

with laboratory calibration. In local fogs the method has revealed large numbers of droplets in the 1μ region as in Fig. 1a. A valuable feature is that the perfect optical quality of the gelatin film enables the insoluble content of the droplets, such as their condensation nuclei, to be seen and counted. The plurality of such particles in most droplets more than a few microns in diameter suggests that collision and coalescence of fog droplets is very common. A 50μ droplet may contain 50 or 100 discrete insoluble particles of 1μ or less.

Obviously, the principle of the water-sensitive gelatin film should be applicable to the detection of volatile droplets of other liquids, provided that a clear film, soluble in that liquid, can be prepared. A requirement known to me was the detection of kerosene droplets in combustion chambers. Screening tests of many kerosene-soluble substances were carried out and a satisfactory film was found in silicone resin R230 (I.C.I., Ltd.). This is spread on a slide and heated off in exactly the same way as for gelatin film. Contrast of the kerosene droplet traces after evaporation is not quite so good as for water on gelatin, but the phase-contrast microscope enables the traces to be seen clearly down to 2μ diam., representing droplets of 0.8μ , as the droplet/ring factor in this case is 0.4 (Fig. 1c).

There is no reason to doubt that suitable clear, soluble films could be found for the detection of a wide range of volatile liquids in the manner described.

K. R. MAY

Microbiological Research Establishment,
Ministry of Supply,
Porton, Wiltshire.
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¹ Liddell, H. F., and Wootten, N. W., *Quart. J. Roy. Meteor. Soc.*, **83**, 263 (1957).

² May, K. R., *J. Sci. Instr.*, **27**, 128 (1950).

Light Emission from Insulating Liquids due to Excitation by d.c. Fields near Breakdown

IN scintillation counter applications^{1,2}, it is well known that dilute solutions of fluorescent organic materials, such as anthracene, in suitable organic solvents will absorb radiation and re-emit at a wave-length characteristic of the solute, when the liquid is excited by ultra-violet or high-energy particles.

While investigating pre-breakdown pulse activity and conduction currents in highly degassed and dehydrated transformer oil of Peruvian origin, it was found that visible light was emitted from the high-stress region at d.c. fields in excess of 600 kV./cm. So far as I am aware, this has not been observed previously in organic liquids. Tests were carried out in uniform fields between 1-cm. diameter nickel and stainless-steel electrodes, with a gap spacing of 89μ . The colour and frequency of the emitted light were similar to the blue fluorescence observed when the oil was excited with an ultra-violet source.

No detailed chemical results are available on the composition of the oil; but it is known that traces of unsaturated polycyclic aromatic compounds are present, and that these give rise to the fluorescence of the oil. In order to test the suggestion that light emission was due to excitation of molecules of this type, observations were made using spectroscopic grade hexane, and hexane samples doped with

scintillation grade anthracene and *p*-terphenyl, dissolved at a concentration of 1 gm./l. No visible light was observed with pure hexane up to fields of 1.1 mV./cm., but light emission, characteristic of the dissolved impurity, was observed in the doped hexane samples.

Microscopic observations of this emission showed, for stresses from 600 to 950 kV./cm., filamentary luminous streamers which completely bridged the oil gap from cathode to anode, with no apparent change in intensity along its length. At higher stresses, the glow appeared to become diffuse over the high-field region.

The light intensity was found to increase in an exponential manner with increasing field, but no noticeable change occurred in the spectrum of the emitted light. Removal of the impurities was found to increase the breakdown strength. For example, fractional distillation of the oil, thus removing most of the fluorescent impurities, raised the breakdown strength of the degassed oil from 1,100 to 1,300 kV./cm. Similarly, the breakdown strength of the doped hexane was raised from 700 to 1,050 kV./cm. by removal of the added impurity.

It is possible that the light emission was due to micro-discharges in the oil rather than excitation of the fluorescent impurities in the liquid phase. By means of a metal bellows, pressure and tension was applied to the liquid in the test cell. No variation in the light intensity was observed, and fracture of the liquid did not occur when the liquid was subjected to tension at pre-breakdown fields in excess of 1,000 kV./cm.

These experiments indicate that fluorescent impurities, such as anthracene, which absorb energy by resonance of electron orbitals into higher states, may be excited by high d.c. fields in the liquid phase, and that the processes involved play some part in the processes which lead to electrical breakdown.

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M. DARVENIZA

Electrical Engineering Department,
Queen Mary College
(University of London),
Mile End Road,
London, E.1.
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¹ Birks, J. B., "Scintillation Counters" (Pergamon Press, London, 1953).

² Kallman, H., and Furst, M., *Phys. Rev.*, **79**, 857 (1950).

CHEMISTRY

Analysis of Hydrocarbons

THE difficulty of separating a mixture of ethane, ethylene, propane and propylene on a single column in gas-phase chromatography has been commented on recently¹. Drs. Barnard and Hughes also mention the difficulty of using some two-stage columns. This mixture can in fact be readily separated on a single column. If it is required to analyse only small samples, a column packed with alumina may be used, either thermostatted at one temperature² or by 'temperature-programming' the column³. When both