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The Three Coefficients of Viscosity of Anisotropic Liquids

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BEFORE and during the War, investigations were reported on the viscosity of anisotropic liquids[1,2,3,4]. As is well known, the flow of an anisotropic liquid influences the orientation of the molecules. On the other hand, the value of the viscosity coefficient depends on this orientation. Therefore this coefficient is a function of the velocity-gradient, and the usual definition of the viscosity coefficient for these liquids loses its significance. If under the influence of any factor the molecules of the liquid should be orientated in one direction and the motion is unable to change this orientation, then we have the viscosity coefficient in the ordinary sense. But in this case we have to deal with the anisotropy of the viscosity, and in case of a liquid of the type of *p*-azoxyanisol we have three principal viscosity coefficients belonging to the three directions of orientation ; these are : (1) direction of the flow ; (2) direction of the velocity gradient ; (3) perpendicular to both these directions. Having given the molecules an orientation by means of a magnetic field in such circumstances that the flow did not change this orientation, I obtained the following values for the three principal viscosity coefficients for *p*-azoxyanisol and *p*-azoxyphenetol[2].

Substance and temperature	Molecules parallel to the direction of the flow, η_1	Molecules parallel to the gradient of velocity, η_2	Molecules perpendicular to the direction of flow and to the velocity gradient, η_3
p-Azoxyanisol 122° C.	$0{\cdot}024 \pm 0{\cdot}0005$	$0{\cdot}092 \pm 0{\cdot}004$	$0{\cdot}034 \pm 0{\cdot}003$
p-Azoxyphenetol 144·4° C.	$0{\cdot}013 \pm 0{\cdot}0005$	$0{\cdot}083 \pm 0{\cdot}004$	$0{\cdot}025 \pm 0{\cdot}003$

These results throw light on those obtained by the other investigators. The results of the older investigators (Eichwald[5] and Dickenschied[6]) obtained by the method of flow through capillary tubes are in agreement with my results. Evidently, in both cases we were dealing with the orientation of molecules parallel to the direction of flow. Zwetkoff and Michajlow[3], using the method of flow through a tube with rectangular cross-section, by application of the strongest available magnetic field and with the smallest possible velocity of flow, obtained values about 80 per cent of my value, η_2. From the dependence of the results on the intensity of the magnetic field, it is clear that these investigators did not reach the state of constant orientation of molecules, and that the flow of the liquid changed this orientation. The results obtained by these authors for the different values of velocity and for different intensities of magnetic field lie between η_1 (orientation parallel to the flow) and η_2 (parallel to the velocity gradient) $\eta_1 \leq \eta_{\text{Zwetkoff}} < \eta_2$.

The measurements recently published by Becherer and Kast[4] were not carried out with constant orientation of the molecules. They were, however, orientated (at least in the layers where the phenomenon of viscosity chiefly takes place) in the planes of friction, but without a definite angle in this plane. The value obtained by these investigators is therefore not one of the three principal coefficients in the sense given by me. Clearly, $\eta_1 < \eta_{\text{Kast}} < \eta_3$, because in my measurements of η_1 and η_3 we have also an orientation parallel to the plane of friction, but once parallel and then perpendicular to the direction of the flow.

Hence the coefficient η_1 was measured by other workers as well as by me. The method of flow through capillaries gives usually the result corresponding to an orientation of molecules in the direction of flow; the other values given by different investigators do not correspond to constant orientation of molecules.

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