Electron ionization of (doped) He nanodroplets: anions, cations and multiply charged species

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Low-mass cations and anions (m<50kDa) formed upon electron bombardment of pristine and doped He nanodroplets (HNDs) were investigated utilizing high-resolution mass spectrometry. With an electrostatic sector-field massive charged HNDs containing up to 10^7 He ions were also analyzed. The formation of various charged or excited species inside the HNDs were identified, i.e., electron bubbles, metastable He*, He^{*-} [1] and He^+. For large droplets and/or high electron currents often two or more of these species can be formed inside one HND and interact with one another. Coulomb repulsion between charged species with the same polarity is expected to lead to the ejection of one of them from the HND. Ion-induced dipole interactions between He* and He^{*-} lead to the formation of He^+ at electron energies below 20eV, which is below the ionization energy of a free He atom [2]. This surprisingly low threshold energy for the formation of He^+ from HNDs was already reported in 1991 by Buchenau et al. [3]. The interaction of the primary charged and/or excited species with dopants inside or on the surface of HNDs provides a wide range of product ions, both positively and negatively charged. The formation of dications from doped HNDs can be explained via sequential Penning ionization [4] or the collision of He^{*-} with a positively charged dopant. He^{*-} is highly mobile [1] and provides, besides a loosely bound electron (He* has an electron affinity of 77meV), a potential energy of 19.7eV, enough to positively ionize all dopants but Ne. Efficient formation of fullerene (cluster) dianions from HNDs doped with C_{60} and C_{70} has been observed and has been assigned to a concerted double electron transfer from He^{*-} [5]. Chemical reactions in heterogeneous dopant clusters driven by the charged and electronically excited species listed above have been studied. For mixed hydrogen-oxygen clusters only the formation of very few water molecules has been observed. However, a dopant cluster consisting of metal atoms and halogen- or oxygen-containing molecules is transformed into a salt nanocrystal with almost perfect stoichiometry [6]. Excess reactants of any kind are simply evaporated and do not show up in the mass spectra.

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