Topic number: 1

LOW ENERGY H$^-$ PRODUCTION BY DISSOCIATIVE ELECTRON ATTACHMENT TO ETHANE AND ETHENE MOLECULES

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Light hydrocarbons are common constituents of fusion edge plasma in tokamaks with carbon walls. Hydrocarbons are also expected to be one of important impurities in new tokamaks with all metal walls. Therefore, it is needed to know the processes involving these molecules for the corresponding plasma modeling and also for understanding of carbon deposit formation. We have recently developed a system for efficient detection of hydrogen negative ions (H$^-$ and D$^-$) [1] and here we present experimental results on low energy H$^-$ production by dissociative electron attachment (DEA) in ethane (C_2H_6) and ethene (C_2H_4).

Dissociative electron attachment to chlorinated light hydrocarbons was rather extensively studied (e.g. [2]) due to their importance for environmental issues but there is less results on such studies for pure HC. One of the reasons for this is also the detection incertitude of light H$^-$ ions characteristic to some of common experimental set-ups. Some information on DEA, being a resonant process proceeding through a negative ion compound state, can be gained by studying resonant elastic or inelastic scattering of electrons (e.g. [3]). However the resonant compound negative ion stabilization occurs usually on a very different way for the two processes so that the information gained from resonant scattering is only complimentary for the interpretation of DEA.

Our new ion detection system [1] was developed particularly for detection of very low energy hydrogen ions in order to use DEA for vibrational spectroscopy of electronic ground state of neutral hydrogen molecules (H_2 and D_2) (e.g. [4]). A combination of electrostatic extraction field and homogeneous magnetic field is used to achieve narrow ion transmission function for zero energy ions having FWHM about 140meV. Low resolution electron beam was used in the present work having full thermal distribution of the electron energy. Although the energy distribution is broad it is accurately known due to the construction details of the electron gun.

Normalized ion yield for H$^-$ form C_2H_6 is shown in figure 1 by open triangles. Normalization was performed so that experimental ion yield is divided by the total electron beam current and gas pressure as read by ionization gauge and corrected for gas sensitivity factor. Ion gauge was also calibrated against absolute capacitance manometer by linear extrapolation from higher pressure where working ranges for both instruments overlap to the lower pressure at which data were taken. Shown normalized ion yield is thus proportional to the cross section for low energy H$^-$ production. Normalized ion yield for H$^-$ from H_2 (peak at 4eV) is also shown in the figure represented by full circles. Fitted curve (dashed line) obtained by convolution of accurate theoretical cross sections [5] by electron energy distribution and ion extraction efficiency is also shown (for details see [1]). This fit is used to determine ion extraction efficiency and also to establish accurate energy scale. The signal due to H$^-$ from DEA to the residual H_2O from the background vacuum (not shown) is subtracted from both experimental ion yields.

Normalized yield of H$^-$/C_2H_6 can be well fitted by the sum of two Gaussian peaks shown as a full line in figure 1. First peak is centered at 9.18 eV and has 1.07 eV width while the second, broader one is at 9.89 eV having 2.59 eV width.

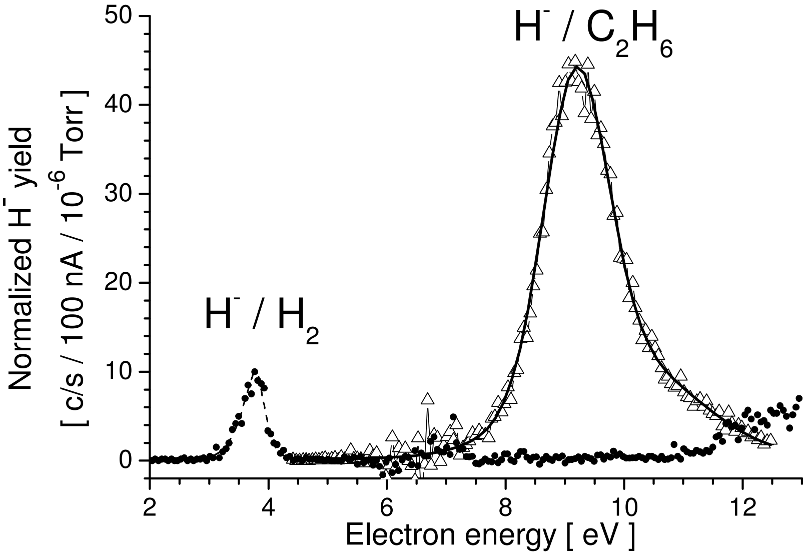

Fig. 1: Normalized yield of H^- from H_2 (full dots) and from C_2H_6 (open triangles). Relative yield height for the two cases is due to the relative production cross section for low energy H^- ions.

Hydrogen ion yield curve for C_2H_4 exhibits three peaks positioned at 7.73 eV, 9.06 eV and 10.63 eV. The third peak is the highest and about 50% higher than 4eV H^-/H_2 peak.

Reference

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