

at low frequencies (50–1,000 c./s.), the loss angle increasing, in each case, with decreasing frequency and with decreasing chain-length of the molecules. This absorption was considered to be due to short-range interaction, which causes the dipoles to reverse their direction in groups. Such interaction has been shown theoretically to lead to enhanced polarization<sup>3</sup> and absorption, and to shift the absorption peak to lower frequencies<sup>4</sup>.

Preliminary dielectric measurements have now been made with a number of crystalline long-chain secondary alcohols, the variation of loss angle with frequency for 14-heptacosanol ( $C_{13}H_{27}.CHOH.C_{13}H_{27}$ ) and 16-hentriacontanol ( $C_{15}H_{31}.CHOH.C_{15}H_{31}$ ) being shown in Fig. 1. Similar results were obtained with a number of other crystalline secondary alcohols of chain-length between 15 and 43 carbon atoms. In contrast to the ketones, it was found that the dielectric absorption was not displaced to lower frequencies with increasing chain-length. This suggests that it may not be associated with rotation of the molecules, but may result from orientation of the hydroxyl groups by rotation about the C—O bond, with two positions of equilibrium stabilized by H-bonding (see Fig. 2). The wide frequency-range of the absorption is presumably due to the varying numbers of hydroxyl groups forming continuous chains. A similar mechanism of reversal of chains of dipoles has been suggested<sup>5</sup> as an explanation of the ferro-electric properties of Rochelle salt.

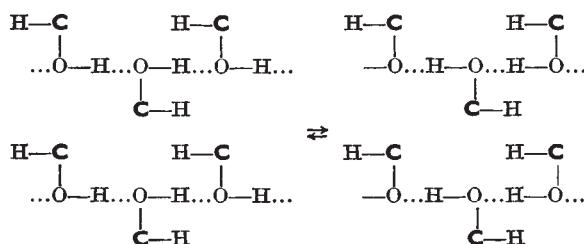


Fig. 2. The two positions of minimum potential energy of the hydroxyl groups in a crystalline secondary alcohol (section normal to molecular chains)

Support for this hypothesis was obtained from measurements with dilute (0.1 *m*) solid solutions of 14-heptacosanol in *n*-octacosane ( $C_{28}H_{58}$ ) and 16-hentriacontanol in *n*-dotriacontane ( $C_{32}H_{66}$ ). In such solutions the hydroxyl groups would be isolated and would give rise to an absorption peak at ultra-high frequencies. As expected, these solid solutions gave negligible dielectric loss throughout the frequency-range 90 kc./s.–50 Mc./s. The absence of an absorption peak similar to that found in solid solutions of ketones<sup>6</sup> may be due to the large size of the hydroxyl group opposing rotational transitions of the molecule as a whole.

More complete details of the results of this work will be published elsewhere.

R. J. MEAKINS  
R. A. SACK

Division of Electrotechnology,  
Council for Scientific and Industrial Research,  
Australia.  
April 20.

<sup>1</sup> Fröhlich, H., *Trans. Farad. Soc.*, **42** A, 3 (1946).

<sup>2</sup> Meakins, R. J. (in the press).

<sup>3</sup> Fröhlich, H., *Proc. Roy. Soc. A*, **185**, 399 (1946).

<sup>4</sup> Sack, R. A., *Trans. Farad. Soc.*, **42** A, 61 (1946).

<sup>5</sup> Beevers, C. A., and Hughes, W., *Proc. Roy. Soc. A*, **177**, 251 (1941).

<sup>6</sup> Meakins, R. J., *Nature*, **162**, 994 (1948).

## Rheological Measurements and Adhesion

THE work described by Dr. E. W. J. Mardles<sup>1</sup> may be considered in relation to our results on yield stresses in lubricating greases<sup>2</sup>, which were determined under conditions of simple tangential shear. We presented evidence to show that at shearing stresses above a certain value (termed the 'first yield stress') flow of grease takes place by slip on a thin film of oil at the grease–solid interface. Flow as a result of breakdown of the bulk grease structure occurs only above a certain higher stress, which is the yield value commonly measured and is called by us the 'second yield stress'.

Following the views of Hardy, which are quoted by Dr. Mardles, we supposed that the first yield stress is due to the development of a rigid structure in the slip film of oil under the influence of adsorption forces, and that its magnitude might depend on the chemical nature of the surface in contact with the grease. Adsorption forces, which are considered to be responsible for the first yield stress, may also affect the thickness of the slip film of oil. Since in some of Dr. Mardles's experiments the possibility of slip appears to be excluded by the geometrical shape of his apparatus, it also seems possible that the adhesion forces may play a part in flow at stresses above the second yield stress involving breakdown of the grease structure.

Slip of the type described is, however, essentially a phenomenon occurring at interfaces, whereas in shear of the main grease structure most of the energy dissipation takes place at distances from the interfaces very great compared with the range of adhesion forces. The effect of the nature of the surface on the flow of the grease would, therefore, be expected to be particularly marked at shearing stresses intermediate in magnitude between the first and second yield stresses, and it is interesting to note that in Dr. Mardles's experiments (Fig. 1) the effects due to the nature of the surface become increasingly pronounced as the shearing stress diminishes with increase in penetration or radial flow.

J. F. T. BLOTT

"Shell" Central Laboratories,  
Fulham,  
London, S.W.6.

W. B. BONNOR

51 Holland Road,  
Kensington,  
London, W.14.

<sup>1</sup> Mardles, E. W. J., *Nature*, **164**, 324 (1949).

<sup>2</sup> Blott, J. F. T., and Bonnor, W. B., *Proc. International Rheological Congress*, **2**, 265 (1948).

## Mixture Law for Viscosity

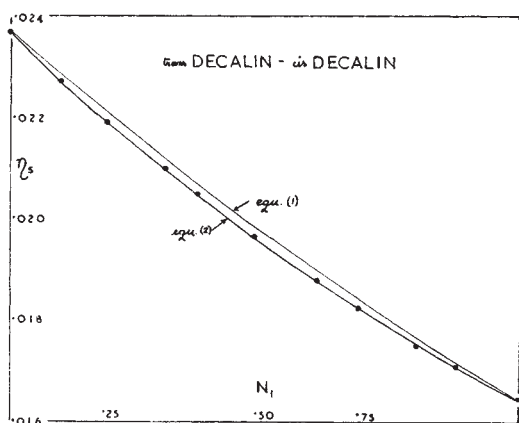
ARRHENIUS<sup>1</sup> proposed the following expression for the viscosity of a solution:

$$\log \eta_s = N_1 \log \eta_1 + N_2 \log \eta_2, \quad (1)$$

where  $\eta_s$  is the viscosity of the solution;  $N_1$  and  $\eta_1$  are the mole fraction and the viscosity of component 1;  $N_2$  and  $\eta_2$  the mole fraction and the viscosity of component 2. However, both positive and negative deviations from this equation are found to occur. From a comparison of vapour pressures and viscosities of solutions, we deduced that in many cases the following equation yields closer agreement with experimental results:

$$\log \eta_s = N_1 \log \eta_1 + N_2 \log \eta_2 + N_1 N_2 d, \quad (2)$$

where  $d$  is a characteristic constant of the system. The accompanying graph shows curves calculated according to equations 1 and 2 (with  $d = -0.0224$ ) for the system *trans*-decalin-*cis*-decalin. The points on the graph represent the experimental results of Bird and Daly<sup>2</sup>.



The constant  $d$  can assume both positive and negative values. We found that  $d$  is positive for systems showing a negative deviation from Raoult's law, and is negative for systems showing a positive deviation from Raoult's law.  $d$  is connected with the constant  $b$  in the simplified Margules equation  $\log \gamma_1 = bN_2^2$  (where  $\gamma_1$  is the activity coefficient of component (1)) by the equation

$$d = C \cdot b. \quad (3)$$

$C$  is the ratio  $\log$  viscosity to  $\log$  vapour pressure. The fact that  $C$  is always negative agrees with the antiparallelism usually found between the viscosity and the vapour pressure of solutions.

Full results of our investigations will be published elsewhere.

L. GRUNBERG

Dr. Rosin Industrial Research Co., Ltd.,  
Exhibition Grounds,  
Wembley, Middx.

ALFRED H. NISSAN

Bowater Development and Research, Ltd.,  
Central Research Laboratories,  
Northfleet, Kent.

June 8.

<sup>1</sup> Arrhenius, *Z. physik. Chem.*, **1**, 285 (1887).

<sup>2</sup> Bird and Daly, *Trans. Farad. Soc.*, **35**, 588 (1939).

### Action of 2,3,5-Triiodobenzoic Acid on Growth of Root Hairs

Zimmermann and Hitchcock<sup>1</sup> found 2,3,5-triiodobenzoic acid to be active as a 'formagen', that is, a substance affecting flowering and growth processes in the tomato. In the *Avena* coleoptile standard test, this compound acts as an anti-auxin<sup>2</sup>, inhibiting the action of indole-3-acetic acid. The present communication deals with the influence of 2,3,5-triiodobenzoic acid on the growth of root hairs, these organs being used as a test object to investigate the growth of a single cell and the growth and structure of cell walls.

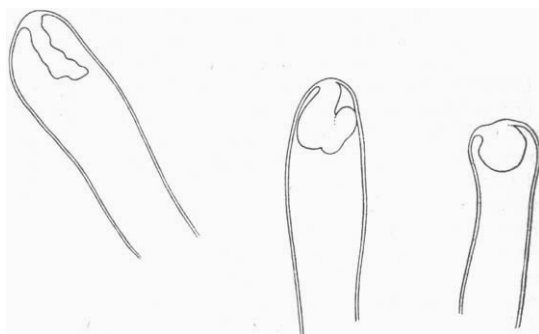


Fig. 1. Tips of root hairs, treated with 2,3,5-triiodobenzoic acid. Note the cellulose masses hanging at the tip

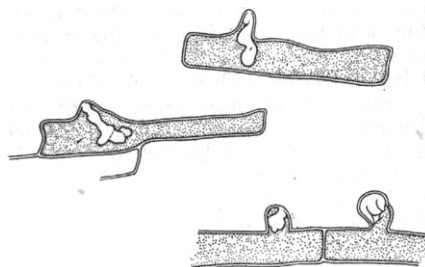


Fig. 2. Epidermal cells with root hair initials. No longitudinal growth; formation of cellulose masses at the tip

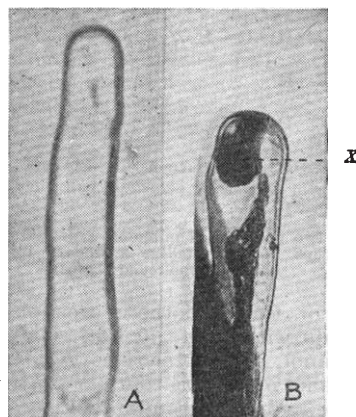


Fig. 3. A. normal root hair tip. B. tip of a root hair, treated with 2,3,5-triiodobenzoic acid, with cellulose mass at X. Preparation stained with chlor zinc iodine to demonstrate the cellulose mass

Seeds of *Lepidium sativum* were germinated upon porous plates soaked with a 0.02 per cent solution of 2,3,5-triiodobenzoic acid. The root hairs develop to a certain extent and then stop growing. Longitudinal growth comes to a stop, but other processes go on, including the formation of cell-wall material. This cell-wall material, instead of being used for the growth of the cell-wall, is accumulated at the tip of the root hair, forming an irregular mass hanging from the tip inside the cell. This is shown in Figs. 1 and 2 and in the photograph (Fig. 3). The material gives the usual cellulose reactions and has no birefringence. We may suppose that it consists for the greater part of cellulose.

It is concluded that 2,3,5-triiodobenzoic acid inhibits the use of cell-wall material for its usual purpose,