CHAPTER - IV

SUMMARY AND CONCLUSIONS
The exchange of matter and energy, which is the principle function of living organism, takes place through membranes. Magnetic field influences the transport properties. Therefore, it was expected that the magnetic field applied across the membrane will effect the transport coefficient of the membranes. In view of this the study of transport processes under the influence of magnetic field was important, as both magnetic field and membranes have wide applications and the work could be extended to the cell of living membranes. In ancient times medical scientists used magneto-therapy for detecting and curing diseases of different nature. As a consequence of magnetic field applied to the biological cells or membranes there is disturbance in the mass transport across biological cells or membranes. It is with this importance, the present work was carried out.

The results and conclusions drawn from different studies have been summarized in terms of the following properties and studies

A. Hydrodynamic permeability
B. Electro-Osmosis
C. Membrane potential

(A). Hydrodynamic Permeability

(i) Permeability Coefficient

The volume flux \( J_v \) under the influence of pressure difference \( \Delta P \), can be given by the following equation if
concentration of the solution is same as both sides of the membrane.

\[ J_v = L_p \Delta P \]

where \( L_p \) is the permeability coefficient.

The value of \( L_p \) has been estimated from the slopes of linear plots of \( J_v \) versus \( \Delta P \).

The permeability coefficient, \( L_p \), decreases with increase in magnetic field and concentration but increases with increase in temperature in all cases. The effect of magnetic field decreases with increase in concentration.

\( L_p \) decrease with increase in voltage in all cases.

(ii) Frictional Coefficient

The permeability coefficient \( L_p \) can be related to the coefficient of friction \( f_{wm} \) between water and membrane, and it can be calculated by the following equation

\[ L_p = \Phi_w \bar{V}_w \| \delta f_{wm} \]

\[ f_{wm} = \Phi_w \bar{V}_w \| \delta L_p \]

where \( \Phi_w \) is the volume fraction of water in the membrane,

\( \bar{V}_w \) is the volume of water, and

\( \delta \) is the thickness of membrane.
Fwm, frictional coefficient, increases with increase in magnetic field strength for all cases. Fwm increases with increase in concentration indicating that water-membrane interaction increase with decrease in solute concentration. The increase in value of Fwm with increase in magnetic field strength is attributed to the formation of an ordered arrangement of magnetic dipoles in the solution due to magnetic field, which offer resistance to flow.

Fwm decreases with increase in temperature and increases with increase in voltage in all cases. Furthermore, the non-linear dependence of Fwm with concentration shows that Spiegler's frictional model is not valid under the influence of magnetic field.

(iii) Activation Parameters

(a) Enthalpy

The variation of permeability with temperature can be written as

$$\log L_p = \text{constant} - \frac{E_n^*}{RT}$$

where $E_n^*$ is the energy of activation,

$R$ is the gas constant, and

$T$ is the temperature

The value of $E_n^*$ can be estimated from the plots of log $L_p$ versus $1/T$. Equating energy of activation to enthalpy of activation $\Delta H^*$ for the flow.

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Enthalpy of activation \( \Delta H^* \) decreases with increase in magnetic field strength in all cases, but in water initially first decreases generally up to 8.0 KG and then increases up to 16.5 KG. The value of \( \Delta H^* \) increases with increase in concentration and voltage.

(b) **Entropy**

The entropy of activation, \( \Delta S^* \), can be estimated from the Eyring rate equation

\[
\eta = \frac{N\eta}{V} e^{-\frac{\Delta S^*}{R}} e^{-\frac{\Delta H^*}{RT}}
\]

\[
\Delta S^* = \frac{\Delta H^*}{T} + R \log \left( \frac{N\eta}{V} \right)
\]

where \( \eta \) is the viscosity of the liquid,

\( V \) is the molar volume,

\( N \) is the Avogadro's number, and

\( h \) is the Plank's constant.

Entropy of activation \( \Delta S^* \) have negative values which suggests that the flow through membrane is more ordered due to membrane-solution interactions. \( \Delta S^* \) decreases with increase in magnetic field strength but the value of \( \Delta S^* \) increases with increase in concentration and voltage.
(c) **Free Energy**

Activation free energy can be estimated from the equation

$$\Delta G^* = \Delta H^* - T \Delta S^*$$

The value of activation free energy decreases as the concentration increases.

(iv) **Equivalent Pore Radius**

The equivalent pore radius can be estimated by the equation

$$r_L = \left(8 \eta k L p / u_{\|} \right)^{1/2}$$

where $k$ is the specific conductance, and $r$ is the pore radius.

The equivalent pore radius decreases with increase in magnetic field strength and voltage but increases with increase in concentration and temperature in all cases.

The equivalent pore radius decreases with increase in magnetic field strength due to change in pore radius/structure of membrane.
(v) **Number of Pores**

The number of pores can be estimated by the equation

\[ n = \left( \frac{8 \eta L^2}{\pi \lambda R^4} \right) \]

where \( \eta \) is the viscosity of the liquid, and

\( \lambda \) is the pore radius.

Number of pores increases with increase in magnetic field strength and increase is more in case of mercuric chloride than others. This suggests that the structure weakens and more pores and holes are added or created in the membrane under the influence of magnetic field. The value of number of pores decreases with increase of concentration and temperature but the value of number of pores increases with increase in voltage.

(B) **Electro-Osmosis**

In electro-osmosis permeability of aqueous solutions of mercuric chloride, cadmium chloride, acetonitrile and dioxane, in the presence of and in the absence of magnetic field has been measured. The following conclusions have been drawn from the results.

(i) **Zeta Potential**

Electrical conductance of a membrane permeant interface can be expressed in terms of zeta potential.
According to double layer picture electro-osmotic permeability is given by the following expression

\[ L_{21} = \eta \delta^2 \varepsilon \frac{1}{\eta \delta} \]

\[ a = \frac{4 \eta \delta L_{21}}{\eta \delta^2} \]

where \( \varepsilon \) is the dielectric constant,

\( \delta \) is the thickness of membrane,

\( \eta \) is the coefficient of viscosity.

The value of zeta potential increases with increase in magnetic field strength, concentration and temperature. The value of zeta potential also increases with increase in voltage.

(C) Membrane Potential

(i) Membrane potential decreases with increase in concentration, magnetic field strength. The order of decreasing membrane potential in various salts is:

\[ \text{LiCl} > \text{NaCl} > \text{KCl} \]

(ii) The maximum value of membrane potential is given by

\[ \left[ (\Delta \phi)_{T=0} \right]_{\text{max}} = R T \ln a_i a_2 \]
The maximum value of membrane potential increases with increase of concentration in all cases and the order of decreasing maximum membrane potential in various salts is:

\[ \text{LiCl} > \text{NaCl} > \text{KCl} \]

(iii) Teorell-Meyers-Siever theory has been used to evaluate the ionic transport number for all three salts. The transport number of ions \( t_i \) in the membrane phase shall be estimated from the membrane potential

\[ t_i = \frac{(\Delta \phi)_{I=0}}{2((\Delta \phi)_{I=0})_{\text{max}}} + 0.5 \]

The transport number decreases with increase in concentration and it also decreases with increase in magnetic field strength in all cases. The order of decreasing in transport numbers in various salts is

\[ \text{LiCl} > \text{NaCl} > \text{KCl} \]

(iv) **Permselectivity (Ps)**

The relative case with which a counter ion migrates through a membrane is expressed in terms of permselectivity
and it is estimated from

$$P_s = \frac{t_+}{t_+ - (2t_+ - 1)t_+}$$

where $t_+$ and $t_-$ are transport numbers of the cation and anion respectively.

Permselectivity ($P_s$) decreases with increase in concentration and magnetic field strength. The order of decreasing permselectivity in various salts is

$$LiCl > NaCl > KCl$$

(v) **Fixed Charged Density**

Fixed charged density $\Delta \phi_x$ is estimated from the equation

$$\Delta \phi_x = \frac{2cP_s}{\sqrt{1 - P_s^2}}$$

where $c$ is the mean concentration of solution on both sides of membrane.

Fixed charged density first decreases with increase in concentration upto 0.06m and decreases upto 0.10m in case of KCl and increases with increase in concentration in all
other cases. The value of fixed charged density decreases with increase in magnetic field strength in all cases. The data shows that the fixed charge density depends on counter-ions and the fixed charged density decreases in the order given below:

\[ \text{Li}^+ > \text{Na}^+ > \text{K}^+ \]