

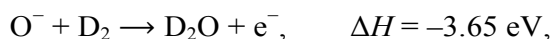
Reactions of O^- with D_2 at low temperatures 10 – 300 K

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Synopsis The reaction of O^- anions with molecular deuterium D_2 has been studied experimentally using a cryogenic 22-pole radiofrequency ion trap. There were observed two reaction channels. In the associative detachment D_2O is formed and for atom transfer formation $OD^- + D$ was observed. The rate coefficients of the reactions have been determined at temperatures ranging from 10 K to 300 K.

The reaction of O^- with D_2 has two exothermic channels corresponding to associative detachment and deuterium atom transfer



Energetically possible are also reactions leading to the formation of metastable D_2O^- anion in three body or radiative association. However these processes have not been detected experimentally. Studies of gas-phase processes involving water and especially those leading to isotopic fractionation [1] is essential for understanding of the water formation in the Universe.

The reactions were studied using a 22-pole radiofrequency ion trap. It was mounted on a cryo-cooler in an ultra-high vacuum system. The measuring procedure was based on iterative filling of the trap with a well-defined number of primary ions O^- where they react with molecular deuterium. The content of the trap were analyzed after chosen times using a quadrupole mass spectrometer and a micro-channel plate detector. Further detail may be found in [2] and references therein.

We studied previously analogous reactions involving O^- and H_2 . At first we measured electron energy spectrum originating from associative detachment [3] at 300 K. Later on we studied both reactions using the 22-pole ion trap [4].

Very interesting dependence on temperature is shown on Figure 1. Up to now the associative detachment has been measured mostly at temperatures higher than 300 K and the observed reaction rate coefficient was about $\frac{1}{3}$ of the Langevin rate. It is explained by the fact that trajectories on only one of three electronic surfaces of the collision system can lead directly to autodetachment.

At lower temperatures we observed unexpectedly high value of the associative detachment rate coefficient. Theoretical model in our paper [4] for the reaction $O^- + H_2$ explained this behavior by rearrangement of the collisional system in a shallow local minimum. The increase of the reaction rate coefficient at low temperatures is in qualitative agreement with the theoretical predictions. The presented data will be compared with classical trajectory simulation model. An isotopic effect will be evaluated.

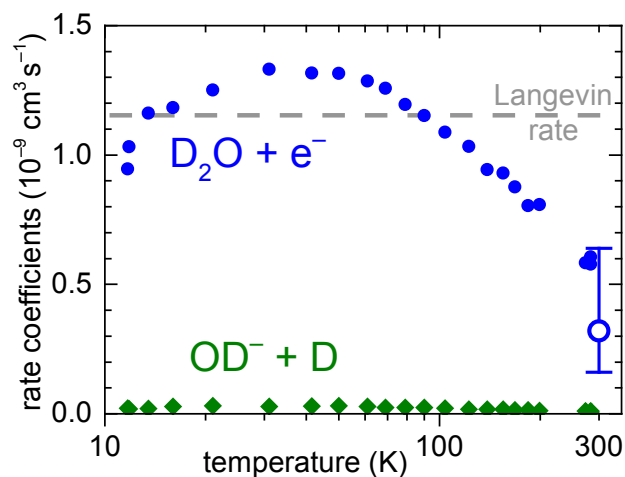


Figure 1. Measured temperature dependencies of the reaction rate coefficients for both channels of $O^- + D_2$ reaction. The open circle indicates results of our previous experiment [4].

We thank the TU Chemnitz, the DFG and prof. D. Gerlich for lending us the apparatus. Supported by GACR 15-15077S and GACR 17-18067S.

References

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