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Some Remarks on Schwédoffs Experiment with a Gelatin Sol

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In 1889 Schwédoff made a wellknown rheological experiment with a 0.5 % gelatin sol [1] in an apparatus (similar to a Couette viscometer) consisting of two co-axial cylinders; the solution was poured into the cylindrical shell. The inner cylinder could be turned by a torsion wire, and the shearing angle, Ω, as well as the torsion angle, Δ, could be determined.

After having made a certain initial twist of the wire Schwédoff read the angle, Ω, that the inner cylinder had rotated. Then he tried to keep Ω constant by means of continuously diminishing Δ, *i. e.* back twisting of the torsion head. He took up Δ as a function of the time t. When he tried to obtain a formula to fit his results he came to the following equation.

$$\Delta = \Delta_{\infty} \left[1 + \left(\frac{\Delta_0}{\Delta_{\infty}} - 1\right) e^{-\frac{t}{\tau}}\right] \qquad (1)$$

τ is a »relaxation» constant. The indices of Δ relate to time. This equation with three constants was well satisfied by Schwédoff's experimental values. Later Hatschek and Jane [2] made investigations on similar sols but were unable to fit their experimental values into equation 1.

In spite of that Reiner [3] has proposed a system of rheological classes, one of which has been named after Schwédoff. Thus that class is based on one single experimental series.

It is now reasonable to suppose that the gelatin sol of Schwédoff's experiment obeyed de Waele—Ostwald's law [5,6] as well as a comparatively concentrated gelatin solution usually does so; compare Auerbach [7], Ostwald [6] and Ostwald and Stuart [8].

I have made experiments with gelatin sols in three types of apparatus *viz.*, the Tsuda viscometer [9], the Bungenberg de Jong, Kruyt and Lens pressure

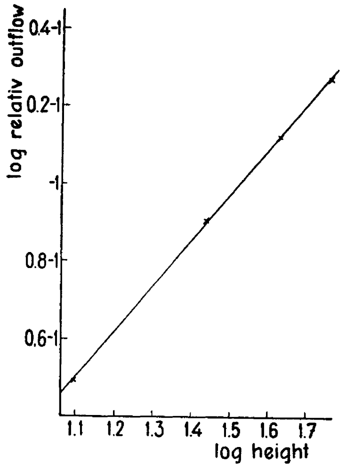

Fig. 1. A gelatin sol in a Tsuda viscometer. log relativ outflow (in cm/s) as a function of the pressure (in cm solution).

viscometer [10] and the Auerbach apparatus [7]. In all these types of instruments gelatin sols behaved like de Waele—Ostwald materials. An example of the experiments is shown in Figure 1.

As is known de Waele—Ostwald's law can be written

$$\psi \cdot \sigma = p^{\beta} \cdot t \tag{2}$$

where β is a constant depending on the material, and ψ is a constant that is identical with viscosity when $\beta = 1$. p is shear stress and σ shear strain.

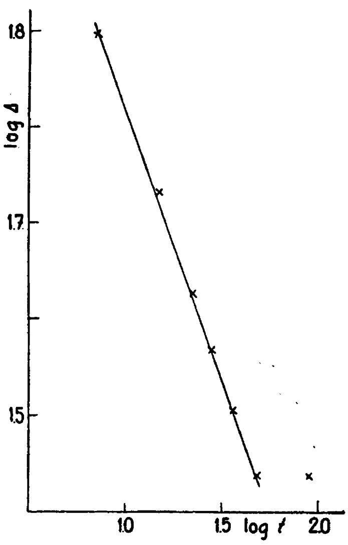

Fig 2. Schwédoffs experiment. log Δ as a function of log time.

In the Schwédoff case Ω was kept constant. That means that there was no streaming after the initial torsion, *i. e.* σ was constant. As p is proportional to Δ, the experimental values ought to follow a straight line in a logaritmic diagram over Δ as a function of t, if de Waele-Ostwald's law is valid. As can be seen from Figure 2 this is also the case. The first value has the greatest experimental uncertainty. As regards the last value it may be that the inner cylinder had got stuck. The other values lie close to a straight line.

SUMMARY

It has been shown that the gelatin sol of Schwédoff obeyed de Waele—Ostwald's law. The so-called Schwédoff class in Reiner's rheological system has therefore no justification.

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