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but Lennard-Jones and Corner⁵ were able to show, on the basis of dimensional considerations, that the parachor is proportional to $V_c^{\frac{1}{3}}T_c^{\frac{1}{3}}$. For non-associated organic compounds, including those in which the molecules are so unsymmetrical as to restrict rotation in the liquid state, they found that the formula

$$P = 0.410 V_c^{\frac{1}{3}}T_c^{\frac{1}{3}}$$

gave slightly better agreement than that of Ferguson and Kennedy. Examination of the available data for liquids of this type reveals that formula (2) is definitely superior to that of Ferguson and Kennedy, and is in general slightly more accurate than that of Lennard-Jones and Corner.

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Cardiff. July 29.

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Paramagnetic Resonance, a New Property of Coal-like Materials

PARAMAGNETIC resonance, which has given interesting information on several structures¹, can be used for studying coal-like materials. Using a microwave spectrometer (9,000 Mc./s.) for electronic paramagnetic resonance, we have observed a characteristic line for coals². This sharp line is associated with a Landé factor of 2, which is the free electron value. These results lead us to believe that this paramagnetism is linked with the structure of coal-like materials and cannot be attributed to the minerals always present, such as iron. In the present communication we give further details on the results observed for coals² and for several coal-like materials in which paramagnetic resonance has been detected.

The samples of coal studied, coming from mines in northern or eastern France, are of different geological ages. They correspond to the following French designations: anthracite, quart-gras, demi-gras, trois-quart-gras, flambant-gras, flambant-sec. The amplitude of the line decreases from the oldest coal (anthracite) to the youngest one (flambant-sec). Roughly, the amplitude gets smaller as the amount of carbon decreases in the samples and as the amount of volatile substances and oxygen increases. Charring modifies the phenomenon considerably. On heating the coals up to 500° C., the line is seen to decrease gradually with increasing temperature. The line disappears quickly on heating the same samples between 500° and 600° C., when graphitization and electrical conductivity appear. After coking is completed (1,000–1,100° C.) no line can be seen. It must be emphasized that several samples of graphite did not give any line with our apparatus, though a weak line has been reported by Castle³. With regard to lignites, the line is absent in a sample from Hostens, present but weak in a sample from Fuveau and in both instances it becomes very strong after heating at 300° C. These results have led us to make some experiments with such materials as charcoals, sugar charcoal and pitches.

Charcoal prepared from pine wood and coconut and also some lightly charred sugars (saccharose, glucose) give a fairly intense paramagnetic resonance line. This line disappears in charcoals activated at 900° C. in presence of combustion gases and steam. No line appears in crude oils; but one is found in pitches which are residues from crude oil distillation. It can be said that paramagnetic resonance appears when carbohydrates are damaged either by Nature, as in coals, or artificially by heating, as in charcoals, sugar charcoal and pitches. The same line appears if the samples (woods, sugars) are irradiated by γ -rays, as was found by two of us⁴, which suggests the same sort of damage. This paramagnetic resonance cannot be attributed to a specific defined structure at present; but further experimental and theoretical work is being carried out.

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¹ Gordy, W., Smith, W. V., and Trambarulo, R. F., "Microwave Spectroscopy", 236 (Wiley and Sons, New York, 1953).

² Étienne, A., and Uebersfeld, J., *J. Chim. Phys.* (June 1954).

³ Castle, *Phys. Rev.*, **92**, 1063 (1953).

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Electroretinal Photopic Sensitivity Curves

SINCE Adrian¹ first suggested the existence of separate rod- and cone-components in the human electroretinogram, there have been attempts to isolate them so as to demonstrate the degree to which their spectral sensitivity curves adhered to scotopic or photopic patterns.

Thus Riggs, Berry and Wayner² determined the function for the B-wave. With a 7.5° foveally centred stimulus-flash, the curve closely resembled the scotopic function but was displaced toward the blue. Armington, Johnson and Riggs³ derived a similar curve for the A-wave of the dark-adapted eye. Again excess blue-sensitivity appeared. Boynton⁴ has supposed this to be related to the part played by stray light. With small stimulus areas a significant portion of the electrical response is due to light scattered over the peripheral retina, outside the focal area. One contributor is Rayleigh scatter, varying as an inverse function of the fourth power of the wave-length, scattering blue more than red. To support this interpretation, Boynton shows that divergence from scotopic values is less when larger areas are used. Johnson and Armington⁵ have confirmed this, demonstrating that with full-retinal stimulation, using an integrating sphere, electrical sensitivity curves for the B-wave of the dark-adapted eye coincide with the usual scotopic luminosity curve.

Armington⁶ has fitted data for the X-wave (Motokawa's designation for Adrian's photopic component) to the CIE photopic luminosity curve. With the photopic receptors we would expect stray light to have less effect. Cones are concentrated near the fovea and are supposed (cf. Stiles-Crawford effect⁷) to be directional. It is disconcerting to find that the X-wave curve diverges from the photopic curve just as the small-area B-wave curve diverges from the scotopic function. No one has used full-retinal stimulation to elicit the X-wave. We cannot say whether such a procedure would bring the X-wave

Fig. 1. Log relative energy at each wave-length to achieve standard response. Maxima of curves adjusted to equality. *S*, Scotopic visibility curve; *RBW*, curve for *B*-wave (ref. 2); *P*, photopic luminosity curve; *JC*, curve for *X*-wave obtained by authors using four per sec. flashes in light-adapted eye. Points indicate photopic peaks of narrow-band filters used. Data of three determinations averaged.

results into line. Armington speculates that it might not. He has used night-blind subjects and found some alleviation of the disparity. This suggests that the *X*-wave of the normal-seeing person, as elicited by Armington's procedures, is partly of scotopic origin or, alternatively, that the peripheral cones of his night-blind subjects had been affected so that the effect of stray light was diminished even though a 'pure cone' index was being observed.

To throw additional light on the problem we have employed a technique suggested by Dodt⁵, in a communication in *Nature* in 1951. He affirms, and we agree, that with a stimulus flickering above a rate of about 20 per sec., scotopic responses appear to fuse, manifesting the equilibrium characteristic of steady illumination. Responses synchronous with 30 per sec. flashes should represent activity of the faster responding photopic system. In the dark-adapted eye there is an initial *B*-wave, following which the 30 per sec. fluctuations appear. These may continue, unaltered, for several minutes. Records

taken after different lengths of time in darkness differ only in the size of the initial *B*-wave.

Using 4 per sec. flashes (to which the above argument does not apply), and delivering these to the light-adapted eye, we confirmed Armington's findings for the normal eye. Total height of response was measured, from trough of *A* to peak of *X*. Fig. 1 shows the form of the curve obtained using a 20- μ V. response criterion. Excess blue-sensitivity is apparent. (Apparatus and treatment of results in this work were similar to those employed in refs. 2-6.)

With 10-msec. flashes delivered to the dark-adapted eye at a rate of 30 per sec., and using a 10- μ V. trough-to-peak response criterion, the 'sensitivity curve' (Fig. 2) resembles the photopic more than the scotopic function, but is still displaced slightly toward the blue and is less sharply peaked.

We must either consider the hypothesis that Rayleigh scatter contributes to the photopic electroretinogram, as it does to the scotopic, or we must admit that neither the employment of night-blind subjects nor the use of flickering stimuli prevents intrusion of a blue-sensitive system, presumably the scotopic, which contributes to the electroretinogram yet fails to show itself during determination of the photopic luminosity curve by the standard procedures.

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⁸ Dodt, E., *Nature*, **168**, 738 (1951).

Fig. 2. Log relative energy at each wave-length to achieve standard response. *P*, Photopic luminosity curve; *F*, curve for 30 per sec. flashes. Triangles represent one set of determinations on subject A.T., squares and circles two sets for subject P.J.

A Disease Epidemic in Fish

AN epidemic has occurred in a fish culture of *Tilapia mossambica* in Southern Rhodesia during June 1954. The disease had a mortality of more than 90 per cent of the exposed population. *Barbus* species were also affected. Fungus was seen mostly on the extremity of the dorsal fin but frequently occurred on the caudal peduncle, the tail and on the inter-orbital region. Affected fish were seen lying in shallow water and gasping at the surface. The intestine was filled with a clear gelatinous fluid. No macroscopic gill lesions were noticed. Although cold (below 56° F.) seems a predisposing factor, the etiology is not clear. Helminth cercaria may be implicated as well as fungus. Histologically gill necrosis associated with an invasion of conidia-like bodies, and kidney and liver cloudy swellings are present.

Further details will be published later.

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