Chapter 5

Conclusions and Future Work

A new design for a crossed electron-molecular beam apparatus featuring a skimmed supersonic gas source, in place of the more traditional effusive gas source, has been presented. In order to place the DCSs measured using the present apparatus onto an absolute scale, a new normalisation technique (SSRDM) that is applicable to supersonic gas beams was also developed. Measurements of the DCS of several stable molecules, using the SSRDM normalisation, were presented and all those results were consistent with previous measurements which used effusive gas beams.

Elastic electron scattering DCSs, at incident energies between 25-50 eV, for the CF_2 radical have also been measured and presented here. These measured cross sections were compared to results from theoretical calculations which were available in the literature, namely an ISVM calculation [32], and a SEP calculation [13]. Reasonable agreement was seen with the DCS of both these theoretical results over the entire energy range studied, with the present measurements somewhat favouring the ISVM results over the SEP results. Neither calculation completely overlaps with the present measurements at all energies and angles studied, however, with both the calculated DCSs exceeding the magnitude of the present results in the backward scattering region. These discrepancies are primarily attributed to the degree of sophistication with which the various calculations handle the description for the polarisation of CF_2.

ICSs and MTCSs were derived from the DCS measurements and presented for elastic electron-CF_2 scattering, between 25-50 eV. These results were compared to four theoretical ICSs and MTCSs, all of which were consistent with the present measurements at all common energies investigated. Most notably, the ICS and MTCS from the least computationally taxing approach, a SE calculation, compared very favourably to the present measurements in this energy region. This is a significant finding for those people looking to model plasma reactor behaviour.

The present measurements now need to be extended to lower energies where resonances in the elastic channel are predicted to occur. All four calculations predict two shape resonances at energies <20 eV. While the theoretical results are in good agreement with each other in the non-resonant energy regions, there are significant discrepancies regarding both the position and amplitudes of these resonances between all four calculations. Therefore an experimental investigation of the elastic scattering within the energy regions of these resonances is necessary to provide some clarification.

Just prior to the submission of this thesis, some of the issues with the low energy operation of the electron monochromator were determined to be due to an oversight in the design of the cylinder lens stack. In essence the final set of deflectors ($D6$) were not adequately shielded from $L4$ by an aperture, whereas apertures were located on either side of all the other relevant deflector sets so that the potentials placed on the deflector did not disturb the lensing of the electrons. A grounded 3 mm aperture was therefore located prior to $D6$ to correct this flaw and, following this change, the electron monochromator immediately produced stable and intense electron beams with energies as low as 2 eV. While this flaw did not affect the operation of the electron monochromator at the intermediate energies studied in this thesis, the energy range that was studied was restricted. Hence, resolving this flaw is a very encouraging result for future experiments conducted with the present apparatus.

The apparatus developed for this research is now fully commissioned, however, there are one or two further technical developments required for the full potential of the system to be realised. The major issue with the present design is the inability of the TOFMS to detect species with a first ionisation threshold >10.48 eV, such as with CF_2. For the present measurements this was not a significant issue, since C_2F_4 has only one decomposition pathway up to temperatures where the decomposition is ∼100%. Nonetheless, future experiments with different precursors, which may have multiple dissociation pathways, will require that all of the species within the molecular beam can be detected. Therefore, the photoionisation source should ultimately be replaced by an electron impact ioniser, that can be continuously varied in energy, to cater for species whose ionisation energy is in excess of 10.48 eV.