

only minor deviations from the line $\eta = \eta_0$ will occur. Plotting $1/\eta$ against $1/T$ clearly shows that the experimental data obtained here do not fit the equation proposed by Dr. A. V. Brancker.

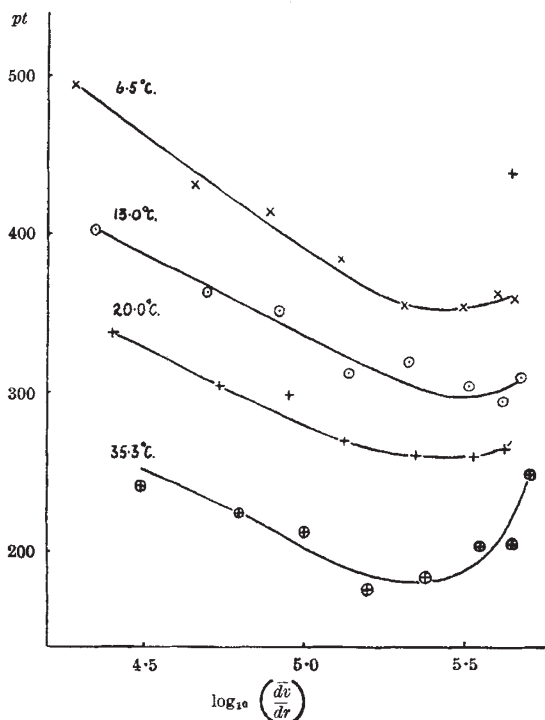
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¹ *Nature*, **166**, 905 (1950).

Temporary Reduction of Viscosity of Liquids at High Rates of Shear

IN view of a recent statement¹ "that solutions of macromolecular substances may show an anomalous fall in the coefficient of viscosity at high rates of shear", it is emphasized once again² that, at sufficiently high rates of shear, any liquid consisting of elongated molecules must be expected to exhibit a decrease of the coefficient of viscosity with increasing rate of shear. This means that there is only a quantitative, but no qualitative, difference between the dependence of viscosity on rate of shear of so-called Newtonian liquids and that of solutions of macromolecular substances. Grunberg and Nissan³ estimated that at a rate of shear of about 10^6 sec.⁻¹ pentane might begin to show an appreciable reduction of viscosity, and Bondi⁴ predicted that temporary reductions of viscosity would become apparent for shearing stresses of more than 10^5 dynes/cm.² for straight hydrocarbon chains with molecular weights of 500 and more. In addition to our own previous results on castor oil and straight mineral oils⁵, experimental evidence is now presented to prove that a chemically defined liquid, such as tetradecane, suffers an appreciable fall of its coefficient of viscosity over a range of rates of shear extending to about 350,000 sec.⁻¹.



Temporary reduction of viscosity of tetradecane at four temperatures

The experimental difficulty mentioned by Ward, Neale and Bilton¹ of keeping the temperature constant at high rates of shear is avoided by the use of a jet viscometer⁶ (enclosed in a temperature jacket to enable one to vary the temperature at which the measurements are taken), where even at the highest rate of shear the total pressure-volume energy converted into heat would produce a rise in temperature of the liquid of only 0.05° C., and this temperature rise is constant over the entire cross-section of the short capillary.

The accompanying diagram and Table 1 show results with tetradecane at four temperatures. In the diagram, the corrected value of the product of the given pressure difference p (in cm. mercury) along the short capillary (of radius r) by the time t of efflux of a given volume V of liquid is plotted against the rate of shear calculated from Poiseuille's

$$\text{equation, that is, } \left(\frac{dv}{dr}\right) = \frac{4V}{\pi r^3 t}$$

Table 1. TEMPORARY REDUCTION OF VISCOSITY OF TETRADECANE

Temperature (° C.)	Low rate of shear viscosity (poises)	Rate of shear (sec. ⁻¹)	Percentage temporary viscosity reduction
6.5	3.2×10^{-2}	263,000	28.1
13.0	2.712×10^{-2}	369,800	25.6
20.0	2.322×10^{-2}	281,800	23.6
35.3	1.811×10^{-2}	223,800	24.3

Owing to the comparatively low viscosity of tetradecane, the present results include the theoretical kinetic energy correction modified by an empirical factor based on Schiller and Kirsten's⁷ $l/2r = 0.029 R$ criterion ($R = \text{Reynold's number}$) for the minimum length of tube, in order that Poiseuille's equation may be applied, as outlined elsewhere⁸.

Table 2. TEMPORARY VISCOSITY REDUCTION OF VARIOUS OILS

Material	Temperature (° C.)	Low rate of shear viscosity (poises)	Rate of shear (sec. ⁻¹)	Percentage temporary viscosity reduction
Castor oil	100.1	21.8×10^{-2}	234,700	24.4
Medicinal liquid paraffin	56.1	28.6×10^{-2}	182,300	17.1
A 30 transformer oil	20.0	21×10^{-2}	228,000	18.0
Straight mineral oil "G"	100.0	14.4×10^{-2}	282,000	26.8
Light mineral oil "A"	75.0	37.7×10^{-2}	146,000	14.7
	13.6	5.59×10^{-2}	134,900	20.6

Since the results with tetradecane are similar to those obtained with a variety of oils free from macromolecular additions (Table 2), it is clear that temporary viscosity reductions can be obtained with any type of liquid, including the so-called Newtonian liquids. High rates of shear are better defined with the jet viscometer⁶ than with a rotational viscometer, where eccentricity and vibrations have a disturbing influence.

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¹ Ward, A. F. H., Neale, S. M., and Bilton, N. F., *Nature*, **166**, 905 (1950).

² Schnurmann, R., and Morris, W. J., "Principles of Rheological Measurement", 203 (London, 1946).

³ Grunberg, L., and Nissan, A. H., *Nature*, **156**, 241 (1945).

⁴ Bondi, A., *J. App. Phys.*, **16**, 539 (1945).

⁵ Schnurmann, R., Proc. Int. Rheol. Congr. Holland, 1948, Pt. 2, 142.

⁶ Morris, W. J., and Schnurmann, R., *Rev. Sci. Instr.*, **17**, 17 (1946).

⁷ Schiller, L., and Kirsten, H., *Phys. Z.*, **22**, 523 (1921).

⁸ Morris, W. J., "Jet Viscometers for High Rates of Shear", M.Sc. Thesis (Manchester, 1948).