS) and the Reflectron-type Time-Of-Flight (RTOF) (Scherer et al., 2006), as well as the COmet Pressure Sensor (COPS). ROSINA is designed to detect and monitor the neutral gas and thermal plasma environment in the comet's coma by in situ investigation. The two mass spectrometers have high dynamic ranges and complement each other with high mass resolution (DFMS) and high time resolution and large mass range (RTOF). Especially the unprecedented sensitivity and mass resolution of DFMS together with the large mass range of RTOF allow determining precisely light species (e.g. isotopologues) as well as detecting heavy organic species. The pressure sensor COPS measures total gas densities, bulk velocities, and gas temperatures.

ROSINA has been collecting data on the composition of the coma and activity of the comet from 3.5 AU to pericentre and out again to 3.5 AU. The Rosetta mission presents a unique opportunity to directly sample the parent species in the thin cometary atmosphere of a Kuiper-belt object at distances in excess of 2.5 AU from the Sun all the way to the pericentre of the cometary orbit at 1.24 AU. The ROSINA experiment continuously measured the chemical composition of the gases in the cometary coma.

Occasionally, a dust grain of cometary origin enters the ion source of a ROSINA instrument where the volatile part evaporates since these ion sources are hot. We will report on the first measurements of the volatile inventory of such dust grains. Volatile release from cometary dust grains was observed with all three ROSINA instruments on several occasions. Because the volatile content of such a dust grain is completely evaporated in such an ion source after a few 100 seconds, the RTOF instrument is best suited for the investigation of its chemical composition since several complete mass spectra are recorded during this time. The rate of dust grains recorded in RTOF is small, and we report on the collection and analysis of 9 dust grains during the October 2014 to July 2016 time period. It is estimated that these grains contain about 1E–15 g of volatiles, which would correspond to a grain of the order of 100 nm in size if made up of volatiles alone. We fitted the recorded mass spectra of RTOF with a set of 61 molecules, and their molecular fragments resulting from the ionisation. The major groups of chemical species are hydrocarbons, oxygenated hydrocarbons, nitrogen-bearing molecules, sulphur-bearing molecules, halogenated molecules and others (including water and CO_2). About 70% of these grains are depleted in water compared to the comet coma, thus, can be considered as semi-volatile dust grains, and the other about 30% are water grains.

The mineral phase of these grains, if there is any, cannot be investigated in these measurements. However, in an earlier investigation the bulk composition of mineral grains on the surface of the comet was inferred from solar wind sputtering of these grains (Wurz et al., 2015).

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