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Water as a safeguard of biomolecules

Scientists in the J. Heyrovský Institute of Physical Chemistry in Prague have introduced a new experimental technique which enables studies of biomolecules in vacuum, surrounded by just few molecules of water. For more than 20 years people were attempting to achieve this – molecular beam of 'microhydrated' biomolecules. However, all the previous methods generated at the best a mixture of biomolecular aggregates (clusters) and mixed biomolecule-water clusters. The newly introduced method allows the study of single hydrated biomolecule with well controlled number of water solvent molecules. This represents an experimental breakthrough.

The need for such technique arises from a quest to understand a molecular mechanisms of radiation damage to biological tissue (that results in, e.g., cancer). Naturally, the most common way of studying such damage is in a biological solution. However, there, many of the details about the radiation damages to DNA on the smallest – molecular – scale remains hidden, because many processes are running simultaneously and their effects are overlapping. The second extreme experimental approach is to look at isolated molecular components of DNA in vacuum and to determine how they are destroyed by various radiations. This approach provides the most detailed insight but completely neglects how the surrounding (in biological tissue mainly water) influences such destruction.

The newly introduced method bridges the gap between the two extreme approaches. Using it, the damage of the molecules can be studied in the deepest detail, but simultaneously taking into account the influence of an elementary water environment. The first results obtained at the Heyrovsky Institute focus on the destruction of nucleobases by slow electrons. Slow electrons are one of the most abundant secondary species formed during interaction of high-energy radiation with living matter. The nucleobases are components of DNA and carriers of the genetic code. When isolated, they are very effectively damaged by slow electrons via a process called dissociative electron attachment. The present work shows that already presence of a few water molecules around the nucleobases stabilizes these molecules – upon the collision with the electrons, the base does not break into fragments but rather forms stable negative ion. The water thus forms a cage that prevents the nucleobases to fall apart.

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Microhydration Prevents Fragmentation of Uracil and Thymine by Low-Energy Electrons
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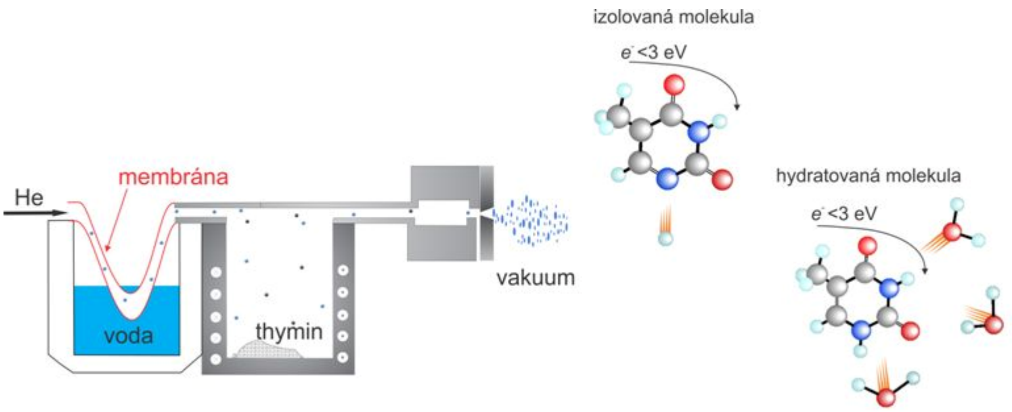
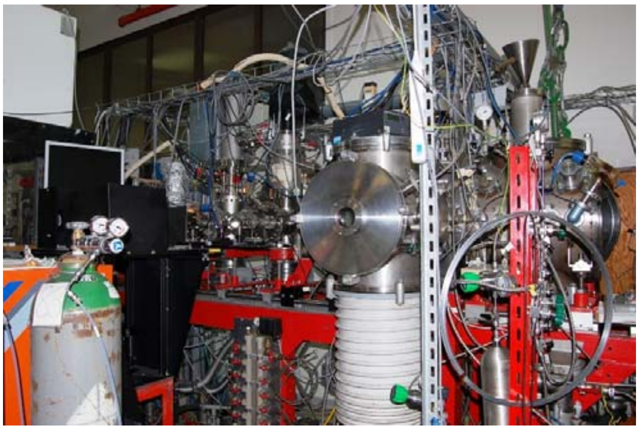
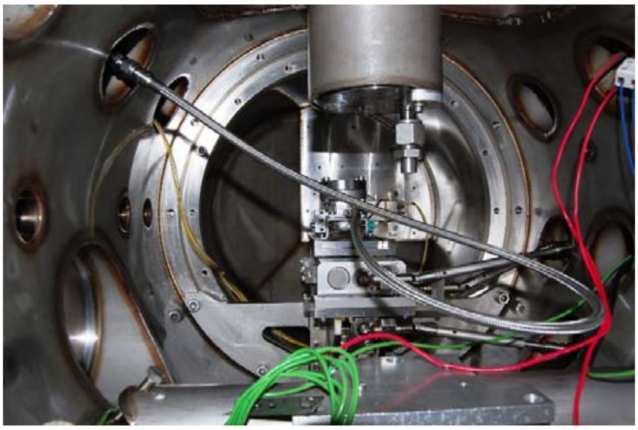
Pictures



The new experimental approach to study micro-hydrated molecules revealed a protective effect of water in the interaction of nucleic acids with electrons. The results are important for understanding the radiation induced DNA damage, where the secondary electrons represent the most abundant reactive species.



CLUB apparatus at the J. Heyrovský Institute of Physical Chemistry, used in the experiments with micro-hydrated molecules.



The source of micro-hydrated molecules - detail.