Influence of Turbulence on Electrokinetic Phenomena; Experimental Determination of the Thickness of the Diffuse Part of the Double Layer

A laminar flow of liquid through a capillary is accompanied by a streaming current given by

$$I_{lam.} = D\zeta\, v_{ax} = 2\,D\zeta\,\bar{v} \tag{1}$$

where

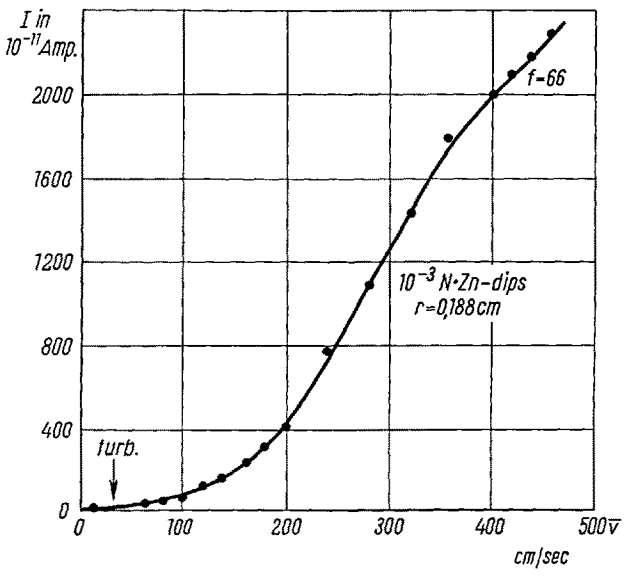
$$\bar{v} = \frac{Q}{\pi r^2} = \frac{r^2}{8\eta}\,\frac{p}{l} \tag{2}$$

is the bulk velocity of the liquid; D is the dielectric constant of the liquid, η its viscosity, ζ the electrokinetic potential, Q the volume of liquid passing per second through a cross section.

The electric charges in the liquid lie in a diffuse layer close to the wall; consequently, in the case of laminar flow, they obtain only very small speeds.

In the case of turbulent flow, however, parts of the liquid near the wall may be carried to the central part of the capillary, and obtain the speed $\bar{v}$; therefore we can expect, as was pointed out to us by Dr. A. KLINKENBERG of the Hague, a big effect of turbulence upon streaming potentials and streaming currents.

Our first experiments were carried out with thrice distilled water; here we measured streaming potentials and streaming currents; in these experiments, turbulence set in at $p = 26{\cdot}5$ cm of water pressure; we measured up to $p = 120$ cm; the results were negative: no influence of turbulence was detected.



Influence of turbulence on streaming current

We then studied benzene, which we had made a little conductant by means of Zn-di-i-propylsalicylate (Zn-dips); the solutions were $10^{-5}N$, $10^{-4}N$, and $10^{-3}N$; the conductivities were 0·5, 1·2 and $2{\cdot}6 \times 10^{-12}$ ohm^{-1} cm^{-1}; the radii of the capillaries were 0·188, 0·116 and 0·044 cm; turbulence set in at $p_t = 6$ cm, 13 cm, and 80 cm of water pressure respectively. There was a big effect of turbulence upon the streaming current I; at low pressure (laminar flow), I is proportional to $\bar{v}$, the charges in the liquid move with speeds of the layers of liquid near the wall; at $p \cong 3p_t$ I begins to increase more strongly; at much higher pressures I is again proportional to $\bar{v}$, but the value of $I/\bar{v}$ is much higher than for laminar flow (*cf.* the fig.). This part of the curve we interprete by supposing that here all the charges in the liquid move with the bulk velocity $\bar{v}$ of the turbulent flow:

$$I_{turb.} = 2\pi r \times q\,\bar{v} = 2\pi r \times \frac{D\zeta}{4\pi\delta}\,\bar{v} = 2\,D\,\bar{v}\,\zeta\,\frac{r}{4\delta} \tag{3}$$

Here q is the charge in the liquid opposite 1 cm^2 of the wall.

The factor

$$f = \frac{r}{4\delta} \tag{4}$$

is the ratio between the slopes of the laminar and the turbulent part of the $I-\bar{v}$-curves. To give only one example, for our $10^{-3}N$ solution of Zn-dips in benzene, measured in the capillary with $r = 0{\cdot}188$ cm, we found $f = 66$, giving $\delta = 7 \times 10^{-4}$ cm.

c \ r	0·188 cm	0·116 cm	0·044 cm	$\varkappa^{-1}$
$10^{-5}\,N$	$f = 12{\cdot}6$	$f = 6$	–	
	$\delta = 37\mu$	$\delta = 48\mu$	–	23μ
$10^{-4}\,N$	$f = 35$	$f = 20{\cdot}6$	–	
	$\delta = 13\mu$	$\delta = 14\mu$	–	15μ
$10^{-3}\,N$	$f = 66$	–	–	
	$\delta = 7\mu$	–	–	11μ

In the table we give the experimental values of f, the values of δ calculated from these, and the values of $\varkappa^{-1}$ ($\varkappa^2 = 4\pi\varepsilon^2 \Sigma n_k z^2_k / D\,k\,t$) although we realize that we are outside the region where the DEBYE-HÜCKEL theory is valid.

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Zusammenfassung

Durch Messungen in 10^{-5}, 10^{-4} und $10^{-3}N$ benzolischen Lösungen von Zn-di-i-propylsalizylat haben wir einen beträchtlichen Einfluss von Turbulenz auf Strömungsströme feststellen können. Dieser Einfluss kann ausgedrückt werden durch einen Faktor f, der in einem unserer Experimente einen Wert von $f = 66$ erreichte; aus den Werten von f kann die Dicke der diffusen Doppelschicht in der Flüssigkeit berechnet werden.

β-Brazan from Isocoumaranone

It has been shown by CHATTERJEA[1], and also independently in a preliminary way by GEISSMAN and ARMEN[2], that the product obtained by the self-condensation of *iso*coumaranone is 3-*o*-hydroxyphenylacetyl-

[1] J. N. CHATTERJEA, J. Indian chem. Soc. *33*, 175 (1956).

[2] T. A. GEISSMAN and A. ARMEN, J. Amer. chem. Soc. *77*, 1623 (1955).