

residue was dissolved in ether, and the solution washed with sodium carbonate solution, dried over anhydrous sodium sulphate and filtered through aluminium oxide. The filtrate was concentrated, yielding a crystalline residue, which was recrystallised from ethanol, giving colourless needles, m.p. 143–144° (2.2 g). Further recrystallisation raised the m.p. to 148–149°. With ferric chloride in alcoholic solution, the substance gives a brownish-violet colour.

$C_{18}H_{16}O_5$ (240.3)			
Calc.	C 59.9	H 6.70	$OCH_3$ 38.7
Found	» 59.6	» 6.74	» 38.6

*Method B:* 2-Hydroxy-4,6-dimethoxytoluene<sup>4</sup> (II) was condensed with methoxyacetonitrile by the Hoesch method, and the reaction product worked up as described by Curd and Robertson<sup>1</sup>. After recrystallisation from ethanol, the substance melted at 146–148° alone or in admixture with a sample prepared by method A.

*Synthesis of 2'-hydroxy-3'-methyl-4',6', $\alpha$ -trimethoxychalkone (III):* A suspension of 2-hydroxy-3-methyl-4,6, $\omega$ -trimethoxyacetophenone (0.5 g) in ethanol (8 ml) was added to a mixture of benzaldehyde (0.5 ml) and potassium hydroxide (2 g) in water (2 ml). The resulting red solution was left overnight in a stoppered flask and then acidified, giving a yellow crystalline precipitate. This material, after three recrystallisations from ethanol, formed pale yellow leaflets, m.p. 117–119° (0.6 g). Ferric chloride in alcoholic solution gives a strong brownish-violet colour.

$C_{19}H_{20}O_5$ (328.4)			
Calc.	C 69.5	H 6.14	$OCH_3$ 28.3
Found	» 70.0	» 6.19	» 28.2

*Synthesis of 3,5,7-trimethoxy-8-methylflavone (IV):* The chalkone (1.0 g) was refluxed with selenium dioxide (1.2 g) in *iso*-amyl alcohol (10 ml) for 40 hours. The solvent was then removed by steam distillation and the residue was dissolved in chloroform. This solution was washed with 2 *N* sodium hydroxide and with water, dried and filtered through aluminium oxide to remove coloured impurities. The filtrate, on concentration, slowly deposited yellow crystals, which were recrystallised twice from methanol, yielding colourless needles (0.04 g), m.p. 154–155°. Colour reactions: ferric chloride, none; magnesium-hydrochloric acid, pink.

$C_{19}H_{18}O_5$ (326.3)			
Calc.	C 69.9	H 5.56	$OCH_3$ 28.5
Found	» 69.1	» 5.05	» 28.1

Oxidation of 2'-hydroxy-4',6', $\alpha$ -trimethoxychalkone by the same method gave a 5% yield of galangin trimethyl ether, m.p. and mixed m.p. 196–198°.

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1. Curd, F. H., and Robertson, A. *J. Chem. Soc.* **1933** 437.
2. Mahal, H. S., Rai, H. S., and Venkataraman, K. *J. Chem. Soc.* **1935** 866.
3. Perkin, A. G. *J. Chem. Soc.* **103** (1913) 1632.
4. Weidel, H. *Monatsh.* **19** (1898) 232.

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## Intermolecular Free Lengths in Liquids in Relation to Compressibility, Surface Tension and Viscosity

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The intermolecular free length between molecules in the liquid state is an essential and characteristic feature. This is evident from the simplicity and generality of application obtained when empirical relations are sought between the intermolecular free length and the properties in liquids which are dependent on intermolecular processes. Those properties include compressibility, surface tension and viscosity. If these properties are designated  $j$  the following simple relation prevails:

$$j = k \cdot L^p$$

where  $k$  and  $p$  assume for each property and each temperature certain constant values irrespective of composition, structure, size and shape of the molecules in the liquid or liquid mixture. The free intermolecular length is defined as

$$L = \frac{2(V_T - V_0)}{Y} \quad (2)$$

where  $V_T$  is the molar volume at the temperature  $T$ . For the compressibility and surface tension,  $V_0$  is the molar volume at absolute zero, according to Sugden<sup>1</sup>. For viscosity,  $V_0$  is the molar volume at the temperature where the fluidity is zero, *i. e.*, the zero fluidity volume according to Friend<sup>2</sup>.  $V_T - V_0$  is thus the available volume for the type of molecular motion that is decisive for the different properties.  $Y = f(36\pi NV_0^2)^{\frac{1}{3}}$  is the molecule surface of one mol of the liquid where  $N$  is Avogadro's number and  $f$  is a form factor which gives the relation between the molecule's surface and the imagined spherical surface which encloses the same volume as the molecule's volume. For low molecular substances  $f \approx 1$ .

For the adiabatic compressibility, there apply at 20°C the empirical values  $p = 2.082$  and  $k = 1.25 \cdot 10^7$  c.g.s. For 53 non-associated liquids (hydrocarbons, hydrocarbon halogens, organic esters and certain nitrogen compounds),  $L$  has been computed both from equ. (1) from compressibility values given in the literature, and according to equ. (2) from molar volumes. The mean deviation in values thus computed for  $L$  is 3.3 %. The deviation is due in part but probably not wholly to the difficulty of determining  $V_0$  exactly. This uncertainty is eliminated in liquid mixtures. Even if the error in  $V_0$  for the different pure liquids forming the liquid mixture amounts to one or two per cent, nevertheless it is possible to compute very accurate values relatively for  $L$  with different concentrations. Thus values computed for  $L$  from equ. (2) for liquid mixtures have been compared with values for  $L$  according to equ. (1) computed from experimentally determined compressibility values in mixtures of the type: Methylene iodide — ethylether, toluene — pentane, diphenylmethane — hexane and pyridine — hexane. The mean deviation in  $L$  for a total of 16 mixtures is 0.8 %. The compressibility has been measured with an

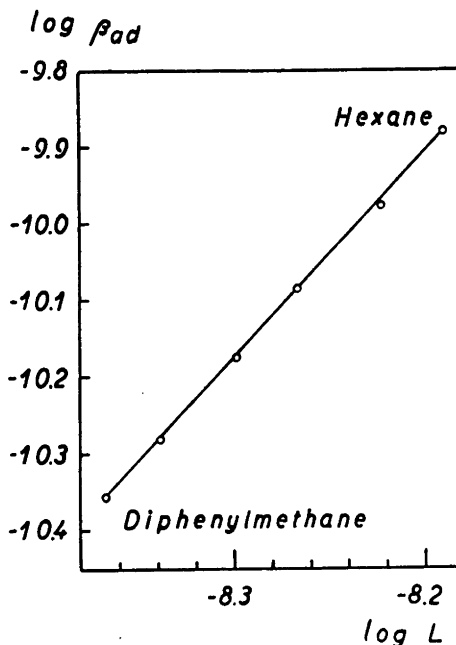


Fig. 1. Adiabatic compressibility ( $\beta_{ad}$ ) plotted as a function of intermolecular free lengths ( $L$ ) in mixtures of diphenylmethane and hexane at 30°C.

accuracy of 0.1 %. In Fig. 1 the compressibility has been plotted in logarithmic scale as a function of  $L$  for mixtures of diphenylmethane and hexane.

A trial of equ. (1) for surface tensions of 31 pure non-associated liquids shows that with certain preliminary values for  $k$  and  $p$  the mean deviation for  $L$  computed according to (1) and (2) is 3.4 %. Considering liquid mixtures the conditions are more involved due to the phase rule of Gibbs, still the relation should be useful in studying surface phenomena.

Equ. (1) is also valid for the viscosity of liquids. In view of the rather divergent definition of intermolecular free length as regards viscosity, this will here be called the intermolecular free fluidity length  $L\phi$ .  $L\phi$  has been computed from (1) with

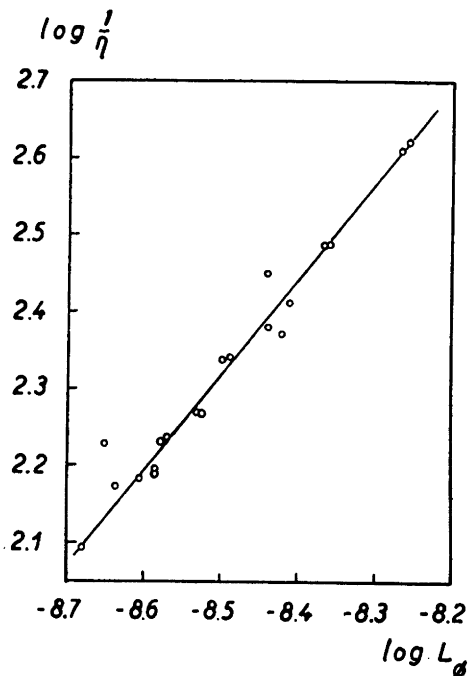


Fig. 2. Fluidities ( $1/\eta$ ) plotted as a function of intermolecular free fluidity lengths ( $L_\phi$ ) of 20 non-associated liquids at 20° C.

viscosity values given in the literature and from (2) by utilizing zero fluidity volumes according to Friend<sup>2</sup> for 20 non-associated liquids. The mean deviation in  $L_\phi$  in this case is 4.3%. Fig. 2 shows in logarithmic scale the fluidities for these 20 liquids as a function of  $L_\phi$  according to (2). The largest deviation is observed with toluene (to the lower left in the figure). With a recalculated value of Friend's  $V_0$  better agreement is obtained.

Owing to their simplicity these relations should be of value in the study of associated liquids. In order to arrive at the degree of association in a liquid there is first determined  $L$  or  $L_\phi$  according to (1) from the values of compressibility or surface tension or viscosity. Then there can be determined from equ. (2) the number of monomers which are forming the associated

complexes. For the lower fatty acids agreeing values are obtained for degrees of association computed from compressibility, surface tension and viscosity. They amount to about 2 and thus agree with the values obtained by other methods.

Full data regarding these and for the constants  $k$  and  $p$  for the different properties at different temperatures will be published in this journal when a larger amount of material has been treated.

1. Sugden, S. J. *Chem. Soc.* **1927** (1780).
2. Friend, J. N. *Trans. Faraday Soc.* **3** (1938) 813.

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### On the Phosphatase Activity of Low-phosphorus *Torulopsis utilis*

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In a previous work Rautanen and Miikkulainen<sup>1</sup> have shown that the starvation of *Torulopsis utilis* yeast in respect to phosphorus is followed by a considerable decrease in various important phosphorus as well as nitrogen fractions of the cells. Concerning the physiological properties of the low-phosphorus yeast cells Wiame<sup>2</sup> has earlier shown with baker's yeast that these cells when placed in a medium containing phosphate have a peculiar ability to synthesize and accumulate inorganic metaphosphate in the cells. When investigating nearer this anomaly in the phosphorus metabolism of the low-phosphorus *Torulopsis* yeast cells we have observed very interesting changes in the activity of the acid phosphatase of the yeast cells of different phosphorus contents.

The cultivation of the normal, low-phosphorus and metaphosphate containing yeast cells was performed as reported earlier<sup>1</sup>. The phosphatase determinations were made both with fresh and dry yeast