



the size of the particles.

5 Gloucester Gate,  
London, N.W.1.  
May 10.

<sup>1</sup> Waller, *Nature*, **166**, 961 (1950).

<sup>2</sup> Kundt, *Ann. Physik*, **127**, 497 (1866).

<sup>3</sup> Andrade *Proc. Roy. Soc., A*, **134**, 445 (1931); *Phil. Trans., A*, **230**, 417 (1932).

<sup>4</sup> Bagnold, *Proc. Roy. Soc., A*, **187**, 1 (1946).

<sup>5</sup> Soellner and Bondy, *Trans. Farad. Soc.* **32**, 616 (1936).

### Fluorescence of Naphthoquinones

ATTEMPTS to devise a method for the identification of vitamin K<sub>1</sub> and other naphthoquinones by filter-paper chromatography led to the chance observation that some of these compounds exhibit a characteristic fluorescence which can be used for their detection. 10 µgm. of vitamin K<sub>1</sub> was chromatographed in a 75 per cent (v/v) aqueous ethanol solution on Whatman No. 1 filter-paper impregnated with silicone. When the paper was dried and held before an ultra-violet lamp (3665 Å.), an area of red fluorescence was seen at *R<sub>F</sub>* 0.20. With prolonged exposure to the ultra-violet radiation (45–60 sec.), the red fluorescence changed irreversibly to an intense, green fluorescence which was stable for at least four months. When sprayed with alcoholic potassium hydroxide, the green fluorescence changed to an orange fluorescence.

Although necessary for proper separation of the substances, silicone-coated paper was not necessary for fluorescence. Spraying the chromatogram with alcoholic solutions of nickel chloride or ammonium iodide, substances that often quench fluorescence<sup>1</sup>, had no effect.

Of nineteen alkyl, hydroxyl or chloro substituted 1,4-naphthoquinones observed on filter-paper, all fluoresced red. 1,4-Naphthoquinone itself had no obvious fluorescence, and neither 1,2-naphthoquinone nor its methyl derivatives fluoresced. None of the substances tested fluoresced in petroleum-ether or ethanol solutions, although some of the crystalline compounds in the solid state did. These observations

apart, and this effect can be recognized also in Fig. 4 of the illustration; compare the eight ridges between the central two nodes with the eleven ridges between the bottom two nodes.

The above facts must also be important at higher frequencies, especially in ranges where the inter-ridge and internodal distances may become comparable to one another. It is interesting to note that Soellner and Bondy<sup>5</sup>, working on the subject of coagulation by ultrasonics, found that the distances between 'nodal lines' were strongly influenced by

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suggest that substituted 1,4-naphthoquinones may react in the same way as those substances, tabulated by Pringsheim<sup>1</sup>, some of which fluoresce only in the solid state, others in rigid media.

A detailed report of reversed-phase partition chromatography on filter paper of the naphthoquinones and their detection by fluorescence will be published elsewhere.

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<sup>1</sup> Pringsheim, P., "Fluorescence and Phosphorescence" (Interscience, New York, 1949).

### Liquid-State Equation for Normal Paraffins

BASED on measurements of liquid density and of heats of vaporization of the normal paraffin hydrocarbons, a very simple relationship has been deduced that appears to be of general applicability to this family of chemical compounds. The equation is as follows:

$$\frac{\rho - \rho_c}{\rho_0 - \rho_c} = \left[ \frac{(1 + \alpha T)(-E/V)}{(-E/V)_0} \right]^{3/4}$$

where  $\rho$  is liquid density at the temperature of measurement<sup>1</sup>;  $\rho_c$  is critical density<sup>2</sup>;  $\rho_0$  is liquid density extrapolated to absolute zero<sup>3</sup>;  $(-E/V)$  is cohesive-energy density of the liquid at the temperature of measurement<sup>4</sup>;  $(-E/V)_0$  is cohesive-energy density of the liquid extrapolated to absolute zero; and  $\alpha$  is a constant ( $= 0.00125$  for the *n*-paraffins).

The above relationship has been applied to the normal paraffins at atmospheric pressure over a range of temperatures from  $-190^\circ$  to  $+345^\circ$  C., and over a range of molecular weights from 44 to 283. The standard percentage error for the 73 points is:

$$100 \left\{ \frac{\sum [(y_{\text{calc.}} - y_{\text{obs.}})/y_{\text{obs.}}]^2}{n} \right\}^{1/2} = 0.57 \text{ per cent,}$$

where  $y = \frac{\rho - \rho_c}{\rho_0 - \rho_c}$  and  $n$  is number of measurements.

Work is in progress to investigate a large number of non-polar liquids to determine whether or not they also conform to this simple equation. Compressibility data on the normal paraffin hydrocarbons are being taken for us by Arthur D. Little, Inc., of Cambridge, Mass., and a study by them of the compressibilities of other liquids is contemplated. At a later date this research will be extended to polar liquids in the hope that their behaviour also may be characterized by some modification of this relationship.

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March 23.

<sup>1</sup> Dornte, R. W., and Smyth, C. P., *J. Amer. Chem. Soc.*, **52**, 3546 (1930). Doolittle, A. K., and Peterson, R. H., *J. Amer. Chem. Soc.*, **73**, 2145 (1951).

<sup>2</sup> Critical density values taken from smoothed curve representing results reported by Deas, M. P., "Physical Constants of the Principal Hydrocarbons" (Texas Co., New York, 1943).

<sup>3</sup> Doolittle, A. K., *J. App. Phys.*, **22**, 1471 (1953).

<sup>4</sup> API Res. Proj. 44, Carnegie Inst. Tech., "Selected Values of Properties of Hydrocarbons", Table 20m (April 30, 1949). Values at other temperatures interpolated or extrapolated by method described in Hildebrand, J. H., and Scott, R. L., "The Solubility of Nonelectrolytes", 434 (Reinhold, 1950).