EXPLORING ALTERATION OF GRAINS IN COMETARY COMAE INDUCED BY ELECTRICAL CHARGING.
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Introduction: The COSIMA (COmetary Secondary Ion Mass Analyzer) instrument on-board the Rosetta orbiter collects dust from the coma of 67P/Churyumov-Gerasimenko (67P/C-G hereafter) and it analyses it by mass spectrometry. The evolution of the dust from its ejection from the cometary nucleus until it is collected by COSIMA remains unclear. During its journey toward the instrument, the grains could have been altered, thus preventing us from analyzing their original composition.

To characterize the alteration undergone by the grains in the cometary coma, we aim to experimentally explore different processes that can lead to modification of their composition and finally being able to trace back the original components present in the grains analyzed by COSIMA.

We will focus on three processes that will be described below: the Workman-Reynolds effect, charging of the grains induced by photoelectrons, and solar wind ions implantation.

The Workman-Reynolds Effect (WRE): During freezing of salt-containing icy-grain at temperatures below 0°C, the overall electric potential of the grains can increase to tens of volts in less than a few hundreds of seconds [1] [2]. This electric potential can facilitate displacement of ions into the icy grains likely leading to chemical reactions.

The maximal potential that an icy grain can reach through the WRE is mostly influenced by the nature and concentration of the impurities [1] [3]. For a mm-sized grain containing NaCl salt, this potential is reached for a concentration of 10^{-3} M [1]. If the type of cation present as a salt has no major influence, the type of anion affects the freezing potential: if the electronegativity of the ion is close to the O electronegativity, the ion will then replace an O atom in the water and will be incorporated in the ice phase. However, the sign of the potential is influenced by the nature of the replacing ion, positive ions leading to negative potentials, negative ions to a positive potential [3].

The grains analyzed so far with COSIMA show a strong signal from Na [4]. It is unclear whether or not this Na is present as a salt or as a silicate but if the original Na bearing compound is a salt, then the WRE cannot be ruled out.

Photoelectric charging: Dust grains ejected far from the cometary surface can acquire charging through emission of photoelectrons, leading to a positive charge on their surface [5]. The potential they acquire is function of the wavelength λ and the photoelectric work function of the particle W:

$$V=(hc/\lambda-W)/e$$

where e is the elementary charge. For work functions varying from 2.9 (calcium) up to 4.8 (carbon) and focusing on short wavelength, grains can reach a potential from 0 to 10 V.

Interestingly, some of the grains collected by COSIMA have been lifted after an electrical potential was applied to them for analysis, and particularly, they were more affected when applying a negative potential, leading us to assume that these grains were positively charged. However, one has to be careful in the interpretation of the dust charge as the spacecraft itself could induce charging of grains.

Solar wind ions implantation: Irradiation of the grains by solar wind ions can result in radiolysis in the icy cometary dust in the coma. Ionization of a water ice grains leads to the formation of H^+, H_2O^+, OH^+ and electrons which then recombine to form new species such as H_2O_2 [6] [7]. This process is quite slow, as an example, the typical timescale for dissociation of H_2O by plasma ions is less than 3 years given solar fluencies between 3 and 5 AU [6].

The porosity of the grains is significant on the ability of forming new species as O, H and OH can escape the solid phase and be trapped in the pores where they can react to form new species.

Influence on grain properties on efficiencies of the above mentioned processes: We aim to explore experimentally the different processes mentioned above for a better understanding of the grain alteration in conditions relevant to the coma of 67P/C-G. Size, porosity and initial composition of the ice are relevant parameters that can influence the charge of the grains, the nature of the chemical reactions that takes place in the ice as well as the timescale of reactions. We aim to distinguish processes that can be neglected and processes that need to be taken into account for the interpretation of COSIMA mass spectra for the families of grains collected so far, i.e. grains of typical sizes ranging from 14 to a few hundred of microns with varying structure (flocculent vs. compact).

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