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**PARAMAGNETIC RESONANCE, A NEW PROPERTY
OF COAL-LIKE MATERIALS**

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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).

⁴ Combrisson, J., and Uebersfeld, J., *C. R. Acad. Sci., Paris*, **238**, 1397 (1954).