Detection of Free Charges from Motor-Car Exhaust Gases

The production of charged entities during combustion is well known[1], and some of these entities have proved to be gaseous ions of low molecular weight containing carbon and hydrogen or oxygen and hydrogen[2]. It is known that ionization takes place in explosion motors and it is used, for example, to detect ignition induced by deposits[3]. Jet aeroplanes are reported to become charged electrically[4]. Part of the charging current (about 500 μamp.) might be due to the preponderance of free charges of a certain sign in the exhaust gases.

In an investigation of the role of unipolar radical ions in radiation chemistry and their radiomimetic properties and possible role in the initiation of lung cancer[5], I have done some preliminary work on the presence of free charges in motor-car exhaust gases and from other sources. The apparatus consisted of a charge collection chamber with a geometry rather similar to that used by Siksna[6] (see Fig. 1). The unit is easily portable (the high-tension device is made with transistors). Careful tests have been done to ensure that creep currents are negligible even under very moist conditions. To this end, the 'Teflon' insulator is heated electrically. The output of the instrument is proportional to the concentration of charge in the gas. In more stationary cases, I have used a large parallel-plate condenser[7] (plate separation distance, 100 mm.; size 300 mm. × 300 mm.) to measure the total current that can be collected, by applying a field-strength of 300 V./cm. This unit measures total rate of production of charge rather than concentration of charge.

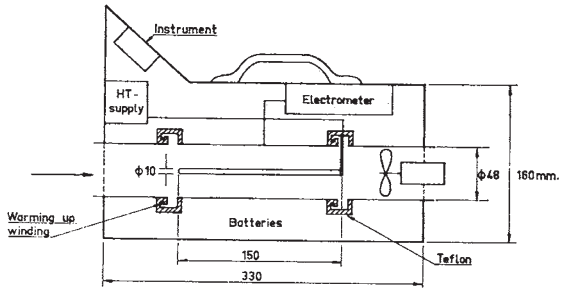

Fig. 1. Portable charge collection apparatus. Air velocity 1 m./sec. Transistorized high-tension variable, 700–1,200 plus or minus. Charge collected at outer electrode is amplified by a conventional electrometer tube circuit. The insulator is heated by mercury batteries. All dimensions are in millimetres

Virtually every car tested (about forty so far) exhibited charge production. On starting the engine, the production is low but increases to high steady states (often $\sim 10^7$ charges/cm.^{2} at full throttle. The total current collected varies from car to car. In the worst case, a current of 100 μamp. was detected, or more than 10^{14} charges/sec. The positive and the negative parts were nearly equal. In this vehicle, the silencer was in bad condition. Small motors, for example, from 'mopeds', were found to yield rather low currents, namely, about 10^{-9} amp., or slightly more than a cigarette[5]. The charges are confined to the exhaust gas cloud. The concentration drops steadily with distance from the exhaust tube. Nevertheless, I have detected charge concentrations on the pavements of streets with heavy traffic and in the back-seats of cars driving behind Diesel trucks. Starting a car in a garage fills the space rapidly, with a charge concentration which, however, drops in some tens of seconds if the car leaves the garage. The charge monitor is provided with variable collector voltage so that some information on the mobility spectra can be obtained. However, the conditions have not been steady enough to facilitate observations of this kind.

The level of the concentration is roughly the maximum that could be expected from a gas-ion recombination[8], but we are not justified at present in making any exact statements on the nature of the charges detected. There are strong arguments[2] for believing that molecular gaseous ions are produced in explosion motors. The fate of these ions will, however, be dependent on the properties of the exhaust tube, the presence of filters (it is known that wool eliminates most of the ions[9]), the humidity and presence of water or oil droplets, dust, etc. The latter may sorb a large part of the original ions. Further work will have to be done to explore the nature of the charges at different times. It is likely that free radicals can be detected by condensing rapidly the exhaust gases from explosion motors, as is the case for cigarettes[10]. In many other instances, apart from explosion motor exhaust gases, charges have been detected, for example, in gas and electrical welding, smoking of cigarettes and cigars[5], household cooking gas and flames and glowing bodies (such as bread-toasters).

Further study of the nature of these charges would seem to link radiation chemistry and radiation biology with the field of air pollution and public health in an interesting way. If it turns out that the charges represent radiomimetic entities, much can be done to reduce them to low levels, for example, by filtering electrically the inlet and outlet gases in motors.

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GEOCHEMISTRY

Apparent Geochemical Association of Bismuth and Thallium

The geochemical association of certain pairs or groups of elements has been noted by several authors, and a classical example is the rubidium/thallium relationship which has been described by Ahrens[1]. In order that such a coherence should be established, it is necessary that not only should a large number of