Low-Energy Electron-Induced Chemistry of CF2Cl2: Implications for the Ozone Hole?

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We report on the first direct investigation of the low-energy electron-induced production of neutral species from the chlorofluorocarbon CF_2Cl_2, commonly known as Freon-12 or CFC-12. Our experiments were motivated by a newly proposed hypothesis, which suggests that low-energy electrons produced by cosmic rays, in addition to UV-vis photons from the sun, interact with chlorofluorocarbons to produce chlorine atoms that subsequently destroy ozone in the Antarctic. Our experimental procedure involves low-energy(5-100 eV) electron irradiation of nanoscale thin films (~10 Å thickness) of CF_2Cl_2 grown at 100 K on a molybdenum single crystal in an ultrahigh vacuum chamber ($p \sim 1 \times 10^{-10}$Torr). Post-irradiation temperature-programmed desorption experiments were used to identify $C_2F_4Cl_2$, $C_2F_3Cl_3$, $C_2F_2Cl_4$, C_2F_3Cl, $C_2F_2Cl_2$, and C_2F_4 as electron-induced radiolysis products of CF_2Cl_2. In contrast to previous studies of photon-induced dissociation, our studies of electron-induced dissociation demonstrate facile C-F bond cleavage in CF_2Cl_2.This finding may have implications for understanding the partitioning of Cl and F among source, sink, and reservoir gases in the stratosphere.