

indicates that a much more probable form has the O-N-O angle in the neighbourhood of 110° - 120° .

Dr. R. M. Badger and Dr. G. Herzberg have suggested independently³ that the wide-angled form is the correct one. The former points out that a ring-like structure would be inconsistent with the low value (641 cm.^{-1}) observed for the frequency ν_2 , while the latter shows that the fine-structure of the ultra-violet bands⁴ indicates a rather flat molecule. On these grounds, they both suggest a re-assignment of the fundamental frequencies as shown in the accompanying table. The object of this re-assignment is to avoid difficulties which would otherwise arise in interpreting the observed contours of the infra-red bands. A discussion of these cannot conveniently be given here.

Fundamental Frequencies of the NO₂ Molecule in cm.⁻¹.

Designation	ν_1	ν_2	ν_3
Sutherland	1373	641	1615
Badger and Herzberg	1615	641	1373

We have recently been making a study of the force fields in triatomic molecules, more particularly of the force constant controlling the bending frequency (ν_2), and from it we find that the wide-angled structure for NO₂ is definitely to be preferred. We find, moreover, that the original assignment of the fundamental frequencies seems more likely to be the correct one. This immediately leads to difficulties regarding the contours of the infra-red bands, which Badger and Herzberg's re-assignment was designed to avoid. Since the latter does not, however, resolve all the difficulties, we feel that an extensive and careful re-examination of the contours of the infra-red bands will be necessary before these can be used as a reliable guide to the shape of the molecule.

A full account of these investigations will be published later elsewhere.

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¹ Sutherland, *Proc. Roy. Soc.*, A, **145**, 278; 1934.

² Bailey and Cassie, *NATURE*, **131**, 239; 1933. Harris, Benedict and King, *NATURE*, **131**, 621; 1933. Schaffert, *J. Chem. Phys.*, **1**, 507; 1933.

³ In private communications, which we gratefully acknowledge.

⁴ Hermann, *Ann. Phys.*, **15**, 89; 1932.

Influence of Viscosity Variation on the Rupture of Plastic Bodies

THE term viscosity has frequently been used in a qualitative sense in describing the properties of solids and particularly of metals, but its use in the quantitative sense which has been developed through the study of liquids is a comparatively recent development. Viscosity may be defined quite generally as the ratio of the shearing stress in any plane to the rate of shear or velocity gradient perpendicular to the plane. Thus defined it appears always to be a variable quantity for solids, its value depending on a number of factors, but particularly on the magnitude of the shearing stress. No emphasis appears, however, to have been laid on the importance of the *degree of variability* of the viscosity in relation to the rupture of plastic solids.

The point is most easily explained by reference to 'runny' materials to which standard viscometric methods may be applied: (we avoid the word 'fluid', because this is sometimes taken to imply a constant viscosity). If some golden syrup is sucked up into a tube 10-20 cm. long, and about 1 cm. in diameter, it will run out quite continuously without forming drops. A clay paste, on the other hand, falls from the end of the tube in 'blobs' (they can scarcely be called drops). The surface tension is about the same in the two cases, and its influence is not large owing to the use of a very wide tube. The difference in behaviour must be due to viscosity. It cannot be a question of the absolute magnitude of the viscosities, as these can be considerably changed by altering the concentrations of sugar and clay without making the two materials behave alike. We can only attribute the difference to the fact that while the viscosity of a sugar syrup is independent of the stress, that of a clay paste varies very greatly, particularly in the neighbourhood of its 'yield value'. Soft soap, when warm, will run from such a tube, and has a viscosity which is not constant like that of syrup, but yet is not as steeply variable as that of a clay paste. It is interesting to observe that in falling from the tube this material forms blobs which, if they do not have to fall too far, do not become completely detached from one another. Its behaviour is thus intermediate, as we should expect.

We are not aware that similar reasoning has, as yet, been applied to the behaviour of solids in tension. In the case of flour dough we have developed, for the quantitative measurement of viscosity, a technique which has been considerably extended and improved in co-operative work with Dr. P. Halton of the Research Association of British Flour Millers, and there are strong indications that shortness in a dough is associated with a particularly rapid decrease of viscosity with increase in shearing stress. We have not sufficient personal experience with metals to make any assertion about their behaviour, but we venture to suggest that the rate of decrease of viscosity (as defined above) with increase in shearing stress may be a determining factor in their tensile strength. A general connexion between the manner of rupture and the degree of variability of viscosity may be found to hold even though the underlying mechanism is quite distinct as between different kinds of materials.

In practice, the position is apt to be obscured by factors in addition to shearing stress which influence viscosity. For example, heather (*Calluna vulgaris*) honey if kept in the tube overnight sets to a thixotropic gel which causes it to fall in blobs, whereas after stirring it behaves substantially like syrup. Again, flour dough strain-hardens on extension. As with metals, this delays 'necking' when cylinders of this material are extended.

The behaviour of rubber in benzene differs from both syrup and clay pastes because it has a much longer relaxation time (ratio of viscosity to rigidity modulus). We suggest, however, that such factors, though introducing complications, do not necessarily upset the postulated relationship between the degree of variability of viscosity and the manner of rupture, and that it may prove illuminating in the study of many materials.

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