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Ninth
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on the
Mechanisms of Fire Ignition and Extinguishment

by
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MECHANISMS OF FIRE IGNITION AND EXTINGUISHMENT

by

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1. Summary

Studies of the effects of halogenated organic inhibitors on the concentrations of electrons and ions in flames were continued. One of the characteristics of this class of inhibitors seems to be their ability to capture low energy electrons and dispose of the acquired energy by dissociation of the inhibitor molecule. Comparison of a normal (uninhibited) premixed flame with an inhibited flame showed that the maximum concentration of electrons occured about 1-1/2 mm upstream from the visible reaction zone in the normal flame and about 1/2 mm downstream from the visible reaction zone in a flame inhibited by CF_3Br.

Information on the capture of electrons by halogenated compounds are available for only a few compounds, which are also known to be inhibitors . An attempt was made to extend the list of such compounds by measuring the amount of inhibitor required to extinguish a glow discharge operating under more or less standard conditions. The attempt was unsuccessful probably because the capture of low energy electrons is only one of many processes which can extinguish such a discharge.

2. Position of Maximum Electron Concentration

When a conducting probe is placed in a plasma it is bombarded by molecules, atoms, positive and negative ions, and electrons. Charged particles may transfer their charges to the probe in proportion to the number of charged particles colliding with it. In a plasma, such as a flame, there are equal numbers of positive and negative charge carriers, but, because of their higher velocities, electrons will tend to make many more collisions than positive ions with the result that the charge acquired by the probe will have a negative sign. The magnitude of the charge may be measured, provided the measuring equipment does not bleed the charge from the probe at too high a rate. Such measurements were made on a normal (unhibited) propane-air flame burning in an Edgerton-Powling burner, and the position of the maximum concentration

of electrons was found to be about 1-1/2 mm upstream from the visible reaction zone. When CF_3Br was added to the mixture, the maximum negative probe potential was found to be about 1/2 mm on the other side (downstream of the visible reaction zone.

Interpretation of these results is difficult. One explanation may be that electrons are captured by the inhibitor to form Br^- ions which are carried through the reaction zone before liberating their charges in some kind of recombination reaction, such as $2\ Br^- \rightarrow Br_2 + 2\ e$. It may also be that, because of their high electron affinity, Br^- ions persist and are carried into a region which is deficient in positive ions, so that the net charge transferred to the probe is negative, but carried by Br^- ions which were measured before recombination , rather than by electrons. In the case of the uninhibited flame, it is known that the concentration of negative ions is low, so the charge acquired by the probe can be attributed to electrons. We can, therefore, conclude only that the position of the maximum negative probe potential shifts downstream as a result of the addition of inhibitor. It is not known whether there is any relation between this effect and the mechanism of inhibition.

3. Extinguishment of Glow Discharges by Inhibitors

It was thought that the property of electron capture by inhibitors could be measured by their ability to extinguish a low pressure glow discharge. A preliminary study by Paul D. Burrow (NBS Report No. 6999) indicated the possibility of relating the efficiency of halogenated organic compounds in quenching glow discharges to their efficiencies as extinguishing agents. A series of ten compounds, eight of them containing halogen, and one known not to capture electrons, were studied in glow discharges and no correlation found. The lack of correlation could probably be attributed to the difference in elctron energy distributions between flames and glow discharges. The low average electron energy in flames is not sufficient to produce the same kind of phenomena which are present in glow discharges. The quenching of a glow discharge may, in addition, be attributed to reactions which have nothing to do with the immobilizing of electrons.