Note on Low Pressure Discharges in Nitrogen

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(Z. Naturforsch. **26 a**, 1935 [1971]; received 7 April 1971)

Some properties of the positive column in a low-pressure discharge in nitrogen were investigated. A form of constricted column at low pressure was observed without the presence of negative ions.

1. Introduction

The position of nitrogen in the fifth column of the periodic table of the elements gives it a low electron affinity (Massey [1]) and a probability of electron capture so that its negative ions are hard to produce and unstable. It is well known that the low-pressure discharge in electronegative gases has characteristic properties which include the ability to form constricted and "pipe" discharge at low discharge current. Kocian [2], when investigating the discharge in nitrogen, observed constriction at less than 1 mm Hg and concluded that this was caused by the presence of N_2^-, although this was afterwards questioned.

Some more electrical and spectroscopic observations have been made in pure N_2 with and without NO and NO_2 admixtures, and are reported in this note.

2. Measurements

Measurements were made in gas supplied by Messer-Griesheim with 99.999 per cent purity, in cylindrical discharge tubes with circular cross-section, with diameters 20, 30, and 50 mm. The electrodes were made of nickel in the form of hollow cylinders 18 mm in length and 5 mm in diameter. Volt-ampere characteristics were taken for pressures of 10^{-1} mm Hg $- 10^{+1}$ mm Hg of N_2 either pure or with 1 percent NO or NO_2 added. The characteristics were measured in the current interval 10^{-4} A $- 10^{-1}$ A. A characteristic is shown in the figure. The results of the electrical measurements may be summarised as follows: The form and position of the volt-ampere characteristics in normal and abnormal regime depend on the pressure, and the diameter of the tube; the discharge is striated here.

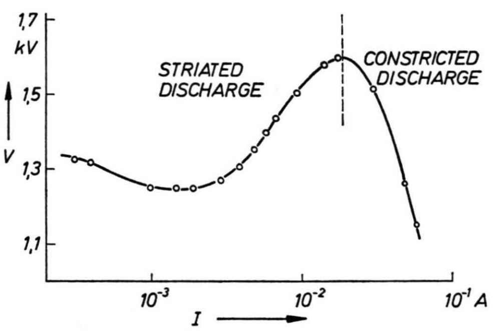

Fig. 1. Volt-ampere characteristic of the low pressure discharge in nitrogen: $r=20$ mm, $p=1$ mm Hg.

A constricted column was observed in the pressure regime 0.5 mm Hg and more with the current 10 − 30 mA, at the boundary between the glow and arc discharge regimes and in the arc discharge. When (r) increased the formation of the constricted column became easier. This form of constricted column had about 1 cm diameter and was either axial or irregularly displaced.

Spectroscopic observations made with a Hilger CH 241/10 spectrograph supplemented by Zeiss rapid photometer G 11 with potentiometric recorder G1B1 showed, apart from the spectra of the filling gases, only Hg I lines, which are very hard to avoid. The Hg I lines were most prominent peripherally. The spectrum can normally give no direct information about the presence of negative ions (Massey [1]).

3. Discussion

Emeleus et al. [3], Woolsey [4], Kenty [5] and others refer to at least three types of constriction: (1) gradual constriction with increasing pressure, (2) the "pipe" discharge; for this a pressure of about 10^2 mm Hg is needed in electropositive gases and about 1 mm Hg in electronegative gases, (3) the diffuse column in electronegative gases.

From our experiments it appears that the constriction and the formation of thread discharge can occur in other than electronegative gases at low pressure. It may be caused by a shortage of high speed electrons (Golubovsky [6]) as a result of elastic and inelastic collisions of these with gas molecules. Because it occurs at higher currents, when the discharge is approaching or has acquired an arc-like character, it may be a general property of the low-pressure arc-discharge in all molecular gases, whether electronegative or not. Further experiments are needed.

We would like to express our sincere gratitude to Prof. Emeleus for his helpful interest and valuable remarks.

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