Electron emission from water molecule in collisions with fast highly charged C, O and Si-ions and scaling law

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Synopsis Double differential cross sections (DDCS) of vapor phase water molecules by similar velocity C^{6+}, O^{8+} and Si^{13+} ion impact have been measured by the electron spectroscopy technique. The total ionization cross sections (TCS) were obtained by numerical integration of the DDCS results. All the existing data have been plotted after scaling. Gradual deviation of the TCS from the first Born predicted q_p^2 –scaling has been observed.

Study of electron emission from water molecule is especially relevant because of its importance in fundamental problems in radiation biology and radiation therapy [1]. So it is important to study differential cross section of emitted electrons from water molecule for interaction with highly charged high-velocity projectiles.

Several experiments have been carried out to study ionization of biological molecules bombarded with high-velocity ions. But when it comes to the measurement of differential cross sections, literature is not so vast and most of the existing results are for light projectiles like e^-, H^+ or $He^{1+,2+}$.

In the present work, we have measured the double differential cross section (DDCS) of emitted electrons for the collision of 4 MeV/u C^{6+}, Si^{13+} and 2.00 - 3.75 MeV/u O^{8+} ion beams with the water vapor target. The DDCS measurements were done using electron spectroscopy technique- based on a rotatable hemispherical e.s. analyzer to detect low energy electron in an angle resolved manner. We have compared our experimental results with the CDW-EIS model (both prior and post versions) calculations. The comparison shows an overall good agreement with the data for C and O for which perturbation strength (S_P) is low. For H-like Si ions for which the S_P is larger the model overestimated the experimental results. Another interesting aspect is the better agreement for O-projectile compared to the C-data wheras the C-projectile is used in hadron therapy.

Using the experimental DDCS data we have, by integration, obtained the single differential cross section (SDCS) and the total ionization cross section (TCS). In order to obtain a scaling law for the TCS data we have plotted the scaled total cross section (TCS/q_p^2) as a function of the projectile velocity. We have compared our present results with other existing results (like H^+ [2-4], He^{2+} [5,6] and C^{6+} [7]) including the 6.0-MeV/u C^{6+} data [6]. Existing data of light projectiles like H^+, He^+ or He^{2+} show a good agreement with the q_p^2 dependence. But clear deviation can be seen for C^{6+}, O^{8+} or Si^{13+}. These data suggests a q_p^n dependence where n is found to be 1.7 ± 0.1 which is different from that obtained for uracil earlier, for which the n was found to be 1.5.

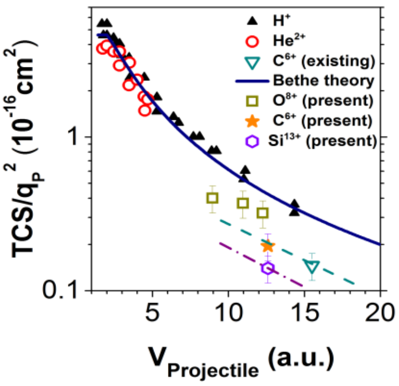

Figure 1. The projectile velocity dependence of scaled TCS i.e. TCS/q_p^2 for different projectiles.

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