High Resolution Electron Attachment to Water Clusters in Helium Droplets

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Synopsis: We have determined the resonance energies for free electron (up to 3eV) attachment to water clusters embedded in helium droplets. In comparison to pure water clusters, shifts and broadening of the resonance features were observed, which shows a pronounced dependence on the water cluster anion size.

Hydrated electrons are of importance in fusion reactions, water droplets in the atmosphere, and living tissue [1]. In a supersonic expansion experiment, it was shown that free electron attachment to water clusters forming $(H_2O)^-_n$ anions with n ≥ 11 that are detectable by mass spectrometry were achieved [2]. In contrast, we previously studied electron attachment to $(H_2O)_n$ with n ≥ 2 in helium droplets using a standard energy source with a resolution of around 1 eV [1]. The maximum of the resonance of low energy electron attachment to water clusters in this experiment was reported at 1.5 eV, which is shifted in comparison to that in the gas phase [1]. This is due to the fact that the projectile electron loses energy to penetrate the helium droplet. After penetration, the electron creates a bubble and moves freely in the superfluid helium droplet. In the case of pure helium droplets, the resonance of the electron capture by helium droplets has a maximum at 1.8-2.3 eV with a threshold at 1.26-1.32 eV, depending on the helium cluster size [3]. In the presented work, we studied electron attachment to water clusters in helium droplets using a high resolution electron beam (100 meV) formed by a hemispherical electron monochromator.

In the conducted experiment, precooled (9-11K) He gas at a pressure of 20 bars expands through a 5 µm nozzle into vacuum in a supersonic expansion. This further decreases the temperature of the He, creating helium nano droplets that are skimmed to a beam. The beam passes through a pick up cell containing water vapor. Water molecules are picked up and cooled down in the He droplet which leads to the formation H_2O^- clusters inside the He droplet. The electron beam crosses the doped helium beam. Formed $(H_2O)^-_n$ anions are selected using a quadrupole mass spectrometer and detected in a channel electron multiplier.

In contrast to the previous measurements, which have much less accuracy in terms of energy beam [1], we observe a sharp resonance for $(H_2O)^-_2$ with a threshold at 0.92 eV, a maximum at 1.14 eV and a full width at half maximum (FWHM) of 250 meV (see Figure 1). This results in a more precise value for the electron surface barrier of the helium droplet.

Measurements of electron attachment for different water cluster sizes in helium droplets were acquired. The resonance for $(H_2O)^-_3$ showed a maximum at 1.26 eV, shifted from that of $(H_2O)^-_2$. In addition, a structure appears at the high energy side broadening the peak. Shifting and broadening of the resonance continues as size of the $(H_2O)^-_n$ increases, for which $(H_2O)^-_{16}$ is shown as an example (see Figure 1).

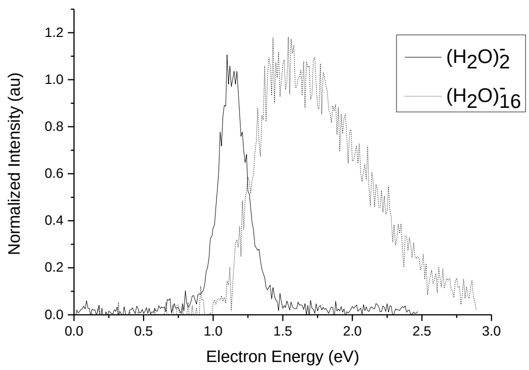

Figure 1. The ion yield of $(H_2O)^-_2$ and $(H_2O)^-_{16}$ clusters formed upon electron attachment to water clusters in helium droplets.

This work was supported by FWF (P24443).

References:

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