THE OXIDATION OF HYDROGEN CHLORIDE IN ELECTRODELESS RADIOFREQUENCY DISCHARGES

Raymond F. Baddour and D. F. Flamm

Department of Chemical Engineering
Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

A study of the oxidation of Hydrogen Chloride in electrodeless glow discharges between 3.75 and 150 torr is described. A cylindrical quartz reactor was used at 2450 mHz in a tapered waveguide section. Other work done at 7 and 20 mHz used cylindrical vessels with external sleeve electrodes and pillbox-shaped reactors with external electrodes painted onto the flat top and bottom surfaces. Power at 20 mHz was coupled from a self-excited oscillator through a coupling coil in the tank and at 7 mHz a helical reasonator was used.

For sufficiently high driving frequencies there is not sufficient time during a cycle for electrons to be swept to the walls of a discharge reactor. Electron loss is then controlled, in a non-attaching gas, by diffusion. For a constant electron momentum collision frequency ν_m, the average power input per unit

$$P = \frac{n_e e^2 E_o^2}{2m\nu_m} \frac{\nu_m^2}{\omega^2 + \nu_m^2}$$

and likewise the electron energy is given by

$$E = E_{dc} - \frac{k\nu_m}{2\omega} E_{dc} \sin 2\omega t$$

where

$$E_{dc} = \frac{e\mu E_o^2}{2k\nu_m}$$

is that energy obtained in a d.c. electric field of magnitude equal to the a.c. R.M.S. value and where ω is the frequency of the applied field, k is the average fraction of energy lost per collision and is assumed constant, m is the electron mass, and E_o is the peak applied field, and μ is the mobility.

The behavior is explained by the balance between electron attachment and detachment processes in the different regions of the discharge.

Limited data were also obtained on the reverse reaction

$$H_2O + Cl_2 = 2\,HCl + \frac{1}{2}O_2$$

which gave some evidence that at moderate pressures the reaction approached an asymptotic composition at long residence time.

Finally it is shown that a major method of energy loss for electrons is vibrational excitation of HCl and subsequent infrared radiation.