Electron induced reactions in nucleobase/water clusters

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In recent years there has been a significant interest in the understanding of damage processes of DNA, also induced by low energy electrons. It has been suggested that ionizing radiation releases a large number of secondary electrons in cells. These electrons achieve kinetic energies in the range of up to few of tens of eV [1, 2]. In this energy regime electron ionization and electron attachment processes may cause chemical transformation of biological matter. The studies by Sanche and co-workers [3, 4] demonstrated that these low energy electrons can induce single and double strand breaks in a film of plasmid DNA upon dissociative electron attachment (DEA). In DEA an electron attaches resonantly and the transient negative ion formed may decay via dissociation of the molecule. This dissociation can be fast and often has only spontaneous electron emission as competitive channel. A large number of studies on electron ionization respectively electron attachment to various simple biomolecules (e.g. DNA bases, sugars, amino acids) in the gas phase have been carried out [5, 6]. Thereby, it turned out that biomolecules often substantially decompose upon electron collisions. In addition, DEA is a very bond and site selective process, i.e. only certain bonds are cleaved in a molecule after capture of an electron with specific kinetic energy [7].
However, for applications in radiotherapy it is highly important to understand how the fragmentation process of biomolecules is modified by surrounding environment. For example, it was shown that electron attachment to nucleobases embedded in helium droplets is strongly modified in terms of the molecular fragmentation pattern compared to the isolated molecule [8, 9]. In this case extensive and slow fragmentation processes have been quenched effectively in the droplet, while direct dissociations via repulsive potential energy surface upon DEA remain.
The studies with doped helium droplets represent a very first approach to investigate the effect of environment. Therefore, in the present study we use clusters of water (the main component of living cells) as a more realistic environment to study electron interaction with a biomolecule when the biomolecule is placed in a water cluster. In order to understand the influence of the water matrix on electron ionization/DEA to a biomolecule we recently developed a new cluster source. Details on development, implementation and first results of electron induced reactions in pure water clusters and mixed nucleobase/water clusters will be presented.

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