

Highly charged ion impact on uracil: Cross sections measurements and scaling

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Synopsis Absolute total ionization cross sections (TCS) of uracil in collisions with highly charge C, O and F ions are measured. The scaling properties of cross sections are obtained as a function of projectile charge state and energy. The measurements are compared with the CDW-EIS, CB1 and CTMC calculations. The absolute double differential cross sections (DDCS) of secondary electron emission from uracil in collisions with bare MeV energy C and O ions are also measured. Large enhancement in forward emission is observed.

The collision of highly charged ions with large molecules is an area of growing interest. These studies provide insight on fundamental many body interactions. Uracil ($C_4H_4N_2O_2$) is a nucleobase of RNA. In the hadron therapy, the ion loses energy continuously and therefore the detail study of the collision products over wide energy range is necessary.

We have measured total cross sections of uracil in collisions with keV to MeV energy highly charged ions [1-3]. The ions were produced in ECRIA (keV) [4] and Pelletron (MeV) accelerators. Uracil powder was heated in an oven. Flow rate of the molecules was monitored in situ. Collision products were analyzed by a recoil ion time-of-flight mass spectrometer in coincidence with ejected electrons. In low energy region (keV), the cross sections increase with projectile energy and then fall sharply in MeV energy range. The measurements were compared with the CDW-EIS, CB1 and CTMC-COB models. The comparisons show a qualitative agreement in the MeV energy range. The cross sections were found to be independent of projectile nuclear charge.

The scaling properties of the cross sections with projectile charge states (q_p) and energy (E_p) can be very useful for radiation damage calculations. Scaling was obtained for MeV energy ions. The cross sections were found to be scaling with $q_p^{-1.5}$ and $E_p^{(-0.75)}$ [5].

Heavy ion impact causes severe damage to DNA and RNA bases inducing the single and double strand break. The secondary electrons produced in these interactions (also known as δ -electrons) are the major source of damage. A

quantitative study of such electrons produced is necessary to understand the microscopic details of the secondary electron emission.

We have studied secondary electron emission from uracil, in collision bare carbon and oxygen ions with MeV energy [6]. The low energy electron spectroscopy is a challenging task. We have measured the absolute e^- DDCS of uracil between 10-600 eV, in an angular range of $30^\circ - 150^\circ$ in steps of 15° . A hemispherical electrostatic analyzer setup was used.

The e-DDCS falls sharply with the electron energy making the contribution of the low energy electrons dominant in the secondary electron emission. For low energy electrons the angular distribution of e-DDCS shows that the cross sections are much higher in the forward angles in comparison to backward angles. The angular distributions are compared with that of the small molecule O_2 [6].

The experimental measurements are compared with the quantum mechanical CDW-EIS model. The sharp fall is although qualitatively reproduced. Given the complexity of the molecule, the comparisons of the absolute values as well as the trends are encouraging. However the discrepancies are observed in angular distributions. The details will be presented.

References

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