labeled compounds was also obtained. Thus, in the basic liver supernatant pattern, three distinct spots (C) were visualized, as compared to only two in the chromatographic system (Fig. 1 C). In the presence of ethanol (D), a shift occurred, consisting of a decrease in concentration of the slowest moving fraction, and an increase in the fastest moving compound. A similar phenomenon was observed in the slices system (A and B).

When adrenaline was present in the supernatant system (M), one radioactive spot, probably corresponding to a monosulfate of adrenaline, moved very slowly. Other compounds, which might have been derivatives of adrenaline containing two or three sulfate groups, moved faster. In the slices system (L), the slow moving spot was found, in addition to two other ^{35}S -labeled compounds.

With noradrenaline as well, a slow moving compound was synthesized in both systems (O:cell-free, N:slices). A few other labeled compounds were also recognized in these cases.

The results of this screening study on the ability of a system of liver slices, or of a cell-free supernatant of liver homogenates, to activate sulfate groups and transfer them to different types of acceptors are in good agreement with those reported by other authors on phenols ⁵⁻⁷, steroids ^{1,8,9} and amines ¹⁰.

Features of special interest in our study were the complicated ester sulfate pattern found in the presence of catechol amines, the failure of sulfatation of free tyrosine in either of the systems, and the interesting shift in the basic ester sulfate pattern in both systems in the presence of small amounts of ethanol (Fig. 1).

The particular value of the chromatographic method used in the present study seems to be that a good overall picture of the occurrence of different types of transferring enzymes and sulfate acceptors in different sulfatation systems is obtained in small-scale experiments.

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Mass Transfer by Forced Laminar Convection at Plane Plate Electrodes

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The investigation of the influence of liquid flow on electrode processes is of great interest for industrial electrolysis and for the theory of metallic corrosion in flowing liquids. Heat and mass transfer at a plane plate in longitudinal flow under laminar conditions have been treated by various authors ¹⁻³ under the assumption of a uniform surface temperature and concentration, respectively. As far as electrolysis is concerned, this postulate probably applies only for limiting current conditions at the electrodes. In normal electrolysis with a uniform current density, the actual boundary condition is a uniform concentration gradient at the electrode surface. This case or the corresponding heat transfer problem does not seem to have been considered earlier.

The notation used in an earlier communication ⁴ is employed, except that x is taken to mean the distance in the flow direction from the leading edge of the electrodes and u denotes the flow velocity in the x -direction in the boundary layer. Furthermore, l is the length of the electrode in the flow direction and $\text{Re}_x = \frac{u_b x}{\nu}$ is the local Reynolds number. The relevant boundary layer equations in integrated form are

$$\frac{d}{dx} \int_0^{\delta_h} u(u_b - u) dy = v \left(\frac{du}{dy} \right)_{y=0} \quad (1)$$

$$\frac{d}{dx} \int_0^{\delta_d} u/c_b - c dy = j \quad (2)$$

with the boundary conditions

$$u = 0, \frac{dc}{dy} = \frac{j}{D} \text{ for } y = 0$$

$$u = u_b \text{ for } y \geq \delta_h, c = c_b \text{ for } y \geq \delta_d$$

For the velocity profile we assume¹

$$\frac{u}{u_b} = \frac{3}{2} \frac{y}{\delta_h} - \frac{1}{2} \frac{y^3}{\delta_h^3} \quad (3)$$

and obtain from (1)

$$\delta_h = \left(\frac{280 v x}{13 u_b} \right)^{\frac{1}{2}} \quad (4)$$

The concentration profile is approximated by the equation

$$c_b - c = \frac{2}{3} \frac{j \delta_d}{D} \left[1 - \frac{3}{2} \frac{y}{\delta_d} + \frac{1}{2} \frac{y^3}{\delta_d^3} \right] \quad (5)$$

With $\frac{\delta_d}{\delta} = r$ and considering that $r < 1$ for high Schmidt numbers one obtains

$$\int_0^{\delta_d} u/c_b - c dy = \frac{u_b j}{10D} r^3 \delta_h^2 \quad (6)$$

and hence

$$\frac{u_b}{10D} \frac{d}{dx} (r^3 \delta_h^2) = 1 \quad (7)$$

Although δ_h and δ_d are functions of x , r may be considered to be independent of x .

Hence, using eqn. (4)

$$r^3 = \frac{13}{28} \frac{D}{v} \quad (8)$$

Finally, we obtain for uniform current density:

$$= 0.774 \text{ Sc}^{-1/3}, \delta_d = 3.59 D^{1/3} v^{1/6} \left(\frac{x}{u_b} \right)^{\frac{1}{2}}, \delta_N = \frac{2}{3} \delta_d$$

$$\Delta c_x = 2.39 j D^{-2/3} v^{1/6} \left(\frac{x}{u_b} \right)^{\frac{1}{2}}, \Delta c_{av} = \frac{2}{3} \Delta c_l$$

$$\text{Nu}_x = 0.417 \text{ Re}_x^{\frac{1}{2}} \text{Sc}^{1/3}, \text{Nu}_{av} = 0.625 \text{ Re}_l^{\frac{1}{2}} \text{Sc}^{1/3}$$

An analogous treatment for limiting current density gives:

$$r = 0.976 \text{ Sc}^{-1/3}, \delta_d = 4.53 D^{1/3} v^{1/6} \left(\frac{x}{u_b} \right)^{\frac{1}{2}}, \delta_N = \frac{2}{3} \delta_d$$

$$i_{\text{lim},x} = 0.331 \frac{zF}{1-t} \Delta c D^{2/3} v^{-1/6} \left(\frac{u_b}{x} \right)^{\frac{1}{2}}, i_{\text{lim},av} = 2 i_{\text{lim},l}$$

$$\text{Nu}_x = 0.331 \text{ Re}_x^{\frac{1}{2}} \text{Sc}^{1/3}, \text{Nu}_{av} = 0.662 \text{ Re}_l^{\frac{1}{2}} \text{Sc}^{1/3}$$

According to an exact numerical solution³, the coefficient for $i_{\text{lim},x}$ and Nu_x is 0.332.

In both cases, one obtains for the concentration difference of an inert conducting electrolyte, such as sulphuric acid in copper refining,

$$|\Delta c^1| = \frac{t^1}{1-t^1} \left(\frac{D^1}{D^1} \right)^{2/3} |\Delta c| \quad (9)$$

where t^1 and D^1 are the transference number and diffusion coefficient of the inert electrolyte.

Forced laminar flow without disturbing free convection is probably best realized with bipolar horizontal electrodes, which act as anodes on the upper side and as cathodes on the under side. Vertical plate electrodes are, however, of greater practical interest in view of the attempts that are being made to develop processes for the electrodeposition of metals at high current densities in a flowing electrolyte⁵. In this latter case, free convection cannot be neglected, except at very high velocities for the forced flow.

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