A NOVEL APPROACH TO MEASURING INELASTIC DIFFERENTIAL CROSS SECTIONS FOR ELECTRON-MOLECULE COLISIONS

I.R. LeClair, S. Trajmar, M.A. Khakoo, and J.C. Nickel

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, 91109, USA
1 Department of Physics, California State University, Fullerton, CA, 92634, USA
2 Department of Physics, University of California, Riverside, CA, 92521, USA

The absolute measurement of inelastic differential cross sections (1\(^2\)CS's) for electrons scattering from atoms and molecules presents a problem especially in the determination of residual energy. It usually requires a precise determination of the instrument response function (IRF) and the scattering geometry, which are difficult to obtain at best. Electron beam properties and the IRF are sensitive to surface conditions, electric and magnetic fields, etc. Even when it is possible to get that information, it is susceptible to drift which can occur during the long times mm-way to acquire data.

Presently, the most commonly accepted calibration procedure goes as follows. Measure relative scattering intensities associated with various channels. 'Then, apply some corrections to these intensities based on some relative \(^1\)\(^1\)CS's. Finally, calibration to the absolute scale is achieved by using a known absolute cross section as a standard. The difficulty in this procedure is to establish a condition under which the dependence of the IRF on the residual energy of the scattered electrons is known. Moreover, the IRF at one impact energy must be related to another impact energy. So far, no rigorous method for overcoming this difficulty is available in practice. A recent discussion of these matters has been given by Trajmar and McConkey.

We are presently investigating a new approach to this problem. In this new approach, the conventional hemispherical (or cylindrical) electron energy analyzer (detector) is replaced with a specially constructed field free drift tube. The tube is terminated with a 40 mm diameter multi-channel plate configured to detect electrons. Time-of-flight (TOF) spectra of electrons scattered from the target molecule are obtained (at fixed impact energies and scattering angles) by pulsing the incident electron beam. The incident beam is produced by an unelected electron gun with an energy distribution of approximately 0.4 CV.

The inelastic to elastic scattering intensity ratios obtained from the TOF spectra represent the corresponding DCS ratios. Under proper conditions, these intensity ratios should be independent of residual energy, impact energy, and the scattering geometry. 'Rem well established elastic DCS's once then obtains inelastic DCS's. These can serve as secondary standards for normalizing relative inelastic DCS's obtained with a conventional electron energy analyzer in crossed-beam experiments over some range of energy loss.

Our preliminary results with CO and 1\(^1\)\(^1\)CO are promising. A sample TOF spectrum from CO (Figure 1) shows the elastic scattering (-1 33 ns) and a\(^1\)\(^1\)CO state excitation (200-300 ns) features. The vibrational levels cannot be resolved with the present setup. From figure 1, the intensity ratio of the a\(^1\)\(^1\)CO feature to the elastic peak is 0.18 \(\pm\) 0.02, which is in good agreement with the recent measurements of Zobel et al.

\[ \begin{align*}
\text{Intensity (arbitrary units)} & \quad \text{time-of-flight (ns)} \\
100 & \quad 125 \quad 150 \quad 175 \quad 200 \quad 225 \quad 250 \quad 275 \quad 300
\end{align*} \]

Figure 1 TOF spectrum of 9.0 eV electrons scattered from CO at 90\(^\circ\). Note the factor of 10 magnification applied to the data over 175 ns.

This work is being carried out at JPL/Caltech and is supported by NASA.

References

1. S. Trajmar and J.W. McConkey in Advances in Atomic, Molecular, and Optical Physics, in press.