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Decoding Magnetic Influence:- Physical Parameters Evaluation Of Aqueous Acetonitrile Through Polymeric Membrane.

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Abstract

The polymeric membrane is used in the present study was prepared by impregnating cellulose acetate dissolved in acetone and aqueous solution of potassium bromide. The flow of water and aqueous solution of acetonitrile through this membrane has been measured at different temperature, composition and magnetic field strengths. The electro osmotic permeability coefficient , enthalpy of activation (ΔH^*), entropy of activation (ΔS^*) , free energy of activation (ΔG^*) , number of pores, pore radius and zeta potential have also been calculated. The flow process of aqueous solution of acetonitrile is thermodynamically not feasible. The dipolar nature of aqueous solution of acetonitrile mixture does affect the membrane structure which is shown by variation in number of pores, pore radius[1] and zeta potential[2-7].

Introduction

Membrane transport phenomena have been the focus of attention and widespread, brisk research activity ever since the utility of variously formed membranes for accomplishing separations of practical interest and their importance in biology work were recognised. An overriding concern of membranologists has always been the development of correlations between membrane structure, properties and function. In spite of powerful tools having become available for such investigations, success on this front has been somewhat limited. Most often the phenomenological approach is preferred, where an attempt is made to understand the behaviour of membranes on the basis of the transport characteristics they exhibit, with the view to ascertain their suitability for accomplishing stipulated tasks. A membrane has been recognised as a thin polymeric film that exhibits permeability to more than one species. The role of the membrane is to act as a selective barrier which allows passage of a certain component out of the mixture. Macroscopic processes like filtration do not rely on the molecular properties of a membrane. The transmission rate through the membrane is expected to be different for each component. For example, permeation through polymeric membranes usually involves both diffusibility and solubility of the permeant species. The first application of the membrane process is given by Staverman [8]. Non-equilibrium thermodynamic studies have been conducted in liquid mixtures in this context. In order to study the concentration dependence of phenomenological coefficients and to verify Onsager relations. In the present study we have carried out the discussion on hydrodynamic flow and electro-osmotic flow for aqueous solutions of acetonitrile at different compositions under different magnetic field strengths at different temperatures. From hydrodynamic permeability, the electro-osmotic permeability coefficient and thermodynamic parameters[9-11] have been calculated. The number of pores, pore radius and zeta potential for the membrane can also be calculated for different concentrations of acetonitrile in water.

Experimental details

1. Reagents
a. Cellulose acetate: AR Grade Riedle Germany
b. Acetone: AR Grade
c. Potassium bromide: E-Merck
d. Acetonitrile: AR Grade
e. Water : Ordinary tap water distilling twice over alkaline potassium permanganate and potassium dichromate in all glass apparatus. The specific conductance of water so obtained was 1-4 x 10^{-7} Scm^{-1} at 25^0C and pH in the range of 6.5 -7.0 at 298K.
f. Mercury: Mercury was purified by distilling under reduced pressure .

It is significant to mention here that all the solution were prepared by weight

2. Preparation of membrane: Cellulose Acetate was dissolved in acetone and mixed up with water to which potassium bromide has been added the materials were taking in the proportion 22.2:66.7:10.0: 1.1 respectively. The cellulose acetate was impregnated into previously thoroughly washed and dried filtered G_2 disc under vacuum at 0.0- 0.5 ^0C. After impregnation the disk was then immersed in hot water at 75-80 ^0C for 24 hours before performing the experiments in order to avoid fluctuation in the permeability of the membrane. The membrane

was prepared by impregnation and it was expected that the flow and there fore, the values of efficiencies of energy conversion mode show a significant change on reversal of the direction of the applied thermodynamic forces all the measurements were carried out in the direction of impregnation.

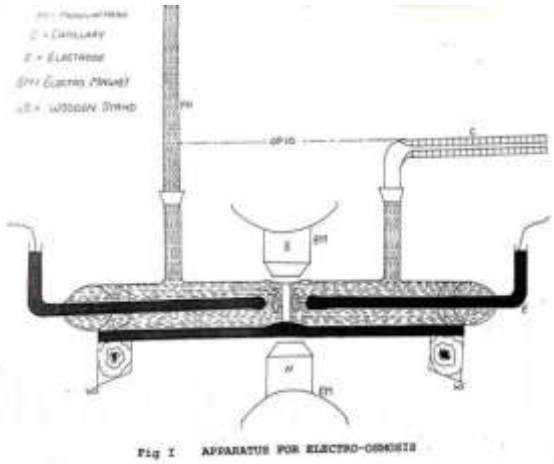


Figure 1

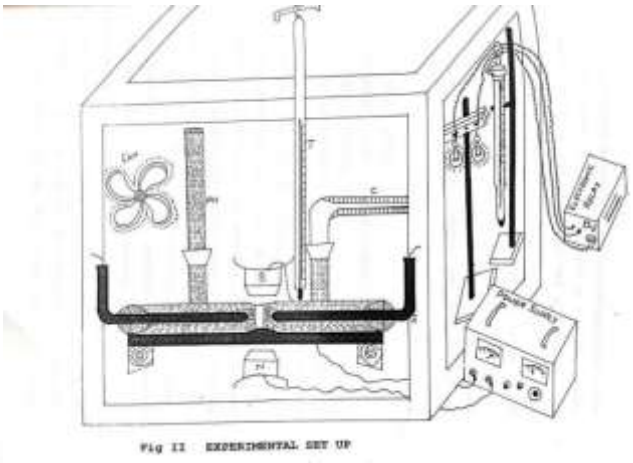


Figure 2

Results and discussion

1. Determination of volume flux (J_V) and hydrodynamic permeability (L_P)

According to of Irreversible thermodynamic processes [12,13] the dissipation function [14] for the transport processes of liquids through a membrane under the influence of pressure difference can be written as

$\phi = J_V \Delta P + J_D \Delta \Pi$ ----------1

J_V = volume flux per unit area of the membrane

J_D = diffusional flow

ΔP = hydrostatic pressure difference

$\Delta \Pi$ = difference in osmotic pressure across the membrane

The linear phenomenological equations relating to flow and forces are given as

$J_V = L_P \Delta P + L_{Pd} \Delta \Pi$ ---------2

$J_D = L_{Pd} \Delta P + L_d \Delta \Pi$ ----------3

Onsager reciprocity relation[15] is

$L_{Pd} = L_{dP}$----------4

L_P and L_d = the mechanical coefficients of filtration and diffusion respectively and L_{Pd} and L_{dP} represents Onsager coefficients.

$\Delta \Pi = RT \Delta C$ ----------5

$\Delta \Pi$ = difference in osmotic pressure across membrane

R= Gas constant

T= temperature

ΔC= change in concentration

In experiment when the concentration of solution is same on both sides of membrane $\Delta \Pi = 0$ and if pressure difference is maintained across the membrane there exists of volume flux (J_V) .The values of J_V (volume flux of water and aqueous solution of acetonitrile) at different pressure, temperature and magnetic field strength across cellulose acetate membrane are calculated as

$J_V = \left(\frac{dx}{dt}\right)\left(\frac{r_i^2}{R_i^2}\right)$ ----------6

x = distance travelled by experimental liquid

t = time taken to travel the distance x

r_i = the radius of capillary

R_i = radius of membrane

The radius of capillary was estimated with the help of travelling microscope supplied by Almicro VM-1 for this purpose, mercury was taken in the capillary Which was measured with the help of the travelling microscope several times the weight of mercury feeling the capillary was noted with the help of equation number 7

$w = \pi r_i^2 dl$-------7

w = weight of mercury

d = density of mercury filling

l = length of the mercury in capillary,

Density of various solutions were determined with the help of calibrated pycnometer .The values of J_V when the membrane was filled by pure water and for aqueous acetonitrile are reported in table 1 and 2 respectively .

Table-I: Hydrodynamic permeability data for water at different temperature and magnetic field strength Across cellulose acetate membrane

Jv x 10^6(m s^{-1})

ΔP x 10^{-3} (Nm^{-2})	Magnetic Field Strength (KG)				
	0.0	4.0	8.0	12.0	16.5
			303K		
1.954	14.4	14.3	12.1	10.0	9.54
2.442	16.6	16.1	15.4	15.1	14.08
2.930	18.3	17.4	16.3	15.8	15.10
3.419	21.1	20.2	19.4	18.3	18.21
3.907	24.1	23.4	23.0	21.2	20.01
			308K		
1.951	16.3	15.5	15.01	14.2	12.04
2.440	19.4	18.6	17.91	17.1	16.3
2.912	22.4	22.1	21.2	20.3	19.1
3.302	23.8	23.2	22.1	21.4	20.6
3.814	28.2	27.3	26.2	25.4	24.6
			313K		
1.921	19.6	19.0	18.6	18.3	17.1
2.341	22.3	21.8	21.1	20.2	19.4
2.882	24.7	23.8	23.1	22.2	21.3
3.218	25.8	25.1	24.2	23.4	22.1
3.772	31.4	30.3	29.1	28.8	27.2

Table-2: Hydrodynamic permeability data for acetonitrile at different temperature, concentration and magnetic field strength across cellulose acetate membrane

Jv x 10^6(m s^{-1})

ΔP x 10^{-3} (Nm^{-2})	Magnetic Field Strength (KG)				
	0.0	4.0	8.0	12.0	16.5
20%					
303K					
0.960	13.77	13.55	13.33	13.28	13.02
1.450	18.40	18.34	18.25	18.21	17.79
1.920	22.73	21.41	20.59	19.55	19.01
2.410	28.39	27.03	26.32	25.00	24.31
2.890	31.77	30.55	29.44	29.02	28.00
308K					
0.960	16.69	16.02	15.42	14.64	13.71
1.440	18.73	18.12	17.31	16.42	15.20
1.920	22.40	21.83	21.27	21.01	19.72
2.410	29.80	29.12	28.71	27.58	26.02
2.890	32.79	32.31	31.82	31.04	30.54
313K					
0.950	18.03	17.52	17.11	16.42	16.20
1.430	20.30	20.08	19.59	18.49	18.21
1.910	25.66	25.50	24.48	24.03	23.72
2.380	30.05	29.81	29.01	28.71	28.22
2.860	35.48	35.03	34.67	34.04	33.61

40%					
303K					
0.920	11.57	11.11	10.04	9.51	9.11
1.380	15.23	14.52	14.18	13.54	13.24
1.840	20.83	20.68	19.65	19.11	18.23
2.300	24.29	23.56	22.72	21.74	20.40
2.770	26.66	26.04	25.59	25.12	24.76

308K					
0.910	13.77	13.44	13.28	12.84	12.12
1.360	17.79	17.04	16.69	16.15	15.42
1.820	23.80	23.10	22.07	21.70	21.04
2.270	26.76	26.04	25.92	25.18	24.76
2.740	30.92	30.08	29.69	29.05	28.21

313K					
0.890	16.52	16.18	15.54	15.23	14.95
1.340	20.81	20.08	19.74	18.21	17.78
1.790	25.01	24.40	23.80	23.71	21.01
2.230	27.48	27.02	26.91	26.22	25.24
2.640	32.25	31.30	29.40	28.77	27.32

60%					
303K					
0.870	9.85	9.66	8.62	8.21	7.24
1.310	13.51	12.82	12.35	11.36	11.21
1.750	18.38	18.32	17.55	17.18	16.14
2.180	21.74	21.28	20.40	20.00	19.21
2.630	25.00	24.40	23.80	23.30	21.30

308K					
0.860	12.82	12.50	11.36	10.63	10.12
1.290	15.62	15.38	14.70	14.49	13.22
1.730	20.41	19.61	18.52	18.86	17.24
2.160	25.55	25.02	24.13	23.59	23.11
2.590	28.50	28.72	27.51	26.21	26.07

313K					
0.850	15.70	15.15	14.12	13.07	12.24
1.270	18.83	18.32	17.21	16.12	15.82
1.710	23.52	23.19	22.13	21.82	21.04
2.130	26.69	26.08	25.87	25.36	24.42
2.560	30.85	30.73	29.63	28.85	27.87

2. Determination of hydrodynamic permeability[16,17] (L_P)

when concentration of solution is a same on both the sides of the membrane then $\Delta\Pi=0$ the volume flow of equation 2 can be given as

$J_V = L_P \Delta P$-------8

L_P = hydrodynamic permeability of the membrane for the experimental liquid . L_P has the character of mobility and represents the velocity of experimental liquid per unit pressure difference for the unit across sectional area of the membrane the value of L_P can be estimated from the linear plots of J_V and ΔP for water and aqueous solution of acetonitrile.

J_V = volume flux per unit area of the membrane

ΔP= hydrostatic pressure difference

The values of hydrodynamic permeability calculated using equation 8 for water and various aqueous solutions have been reported in table 3 it is clear that L_P varies non linearly with pressure as in figure 3

Table-3: Permeability coefficient (L_p) of aqueous solutions of acetonitrile across cellulose acetate membrane at different magnetic field strength, temperature and concentration.

$L_p \times 10^8 (m^3\ M^{-1}\ sec^{-1})$

Conctration ($m\ L^{-1}$)	Magnetic Field Strength (KG)			
	0.0	4.0	8.0	12.0
303K				
20	0.38	0.37	0.33	0.32
40	0.37	0.30	0.29	0.29
60	0.27	0.26	0.25	0.25
308K				
20	0.50	0.47	0.47	0.45
40	0.39	0.37	0.36	0.35
60	0.33	0.32	0.31	0.24
313K				
20	0.54	0.51	0.50	0.49
40	0.51	0.43	0.42	0.42
60	0.48	0.46	0.42	0.40

3. Determination of frictional coefficient

The frictional coefficient of the phenomenology coefficient in the transport processes through membrane has been given by Kedem and Katchalsky[14] . The explicit treatment of frictional forces may be approach by considering the simple case of water filtration through membrane if pure water is placed on both sides of the membrane then the driving force provided by a difference in pressure which is balanced by mechanical filtration force between water and membrane matrix under the condition of steady flow, therefore the mechanical filtration force X_{wm} is given by equation number 9

$X_{wm} = F_{wm} (V_w - V_m)$ ---------9

F_{wm} = coefficient of friction between water and the membrane and it is measured of resistance offered by the membrane to water penetration

V_M and V_w = the volume of mixture and water respectively.

The simple use of translation of thermodynamic coefficient into frictional coefficient the permeability coefficient L_P can be related to coefficient of friction F_{wm} by a simple relation equation number 10

$$L_P = \frac{\Phi_w \bar{V}_w}{\delta F_{wm}} \text{----------10}$$

Φ_w = water content of the membrane and is expressed as the volume fraction of the total membrane volume and is numerically equal to fraction of membrane surface available for the permeation of solution. It was determined by the method described by Ginzberg and Katchalsky[18] and the value obtained was 0.021.

δ = thickness of the membrane and value in the given case is 4.5×10^{-3}m

$\bar{V}_w$ = molar volume of water

The values of coefficient of friction calculated using equation 10 solutions have been reported in table 4

Table-4: Frictional coefficient of aqueous solutions of acetonitrile across cellulose acetate membrane at different magnetic field strength, temperature and concentration.

$F_{wm} \times 10^{-10} (m^{-1}\ mol^{-1}\ NS)$

Conctration ($m\ L^{-1}$)	Magnetic Field Strength (KG)				
	0.0	4.0	8.0	12.0	16.5
303K					
20	2.11	2.17	2.44	2.51	2.68
40	2.46	2.68	2.77	2.77	3.09

60	2.98	3.09	3.21	3.21	3.49
308K					
20	2.17	2.17	2.23	2.30	2.36
40	2.36	2.41	2.41	2.49	2.74
60	2.44	2.51	2.59	3.35	3.65
313K					
20	1.49	1.87	1.91	1.91	1.96
40	1.58	1.88	1.98	1.99	2.07
60	1.67	1.95	2.08	2.01	2.17

4. Determination of enthalpy of activation (ΔH^*), entropy of activation (ΔS^*) and free energy of activation (ΔG^*)
Different membranes used in alternate energy devices have been characterised in terms of parameters of activation .The variation of hydrodynamic permeability with temperature can be written as equation number 11

$\ln L_p = k - \frac{E_n}{RT}$ ----------11

k = constant
E_n= energy of activation
R = gas constant
T = temperature

Energy of activation can be taken as enthalpy of activation [19] (ΔH^*). By using Eyring equation [20] for the flow entropy of activation is calculated from equation 12

$$\eta = \frac{Nh}{\frac{\Delta S^*}{\bar{V} e^{R}} e^{\frac{\Delta H^*}{RT}}} \quad \text{----------12}$$

η = viscosity of liquid
$\bar{V}$ = molar volume
N= Avogadro's number
h= Planks constant
equation 12 can be written as

$\Delta S^* = \frac{\Delta H^*}{T} + R\, ln(\frac{Nh}{\eta \bar{V}})$ --------13

ΔH^* = enthalpy of activation
ΔS^* = entropy of activation
The free energy of activation can be calculated from equation 14

$\Delta G^* = \Delta H^* - T\Delta S^*$----------14

ΔG^* = free energy of activation
The estimated values of ΔH^*, $\Delta S^*$and ΔG^*have been recorded in Table 5-7
Enthalpy of activation is ploted against magnetic field strength .Its sample graph is in figure 3

Table-5: Enthalpy of activation for aqueous solutions of acetonitrile across cellulose acetate membrane at different magnetic field strength and concentration.

ΔH^* X 10^3(J mol^{-1})

Concentration (m L^{-1})	Magnetic Field Strength (KG)				
	0.0	4.0	8.0	12.0	16.5
20	2.17	2.22	2.24	2.32	2.44
40	2.49	2.92	3.25	3.26	3.30
60	3.82	3.99	4.15	4.32	4.57

Table-6: Entropy of activation for aqueous solutions of acetonitrile across cellulose acetate membrane at different magnetic field strength and concentration.

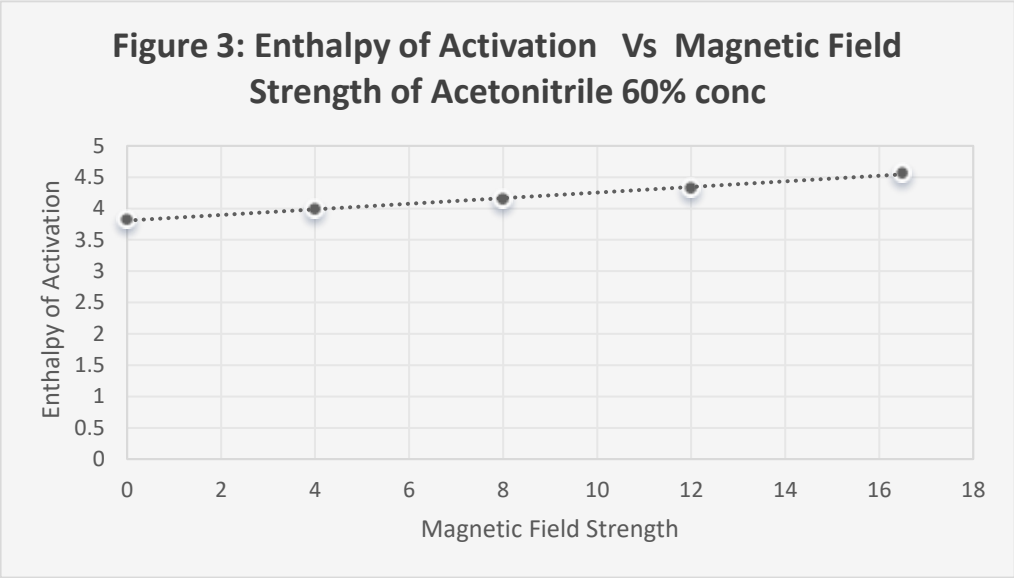
ΔS^* (J mol^{-1})

Concentration (m L^{-1})	Magnetic Field Strength (KG)				
	0.0	4.0	8.0	12.0	16.5
20	-81.96	-81.77	-81.72	-81.44	-81.11
40	-76.12	-74.69	-73.63	-73.57	-73.46
60	-74.61	-74.06	-73.51	-72.96	-72.11

Table-7: Free Energy of activation of aqueous solutions of acetonitrile across cellulose acetate membrane at different magnetic field strength and concentration.

$\Delta G^* \times 10^4$ (J mol^{-1})

Concentration (m L^{-1})	Magnetic Field Strength (KG)				
	0.0	4.0	8.0	12.0	16.5
20	2.70	2.70	2.70	2.70	2.70
40	2.55	2.55	2.55	2.55	2.55
60	2.64	2.64	2.64	2.64	2.64



5. Determination of equivalent pore radius and number of pores

Magnetic field when applied on the membrane exerts change in structure of the membrane which has been characterised in terms of pore radius , number of pores and zeta potential, expressing the electrical character of membrane permanent interface. These parameters can be estimated in the light of capillary model , according to which a porous membrane is supposed to be composed of a bundle of 'n' capillaries entering a porous medium on the face and emerging on opposite face. Although any structure of the porous medium is not simple as describe by capillary model yet it has been successfully used by many authors [21-24] according to this model question 16 can show

$L_{22} = \frac{n\pi r^4}{8\eta\delta}$ ----------15

$L_{11} = \frac{nk\pi r^2}{\delta}$ --------16

L_{22} = hydrodynamic permeability

L_{11}= electric conductance of the membrane

n = number of pores

r= equivalent pore radius

η = the absolute viscosity

k = specific conductance

Equivalent radius for different systems across cellulose acetate membrane at different magnetic field strength has been calculated by rearranging the equation 15 and 16 as

$r = \frac{8\eta k L_{22}}{(L_{11})^{1/2}}$ ----------17

It is possible to calculate pore radius of membrane . Now number of capillaries can be easily calculated.

The number of pores for different systems across cellulose estate membrane has been calculated by arranging equation 15 as

$n = \frac{8\eta k L_{22}}{\pi r^4}$ ---------18

The values of 'r' and 'n' obtained membrane have been recorded in cables 8 and 9

Pore radius and no. of pores plotted against magnetic field strength. Its sample graphs are in figures 4,5.

Table-8 Pore radius of aqueous solutions of acetonitrile across cellulose acetate membrane at different magnetic field strength, temperature and concentration.

r x 10^4(m)

Conctration (m L^{-1})	Magnetic Field Strength (KG)				
	0.0	4.0	8.0	12.0	16.5
303K					
20	1.58	1.56	1.47	1.45	1.45
40	1.25	1.09	1.07	1.07	1.02
60	0.87	0.85	0.83	0.83	0.80
308K					
20	1.58	1.58	1.56	1.54	1.52
40	1.43	1.39	1.39	1.36	1.35
60	0.94	0.92	0.88	0.86	0.83
313K					
20	1.89	1.69	1.67	1.67	1.65
40	1.60	1.60	1.59	1.57	1.54
60	0.98	0.96	0.95	0.84	0.80

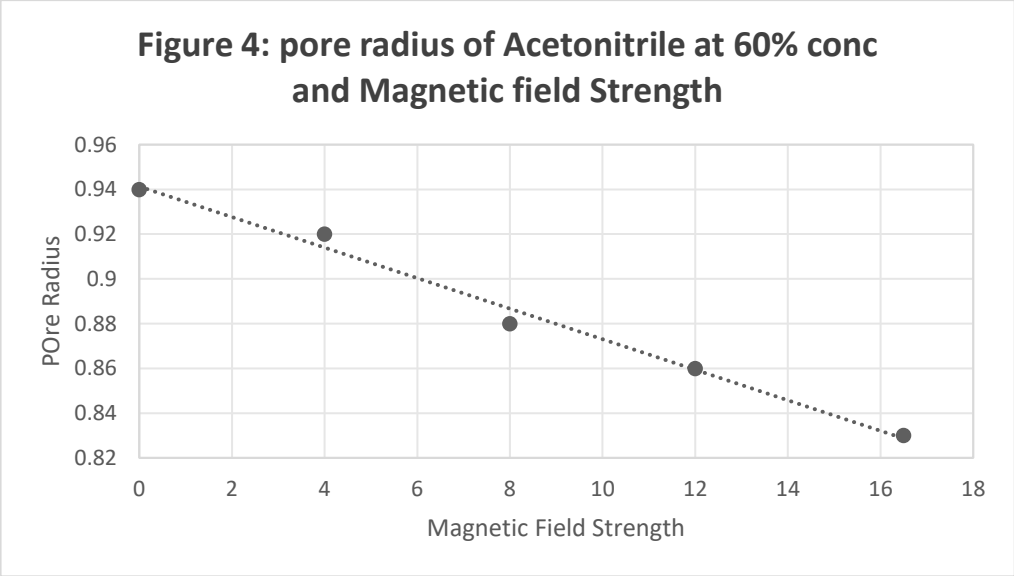
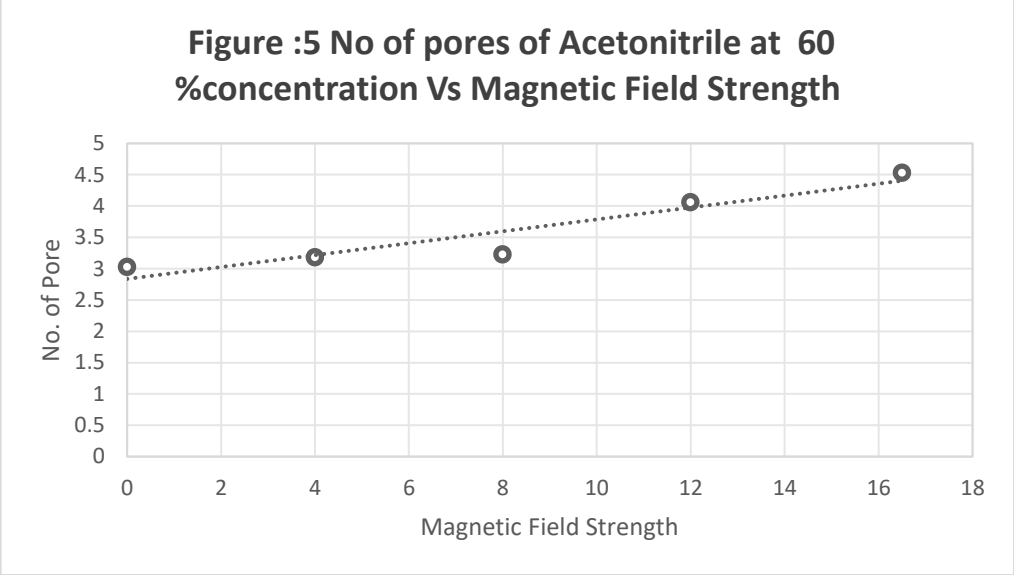


Table-9:Number of pores of aqueous solutions of acetonitrile across cellulose acetate membrane at different magnetic field strength, temperature and concentration.

n x 10^{-5}

Conctration (m L^{-1})	Magnetic Field Strength (KG)				
	0.0	4.0	8.0	12.0	16.5
303K					
20	0.65	0.67	0.76	0.78	0.78
40	1.60	2.13	2.21	2.21	2.40
60	4.33	4.57	4.86	4.86	5.13
308K					
20	0.57	0.57	0.58	0.60	0.61
40	1.09	1.15	1.15	1.20	1.21
60	3.03	3.18	3.23	4.06	4.53
313K					
20	0.39	0.49	0.50	0.50	0.52
40	0.67	0.67	0.68	0.70	0.72
60	4.97	5.16	5.66	5.88	5.36



6. Determination of Zeta potential(ζ)

Zeta potential (ζ) plays important role in very applications such as micro fluids [25-27] colloid chemistry[28-29] and membrane fouling. The zeta potential is influenced by surface composition , as well as solution properties such as a nature of the ions and ionic strength. Measurement of streaming potential in channel geometry is the most commonly used technique for characterizing zeta potential of flat surfaces. However electrophoresis[30] have also been used to characterise zeta potential .

Electrical character of the membrane interface can be expressed in terms of zeta potential. Zeta potential is an informative property directly related to electro kinetic charge density .In case of technical membranes for example zeta potential is believed to be correlated with the mechanism of rejection of charged solute and with the interactions between membrane surface and various charged for foulants (colloidal and macro molecular). Experimentally zeta potential of macroscopic surface is obtained is from the measurement of streaming potential according to double layer picture the overbeak analysis of electro kinetic effects [31] the electro osmotic permeability is given by equation 19

$L_{21}=L_{12}=\frac{n\zeta\epsilon r^2}{4\eta\delta}$----------19

$L_{21}=L_{12}$= electro osmotic permeability

ϵ = dielectric constant

ζ = Zeta potential of solid liquid interface

Equation 19 can be rearranged to calculate ζ

$\zeta=\frac{4\eta\delta}{n\epsilon r^2}L_{12}$--------20

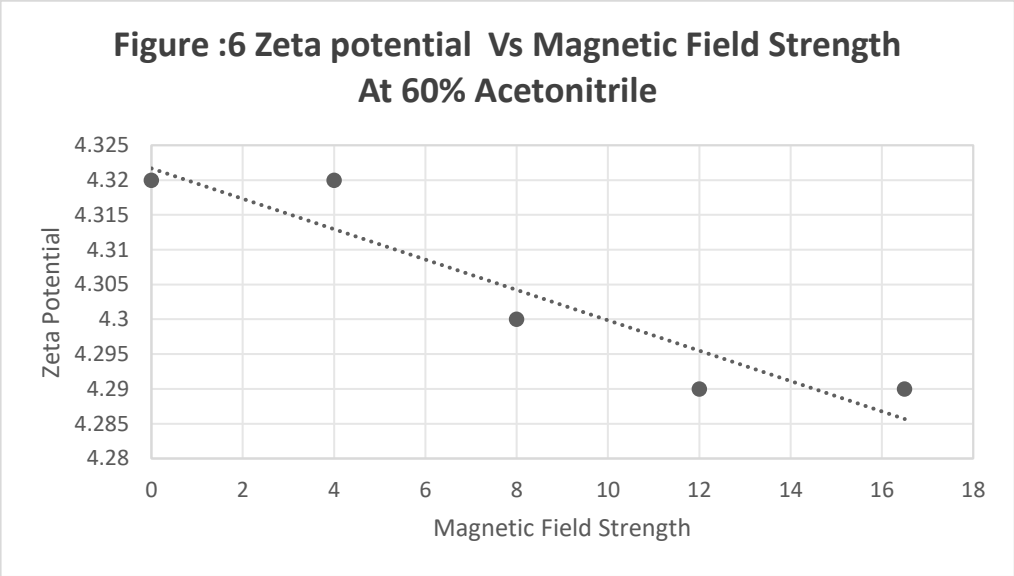
The values of zeta potential obtained for membrane have been recorded in table 8

Zeta potential plotted against magnetic field strength is given in figure 6.

Table-8: Zeta potential of aqueous solutions of acetonitrile across cellulose acetate membrane at different magnetic field strength, temperature and concentration.

Ɛ x 10^4(v)

Conctration (m L^{-1})	Magnetic Field Strength (KG)				
	0.0	4.0	8.0	12.0	16.5
303K					
20	0.86	0.85	0.85	0.84	0.84
40	1.26	1.24	1.24	1.24	1.23
60	2.68	2.68	2.67	2.67	2.66
308K					
20	2.17	2.12	1.86	1.85	1.73
40	2.64	2.64	2.62	2.62	2.60
60	4.32	4.32	4.30	4.29	4.29
313K					
20	2.39	2.34	2.29	2.14	2.13
40	5.27	5.36	5.25	5.23	5.23
60	6.17	6.17	6.16	6.16	6.10



7. Discussion of results

The data of J_V shows that it decreases with increase in composition and magnetic field strength of acetonitrile and increase with temperature. The addition of acetonitrile in water disturbs the dipole distribution and as a result structural rearrangement takes place. Further theHydrodynamic permeability[37-42] is inversely proportional to the viscosity and effect of magnetic field on permeability coefficient (L_P)of membrane is similar to the effect of magnetic field on viscosity [21,22]. The effect of magnetic field on permeability coefficient L_P is much more pronounce to them on viscosity of solutions. This suggests the membrane structure under the influence of magnetic field also changes. However the structural changes of membrane shall be limited to its porocity and to the electrostatic charge density Which the membrane may have on the surface or on the inside walls. Under the influence of the membrane the ions present in the solution get aligned in a particular fashion in the forms of dipoles, parallel to the direction of magnetic field. The decrease in permeability coefficient L_P with the magnetic field strength may therefore, be attributed to the increase in dipole dipole interactions and structural changes of the membrane. Recently it has been reported in [32] that there is an orientation of cellulose micro crystals by magnetic field and same the effect maybe asssumed to affect the structure of the membrane in such a way that the values of permeability coefficient decreases under magnetic field strength.

In general the value of frictional coefficient shows increase with increase of magnetic field strength. However the rise in temperature F_{wm} values do not show a regular trend the variation in the value of F_{wm} can be correlated to the structural consequences resulting from interactions of water acetonitrile dipoles at the given composition. The membrane solution interactions also vary with the content of acetonitrile of the medium . The non linear dependence of F_{wm} with composition shows that Spiegler's [33] frictional model is not valid under the influence of magnetic field.,

In thermodynamic parameters[43-46] , the value of ΔH^* increases with increase in magnetic field strength in all cases The ΔS^* values also increase in magnetic field strength and composition and has all negative values which suggest that the flow through membrane is more ordered due to membrane solution interaction.

The value of ΔG^* so slide decrease with increase in acetonitrile composition in the solution remain almost constant with increase in magnetic field strength the positive values of ΔG^* in all cases shows that flow is not favored across the porous medium.

The data suggest that equivalent pore radius[47-51] decreases with the increase of magnetic field strength this may be attributed to the change in the poor structure[34] of the membrane. Number of pores[35,36] increase with increase in magnetic field strength suggest a change in total physical characteristics of the membrane the decrease of equilateral radius may also suggest structure of membrane and diameter vary which may attributes to the increase in number of pores[52-54] in the membrane with the change in its structure.

The data suggests that the value of ζ decrease with increase in magnetic field strength increase in concentration and temperature.

4. Conclusion

The results of the present study indicate that the dipolar interaction between the two solvents (water and acetonitrile) are influenced by the strength of the magnetic field. As the magnetic field intensity increases, variations are observed in the pore radius, number of pores, and zeta potential of the membrane. These changes reflect the structural modifications of the membrane caused by the magnetic field. As the value of ΔG^* is positive the flow process of aqueous solution of acetonitrile is thermodynamically[34] not feasible.

List of symbols
J_V = volume flux per unit area of the membrane
J_D = diffusional flow
ΔP = hydrostatic pressure difference
ΔΠ = difference in osmotic pressure across the membrane
ΔΠ = difference in osmotic pressure across membrane
R= Gas constant
T= temperature
ΔC= change in concentration
x = distance travelled by experimental liquid
t = time taken to travel the distance x,
r_i = the radius of capillary
R_i = radius of membrane
w = weight of mercury
d = density of mercury filling
l = length of the mercury in capillary,
L_P = hydrodynamic permeability of the membrane
J_V = volume flux per unit area of the membrane
ΔP= hydrostatic pressure difference
F_{wm} = coefficient of friction between water and the membrane
V_M and V_w = the volume of mixture and water respectively.
ϕ_w = water content of the membrane
δ = thickness of the membrane
$\bar{V}_w$ = molar volume of water
k = constant
E_n = energy of activation
R = gas constant
P = temperature
η = viscosity of liquid
$\bar{V}$ = molar volume
N= Avogadro's number
h= Planks constant
ΔH^* = enthalpy of activation
ΔS^* = entropy of activation
ΔG^* = free energy of activation
L_{22} = hydrodynamic permeability
L_{11}= electric conductance of the membrane
n = number of pores
r= equivalent pore radius
η = the absolute viscosity
k = specific conductance
L_{21}=L_{12}= electro osmotic permeability
ϵ = dielectric constant
ζ = Zeta potential of solid liquid interface

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