SF₆ DIELECTRIC MOLECULES: ELECTRON SCATTERING DYNAMICS AND POSSIBLE APPLICATIONS

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Abstract: Electron scattering dynamics have been investigated experimentally for the energy range of 0.8-1000eV, using an absorption type time-of-flight apparatus. The elastic process has been also studied theoretically using the continuum multiple scattering method. The present cross section results are found to reasonably agree with the previous similar results by other groups in the energy region we overlap. Peaks have been observed at 2.5, 7.0, 12.0 and ~30 eV and attributed to the $a_{1g}$, $t_{1g}$, $t_{2g}$ and $e_g$ resonances studied by Dehmer et al.

1. INTRODUCTION

SF₆, sulfur hexafluoride, is a man-made gas, and now is one of the most widely and extensively used gases for commercial and research applications. Therefore, its various physical and chemical properties, and dynamical behavior under various application conditions have been broadly studied. However, it is also now known as one of the most serious greenhouse gases since it is an efficient absorber of infrared radiation at wavelength near 10.5 μm, and is solidly stable in chemical and photolytic reactions and hence, stays permanently once released in air. Hence, concerns over its environmental impact have newly acquired interests for more comprehensive study of this gas.

Earlier studies on the dynamical aspects of this molecule include, total cross section measurements by electron and positron impact by Dababneh et al., electron impact by Kennerly et al., Kasperski et al., and electron attachment studies by Spence and Schulz. Phelps and Van Brunt have compiled a lot of available data on electron impact, and published a large set of cross section data for a wide range of energy from 1 meV to 1 keV.
2. EXPERIMENTAL AND THEORETICAL PROCEDURES

2.1 Experimental

The apparatus used for the total cross section (TCS) measurements investigated here is a linear transmission type time-of-flight (TOF) with a 600 mm path length. Details about the apparatus and procedure can be found in our earlier report. Only a few characteristics are highlighted here. A $^{22}$Na radioisotope with an activity of 90 $\mu$ Ci was used for the beam source, with the slow electron beams, of energy width of around 1 eV (FWHM), being produced as secondary electrons resulting from multiple scattering from the tungsten moderator.

In this experiment a magnetic field is used for beam transportation. Hence, a forward scattering correction is necessary for the measured TCS values. Details about the simulation method for this correction have been published elsewhere. The correction for these TCSs for electron scattering was carried out using the differential cross sections of Srivastava et al. and Sakae et al.

The TCS values, $Q_t$, are given as

$$Q_t = (-1/nl) \ln(I_g/I_v),$$

where $n$ and $l$ are gas density in the collision cell and the effective length of the collision cell. $I_g$ and $I_v$ are the beam intensities in the gas run and the vacuum run, respectively. The independence of TCS values on the cell pressure was ensured for electron collision. As shown in Figure 1(a), no systematic variation showing the pressure dependence of TCS is observed.

2.2. Theoretical

The theoretical approach employed is the continuum multiple-scattering (CMS) method, which is a simple but efficient model for treating electron scattering from polyatomic molecules. The scattering part of the method is based on the static-exchange-polarization potential model within the fixed-nuclei approximation. The Schrödinger equation in each region is solved numerically under separate boundary conditions, and by matching the wave functions and their derivatives from each region, we can determine the total wave functions of the scattered electron and hence, the scattering matrix. The