Studies on Stigmasterol Liquid Membranes

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Synopsis. Cellulose acetate supported stigmasterol liquid surfactant membrane has been characterized by measuring membrane potentials, using NaCl solutions of different concentrations. Fixed charge density, $\phi\overline{X}$, permselectivity, P_s, have been estimated from ionic transport numbers. Variation of membrane potential with pH and concentration of NaCl solution has also been examined.

Experimental

Cellulose acetate film was prepared as reported elsewhere.[1] The thickness of the film used was 7×10^{-5} m and its cross-sectional area was 1.73×10^{-4} m^2. Water content determined as usual[2,3] was found to be 11.5%.

Results and Discussion

Liquid membranes are formed at every interface encountered by a surfactant solution. Such membranes are of immense importance owing to many of their biological and technological applications.[4—8] The formation of liquid membrane was ascertained by measuring membrane resistance using stigmasterol suspensions of different concentrations. The resistivity changed due to accumulation of stigmasterol in the interfacial region, approaching a constant value after 3—4 h (Fig. 1). Membrane potential was measured using the experimental cell of the type:

Reference Calomel Electrode	Solution	Membrane	Solution	Reference Calomel Electrode

The formation of liquid membrane results in the lowering of membrane potential as it is clear from membrane potential values given in Table 1.

For cellulose acetate which is practically uncharged, the selectivity is considerably low. Permselectivity was estimated using the equation[9]

$$P_s = \frac{\bar{t}_+ - t_+}{t_+ - (2t_+ - 1)\,\bar{t}_+}. \tag{1}$$

The transport number on the basis of TMS theory may be given as [10]

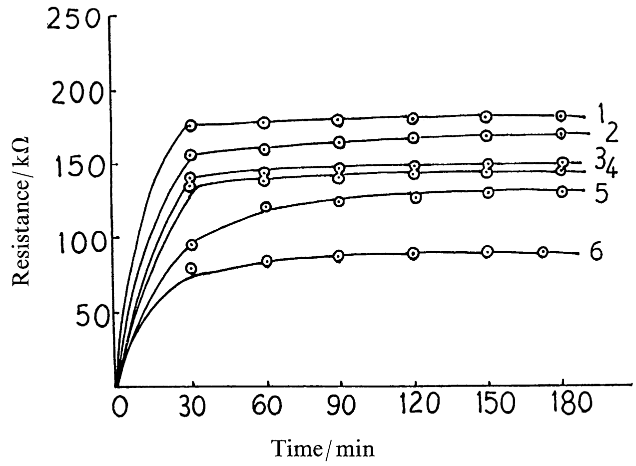

Fig. 1. Variation of resistance with time during liquid membrane formation 1, 30 nM; 2, 25 nM; 3, 20 nM; 4, 15 nM; 5, 10 nM; 6, 5 nM.

Table 1. Membrane Potential Data

Mean concn / mol dm^{-3}	C_1 / mol dm^{-3}	C_2 / mol dm^{-3}	E/mV With Stigmasterol	E/mV Without Stigmasterol
0.075	0.10	0.05	6.8	7.3
0.15	0.20	0.10	6.2	6.8
0.30	0.40	0.20	5.7	5.9
0.60	0.80	0.40	4.9	5.1
0.75	1.00	0.50	4.0	4.5

Table 2. Transport Numbers Derived Using Eq. 2

Mean concn / mol dm^{-3}	f_1	f_2	E_{max}/mV	Cellulose acetate $\bar{t}_+$ Without Stigmasterol	Cellulose acetate $\bar{t}_+$ With Stigmasterol	t_+
0.075	0.7730	0.8336	16.13	0.7107	0.7232	0.402
0.15	0.6949	0.7730	15.31	0.7024	0.7219	0.392
0.30	0.5976	0.6949	14.15	0.7013	0.7083	0.388
0.60	0.4828	0.5976	12.52	0.6955	0.7035	0.379
0.75	0.4430	0.5623	11.87	0.6684	0.6895	0.376

$$\bar{t}_{+}=\frac{E}{2E_{\max}}+0.5, \quad (2)$$

where the symbols have their usual meaning. A simplification of TMS theory gives:

$$E=\frac{RT}{F}(2\bar{t}_{+}-1)\ln\frac{a'}{a''} \quad (3)$$

and if the membrane is ideally selective,

$$E_{\max}=\frac{RT}{F}\ln\frac{a'}{a''}. \quad (4)$$

Permselectivity is related to fixed charge density as[11]

$$\phi\bar{X}=\frac{2\bar{C}P_s}{\sqrt{1-P_s^2}}, \quad (5)$$

where $\bar{C}$ is the mean concentration. Transport numbers derived using Eq. 2 alongwth the values of $E_{\max}$ and activity coefficient (f_1 and f_2) using Eq. 4 are given in Table 2. The values of t_+ (solution) have been obtained from Ref. 12. Permselectivity and and fixed charge density values derived using Eqs. 1 and 5 are given in Table 3. It is clear that the fixed charge density increases with increasing mean concentration.

Cellulose acetate is reported[13] to contain a low concentration of weakly ionizable carboxyl group. In Fig. 2 the membrane potential against pH has been plotted, which shows that due to reduction in selectivity of the cellulose acetate, membrane potential increases with decreasing pH values. A steady increase in the values of membrane potential has been observed when cellulose acetate film supports stigmasterol liquid membrane. Table 4 includes the values of permselectivity and fixed charge density at different pH values.

The values for various parameters in the case of stigmasterol liquid membrane supported on cellulose acetate film are larger than those obtained by Singh and Tiwari,[1] showing that it is more effective surfactant than cholesterol. This may be attributed to basic structural difference between stigmasterol and cholesterol. Stigmasterol inspite of having the same skeleton as cholesterol, possesses a double bond in the side chain. The presence of two sp^2 carbons, which essentially have higher electronegativity than sp^3, would be responsible for enhanced surface activity of stigmasterol leading to

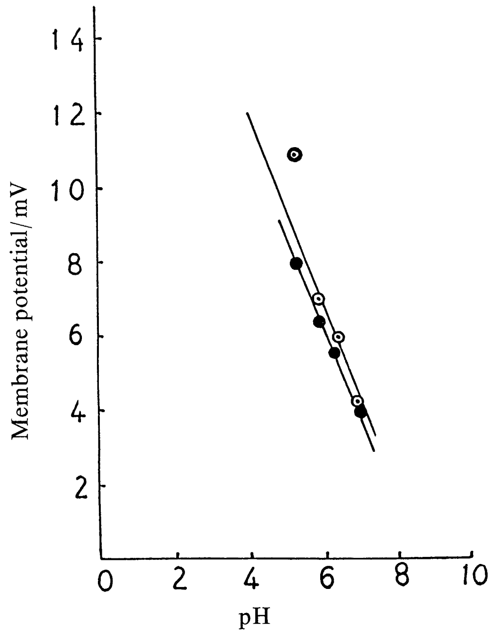

Fig. 2. Variation of membrane potential with pH: ⊙ without stigmasterol, ● with stigmasterol. Mean concentrations of sodium chloride solution used is 0.30 M; C_1=0.40 M; C_2=0.20 M.

Table 3. Permselectivities and Fixed Charge Densities ($\phi\bar{X}$ in mol dm^{-3})

Mean concn mol dm^{-3}	Cellulose acetate P_s Without Stigmasterol	P_s With Stigmasterol	$\phi\bar{X}$ Without Stigmasterol	$\phi\bar{X}$ With Stigmasterol
0.075	0.5866	0.5660	0.1087	0.1030
0.15	0.6021	0.5709	0.2262	0.2541
0.30	0.5859	0.5747	0.4338	0.4214
0.60	0.5908	0.5782	0.8787	0.8506
0.75	0.5732	0.5397	1.0493	0.9617

Table 4. Transport Numbers Permselectivities and Fixed Charge Densities at Different pH Values ($\phi\bar{X}$ in mol dm^{-3})

pH	Cellulose acetate $\bar{t}_+$ Without Stigmasterol	$\bar{t}_+$ With Stigmasterol	P_s Without Stigmasteral	P_s With Stigmasterol	$\phi\bar{X}$ Without Stigmasterol	$\phi\bar{X}$ With Stigmasterol
6.92	0.6448	0.6342	0.4823	0.4645	0.3303	0.3147
6.45	0.7084	0.6977	0.5860	0.5690	0.4339	0.4152
5.90	0.7434	0.7224	0.6409	0.6082	0.6526	0.4597
5.30	0.8249	0.7780	0.7265	0.6936	0.7078	0.5777

an increase in the values of various parameters.

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