

displacements are to be single-valued². Hence, if we define

$$T_{ij} = \lambda \frac{\partial \varepsilon_{ij}}{\partial t}, \quad (3)$$

then from (1), (2), (3)

$$\lambda = 2(1 + q)\mu. \quad (4)$$

This 'coefficient of viscous extension' allows one to synthesize the Navier-Stokes viscous fluid theory with a theory on the straining of solids. The coefficient λ in the flow case is analogous to Young's modulus in the static strain case. However, it should be noted that in (1) and (3) only *time-rates of straining* occur, so that my theory on strains of any magnitude can be used to give a general theory on straining that incorporates flow in solids and viscous fluids. As presented here, the coefficient of viscous extension λ is a non-constant tangent modulus if the substance is quasi-viscous⁶. The transverse contraction ratio q will have the value $\frac{1}{2}$ in solids as well as liquids if volume changes do not occur. However, caution is necessary in view of the static 'plastic' transverse contraction ratio value 0.36 for duralumin⁷ found by me; this has been checked with a photo-grid and a specially designed optical extensometer⁸. Further, the same value was found for changes in thickness of the tensile specimen.

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¹ Swainger, K. H. (communicated to *Phil. Mag.*, Dec. 27).

² Swainger, K. H. (communicated to *Phil. Mag.*, Oct. 14).

³ Swainger, K. H., *Phil. Mag.*, (7), **38**, 422 (1947).

⁴ Swainger, K. H., *Nature*, **180**, 399 (1947).

⁵ Swainger, K. H., *Phil. Mag.*, (7), **36**, 443 (1945).

⁶ Houwink, R., and Burgers, W. G., "Elasticity, Plasticity and Structure of Matter", 10 (Camb. Univ. Press, 1940).

⁷ Swainger, K. H., *Nature*, **158**, 165 (1946).

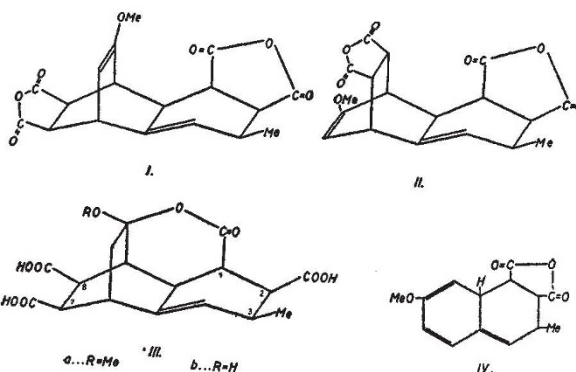
⁸ Swainger, K. H., and Twyman, J., *J. Sci. Instr.* (in the press).

Addition of Maleic Anhydride to Anethole

ONE of us¹ has earlier obtained a small amount of a crystalline compound (m.p. 241°, decomp.) of anethole with two moles of maleic anhydride, the main bulk of the reaction product being a heteropolymer^{1,2,3}. We found that, if a small amount of dimethylaniline is added, the formation of the heteropolymer product is prevented and the yield of the crystalline adduct was as high as 60 per cent. We have confirmed the structure previously proposed¹ and our work led further to the determination of the steric configuration of the compound.

If we assume an *endo-cis* type addition⁴ and start from anethole, which may be supposed to be a *trans* anethole, then the formation of four possible stereoisomers (that is, two racemates) could be expected, namely, I, II and their respective antipodes. The properties of our compound agree with those expected from I.

The following reactions may be cited in favour of I and excluding II. Mild alkaline hydrolysis leads to III (a); if the hydrolysis is more energetic, III (b) is obtained. The ultra-violet absorption spectrum of III (b) does not show the characteristic band of a



carbonyl group. This acid forms heterocyclic compounds with hydroxylamine as well as with phenylhydrazine; hence one of the carboxyl groups participates also in the condensation. When III (b) was boiled with 5 *N* hydrochloric acid, the carboxyl groups in positions 1 and 8 became a *trans* position and an isomeric *trans* keto-acid was obtained containing a free carbonyl group, the presence of which was revealed by the ready formation of a regular oxime and by its absorption spectrum. The olefinic bond of III (b), which is resistant to catalytic hydrogenation, was confirmed by the addition of two hydroxyl groups. If compound I is heated with sulphur to 300°, it decomposes with formation of maleic anhydride and the anhydride of 3-methyl-7-methoxy-naphthalene-1:2-dicarboxylic acid.

The formation of the compound I makes it clear that, from the point of view of diene synthesis, anethole behaves as a conjugated tetraene, that is, it gives first with one mole of maleic anhydride the labile primary compound IV, which in turn reacts instantaneously with another mole of maleic anhydride, forming the stable end-product I.

Our observation seems to be of interest from the following two points of view: (1) So far as we know, this is the first *proved* example of the possibility of disturbing the aromatic character of a mononuclear system through a Diels-Alder reaction. Such a process leading to a compound of analogous structure to I had been suggested but later rejected by Wagner-Jauregg⁵ in the case of the Diels-Alder reaction of *as*. diphenylethylene. This structure has, however, recently been accepted by Bergmann and co-workers⁶, but was not established by them in a decisive manner. (2) From our results it is probable that the Diels-Alder reaction of some styrene derivatives is initiated by the heteropolar resonance form of the partners⁷.

The full details of these investigations will be published elsewhere.

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¹ Bruckner, V., *Ber.*, **75**, 2034 (1942).

² Hudson, B. J. F., and Robinson, R., *J. Chem. Soc.*, 715 (1941).

³ Tamayo, M. L., and Avestarán, D., *An. Física Quím.*, **36**, 44 (1940); **37**, 392 (1941). These authors did not recognize that the uncrystallizable compound (m.p. 311-312°, decomp.) prepared by them was a heteropolymer.

⁴ Alder, K., *Angew. Chem.*, **50**, 510 (1937).

⁵ Wagner-Jauregg, Th., *Ber.*, **63**, 3218 (1930); *Ann.*, **491**, 1 (1931).

⁶ Bergmann, F., et al., *J. Amer. Chem. Soc.*, **69**, 1773, 1777, 1779 (1947).

⁷ Compare Bergmann, F., et al., *J. Organ. Chem.*, **8**, 179 (1943). Hudson, B. J. F., and Robinson, R., *J. Chem. Soc.*, 715 (1941). Eistert, B., "Tautomerie und Mesomerie", 110 (Stuttgart, 1938).