Formation of positive and negative ions in the gas phase of D-ribose by low-energy electrons

Formation of positive and negative ions in the gas phase of D-ribose by low-energy electrons

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Synopsis Using a hypocycloidal electron spectrometer the total dissociative electron attachment cross section and the ionization cross section for D-ribose molecule were studied in the E<30 eV energy range. A clear structure near zero energy and in the 6.0–9.5 eV range is observed in the dissociative electron attachment cross section. These features appear due to the formation of negative ion fragments of the molecule. The ionization potential of the D-ribose molecule was determined at 9.74 ± 0.02 eV. In the total ionization cross section weak features are observed, which most likely due to the formation of positive ion fragments of the initial molecule.

D-ribose ($C_5H_{10}O_5$) belongs to monosaccharides, the most abundant group of biomolecules, with five C atoms. This molecule is a part of the building blocks that form DNA and RNA molecules. D-ribose is also contained in ATP and NADH, which are critical for the metabolism. Here we report on the results of our studies on the total cross sections for the production of both positive and negative ions of the D-ribose molecule by slow (<30 eV) electrons.

In our experiments, a hypocycloidal electron monochromator [1] was used to produce an electron beam with at least 0.2 eV energy resolution. The ribose powder (Sigma-Aldrich, 99% purity) placed into a quartz ampoule was heated up to ~80ºC in a stainless-steel reservoir, filling thus the gas cell (at P≈10^{-3}Torr). The produced ions were extracted to the collector mounted perpendicularly to the electron beam direction. A low negative potential was applied to the collector for detecting the positive ions, while for the negative-ion detection its polarity was changed to positive.

Figure 1 shows the total cross section of dissociative electron attachment to D-ribose molecule measured at 80ºC in the 0.00–11.00 eV electron energy region. An intense peak near zero energy and two lower-intensity maxima in the range of 6.00–9.50 eV can be observed. Based on the results of Ref. [2] we assume that the observed features appear due to the formation of $C_5H_8O_4^-$, $C_5H_6O_3^-$, $C_4H_5O_3^-$, $C_3H_4O_2^-$, $C_3H_3O_2^-$, $C_2H_3O_2^-$ and OH^- ion fragments.

We also measured the total ionization cross section for the ribose molecule within the energy range from the threshold up to 28 eV. The ionization potential was determined at E_i = 9.74 ± 0.02 eV. The thorough measurements confirm that the observed weak features in the ionization curve are to be related to the formation of positive ion fragments of the initial molecule.

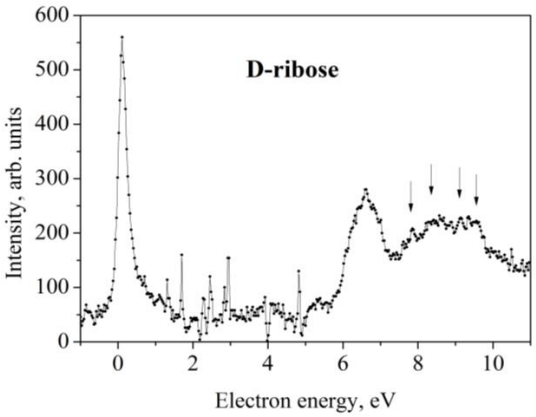

Figure 1. The total dissociative electron attachment cross section for the D-ribose molecule measured by slow electrons.

References

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