

by Dr. B. Pullman<sup>10</sup> using the method of molecular orbitals.

The structure is being refined by three-dimensional analysis.

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### Dielectric Properties of some Clathrate Compounds of Quinol

THE term 'clathrate compound' has been suggested for that type of molecular complex in which molecules of one compound are held in cavities in the crystal structure of another. Whether a compound can be entrapped in a particular clathrate structure is determined by the physical dimensions of its molecules. Quinol forms clathrate compounds with a number of elements and compounds, and X-ray crystallographic studies of some of these have been made (see, for example, ref. 1). The  $\beta$ -quinol crystal structure contains cavities approximately spherical in shape, the ratio of the number of available cavities to quinol molecules being one to three.

It seemed likely that clathrate compounds of quinol and polar molecules might possess interesting dielectric properties which would provide evidence regarding the freedom of orientation of the polar molecules in the cavities. A number of such compounds were therefore prepared and, after powdering, pressed into disks suitable for measurement. It has been previously reported<sup>2</sup> that quinol specimens prepared in this manner give dielectric absorption at low frequencies, which decreases with time. In the accompanying table the values of the relative permittivity ( $\epsilon'$ ) listed at 50 kc./s. are those obtained after this low-frequency absorption has decreased to such an extent that the relative permittivity has reached a constant value. For the pure quinol,  $\epsilon'$  is only slightly in excess of the square of the refractive index<sup>1</sup> ( $n_D = 1.63$ ), indicating the absence of any strong absorption at frequencies up to those in the visible region. The clathrate compounds give larger values of  $\epsilon'$ , however, although the refractive indices are similar to those of pure quinol. For the first three clathrate compounds shown in the table, the enhancement of the relative permittivity is nearly proportional to the square of the dipole moments of the polar molecules, which indicates that it is the orientation of these molecules in the structural cavities which results in the enhancement of  $\epsilon'$ .

It was expected that such a mechanism would give rise to a region of energy absorption at ultra-high radio-frequencies. As can be seen by reference to the table, the appreciable loss factors measured at 8,600-Mc./s. for the methanol, hydrogen cyanide and sulphur dioxide compounds are an indication of this. The peak in the absorption is evidently at higher

Quinol compound	Dipole moment of polar molecule (ref. 3) (in $D$ units)	$\epsilon'$ at 50 kc./s.	$\epsilon'$ at 8,600 Mc./s.	$\epsilon''$ at 8,600 Mc./s.
Quinol cryst. from alcohol		2.9	—	—
Quinol cryst. from water		2.8	2.8	< 0.002
Clathrate compound with:				
Methanol	1.66	4.6	4.6	0.14
Hydrogen sulphide	1.1	3.4	3.2	< 0.002
Hydrogen cyanide	2.6-3.0	9.2	8.2	0.57
Methyl cyanide	3.4	3.1	3.1	< 0.003
Sulphur dioxide	1.7	3.9	3.7	0.015

frequencies, however, since the values of  $\epsilon'$  at 8,600 Mc./s. are either the same as, or only slightly lower than, the values at 50 kc./s.

Although the dipole moment of methyl cyanide is larger than that of any of the other polar compounds tested, its clathrate compound with quinol shows only a small enhancement of the relative permittivity. This could be due to the larger size of the methyl cyanide molecules, compared to the other compounds, which reduces their freedom of orientation in the crystal lattice. The X-ray data<sup>1</sup> indicate that methyl cyanide causes a considerable distension of the quinol crystal lattice, and this suggests that the molecules are held more firmly in position. A similar explanation may account for the fact that the value of  $\epsilon'$  for the sulphur dioxide compound is lower than that to be expected from the dipole moment; X-ray data indicate that the sulphur dioxide compound also possesses a slightly distended lattice.

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### Solid Films on Electropolishing Anodes

To explain the characteristic avoidance of etching on an electropolishing anode, Hoar and Mowat<sup>1,2</sup> postulated the formation upon it of a compact solid film, dissolving at its outer surface as fast as it is formed anodically from the metal. We believe we have now obtained direct evidence of the presence of such a film during the electropolishing of copper and  $\alpha$ -brass anodes in the 50/50 v/v orthophosphoric-acid/water bath.

A conventional electropolishing arrangement of a horizontal sheet anode with a similar cathode 1 in. above it was used. Through holes in the cathode, mercury could be introduced from a microburette so that it fell upon the anode in small drops from the tip of the burette,  $\frac{1}{4}$  in. above the anode. The following observations were made.

(1) Mercury was dropped on to a copper or  $\alpha$ -brass anode that was etching anodically, with 0.9 V. across the cell. The drops wetted the surface immediately, usually in less than a second, and then spread over it. Spreading continued steadily while the specimen