Research Article

Electrokinetic Behavior of Aqueous Solutions of Ammonium and Sodium chlorides and alkaline Solutions of Oxalic Acid and Uric Acid Solutions Across Urinary Bladder Membranes

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ABSTRACT

Electrokinetic studies of aqueous solutions of ammonium chloride and sodium chloride and alkaline solutions of oxalic acid and uric acid solutions have been made across urinary bladder membranes of goat. The two types of solutions have some similarity and several diversities as regards their occurrence and interactional properties with bladder are concerned. Kinetic energy term α_1 related with effective pressure and polarizability term α_2 have been computed for all the permeants. Methodology of non equilibrium thermodynamics have been used to explainthe data. It has been found that polarizability behavior of stone forming materials undergoes drastic changes as compared to other permeants.

INTRODUCTION

Urine is a multi-component system[1,2]. Ordinarily it is transparent and slightly acidic in nature. Proper excretion of urine is the clinical index of renal function[3]. Proper voiding pattern is a sign of proper interactional property of the urine constituents and the bladder itself. Transparency of the urine is due to collective role of constituents of urine. For example, Urea a major constituents of urine, is a better solvent for polar and non-polar solutes[4]. Similarly it is claimed that uric acid is held in solution in urine by urea and disodium hydrogen phosphate present. Increase of one or more constituents leads to super saturation. As a result of which precipitation takes place.

Since many vegetables and fruits eg.- asparagus, apples, grapes, lettuce, rhubarh, spinach, tomatos contain oxalates. It seems that they are responsible for most of the oxalic acid in urine.There is also experimental evidence that part of oxalic acid of urine is formed within the organism in the course of protein and fat metabolism. Incomplete combustion of carbohydrates also leads to formation of oxalic acid in urine.

Uric acid content of urine is of importance in relation to formation of uric acid calculi. It occurs in urine in the form of urates and upon acidifying the liquid uric acid is liberated and deposits in crystalline form.

Oxalic acid and uric acid are stone forming crystalloids. Ammonium chloride and Sodium chlorides are constituents of urine. The vetenary indication for ammonium chloride[5] is as a urinary acidifying agent to help, prevent and dissolve certain type of urolith, to enhance renal excretion of some type of toxins or drugs or to enhance the efficiency of certain anti microbials. Thus stone forming crystalloids have just the opposite property in urine solution.With this end in view, electrokinetic behavior of these solutions have been studied in detail and methodology of non-equilibrium thermodynamics have been used to explain the data.

THEORETICAL

Using methodology of non-equilibrium thermodynamics, volume flow and current flow may be expressed as [6-7]

$$Jv = L_{11}\Delta p + L_{12}\Delta\psi + L_{112}\,\Delta p\,\Delta\psi + 1/2\,L_{111}\,(\Delta p)^2 + 1/2\,L_{122}\,(\Delta\psi)^2 + 1/2\,L_{1112}\,(\Delta p)^2\,\Delta\psi + 1/6\,L_{1111}\,(\Delta p)^3 + 1/2\,L_{1122}\,(\Delta p)\,(\Delta\psi)^2 + 1/6\,L_{1222}(\Delta\psi)^3 + \ldots\ldots$$

and

$$I = L_{21}\Delta p + L_{22}\Delta\psi + L_{212}\,\Delta p\,\Delta\psi + 1/2\,L_{222}\,(\Delta\psi)^2 + 1/2\,L_{211}\,(\Delta p)^2 + 1/2\,L_{212}\,(\Delta p)^2\,\Delta\psi + 1/6\,L_{2222}\,(\Delta\psi)^3 + \ldots\ldots + 1/2\,L_{2122}\,(\Delta p)\,(\Delta\psi)^2$$

where Lii, Ljj, Lijk, Lijkl, (i,j = 1,2) are phenomenological coefficients L1112, L1122, L2112, L2122 etc are higher order phenomenological coefficients Kinetic energy term (α_1) which is related with effective pressure across the membrane is given as [8]

$$\alpha_1 = \frac{L_{111}A^2}{\rho L_{11}^3} = -\left(\frac{L_{1111}A^4\,1/2}{3\rho^2 L_{11}^5}\right)$$

And polarization term α_2 related with destination power of the membrane is expressed as 8

$$\alpha_2 = \frac{L_{1222}A^2}{3\rho L_{11}^2 L_{12}\,\alpha_1} - \frac{\alpha_1 \rho L_{12}^2}{2A^2}$$

$$= \frac{L_{1122}A^2}{\alpha_1 \rho L_{11}^3} - \frac{3\alpha_1 \rho L_{12}^2}{A^2}$$

where L_{1122} & L_{1222}, L_{111} and L_{1111} are higher order phenomenological coefficients.

EXPERIMENTAL

MATERIALS

Two set of permeants have been chosen –

1. Aqueous solutions of Ammonium and Sodium Chloride.
2. Alkaline solutions of oxalic acid and uric acid.

Choice of Membrane

Membrane chosen for experimental study in urinary bladder membranes of goat. It was chosen due to easy availability and capacity to withstand high pressure membrane was isolated from the animal and immediately dipped in dilute brine solution. Care was taken to see that the membrane contains some urine. After keeping the membrane for sometime in brine solution, it was then dipped in formalin alcohol solution (100 parts water + 125 parts 95 % alcohol and 10 parts 40 % formeldehyde) as described earlier[9].

Experimental Procedure

Hydrodynamic permeability measurements[9] are carried out by applying pressure across one side of the membrane and volume flow is noted with the help of capillary tubes on the other side volume flow (Jv) is given as –

$$Jv = \frac{\Pi r^2\,dx}{dt} = L_{11}\,(\Delta P) + \ldots\ldots$$

where r is the radius of the capillary tube. x is the distance travelled and t is the time.

Electro-osmotic permeability[10-11] is noted by noting the rate of advancement of liquid column as a result of application of an electrical potential across the membrane.

$$Jv = L_{12}\,(\Delta\psi) + \ldots\ldots$$

RESULTS AND DISCUSSION

Ordinarily uric acid occurs in urine in the form of urates and upon acidifying the liquid the uric acid is liberated and deposits in crystalline form. In addition to being a constant urinary constituents, uric acid is present in small amount in normal human blood.

Oxalic acid is a constituent of normal urine. It seperates out from neutral or alkaline solution as insoluble crystalline calcium oxalate.

Ammonia is quantitavely the most important of the nitrogen end product of protein metabolism. Ammonia content of urine appears to be related primarily to the acid-base balance of the body. Acid forming foods also increase ammonia output. The cataion normally excreted in greatest quantity by the kidney, under ordinary diatary conditions is the ammonium ion.

Next to urea, chloride make up the cheif solid constituents of urine. Daily excretion varies widely with dietary intake. Urine chlorides may be extremely low in case of severe diabetes insipidus. Excessive amount of sodium and chlorides are excreted in the urine in case of addisions disease (Adrenal cortical insufficiency) while the excretion of these substances are decreased in cortical hyper function (cushing syndrome).

The mechanism by which kidneys excrete potassium ion differ from those of sodium ion.

Urinary process is the development of pressure, sustenance of pressure and finally release of pressure[12]. Development of pressure gives rise to streaming potential and finally streaming current which is nothing but micturition waves[10]. Interaction of urine with bladder surface must generate sufficient energy so that most of the urine is expelled out. If energy conversion tendency is poor, it may lead to residual urine. Sluggish flow of urine or stasis of urine leads to several types of complications. Electro kinetic studies of uric acid, oxalic acid and ammonium chloride and sodium chlorides may be summarized as follows.

Kinetic energy term (α_1) which is related with effective pressure across the membrane and polarizability term (α_2) related with distentation power of the bladder may be expressed as follows –

1. Effective pressure term (α_1) increases with increase in concentration and α_2 decrease in case of ammonium chloride solution as shown in table 1.0 reverse trend is followed by NaCl.
2. Effective pressure term (α_1) for NaCl decrease with increase in concentration and α_2 increases with increase in concentration as shown in table 1.0.
3. Effective pressure term (α_1) for urine-oxalic acid mixture increases with increase in concentration of oxalic acid in urine while α_2 decreases abruptly as given in table 2.0.
4. Effective pressure term (α_1) for urine-uric acid solution increases with increase in concentration of uric acid in urine while α_2 decreases abruptly with increase in concentration of uric acid as shown in table 2.0.

Table 1.0: Values of α_1 and α_2 for ammonium chloride and sodium chloride[13]

Conc. (moles/litre)	Ammonium Chloride		Sodium Chloride	
	α_1 $m^{-1}s^2kg^{-1}$	α_2 $m^3v^{-2}J$	α_1 $m^{-1}s^2kg^{-1}$	α_2 $m^3v^{-2}J$
0.02	1.2	- 6.3	392.5	- 27.00
0.04	1.6	- 6.8	257.5	- 14.55
0.06	2.3	- 7.7	31.75	- 10.39
0.08	3.3	- 8.3	6.44	- 6.06
0.10	3.7	- 8.6	0.89	- 5.46

Table 2.0: Values of α_1 and α_2 for urine-oxalic acid and urine-uric acid[14]

Conc.	urine-oxalic acid		Conc.	urine-uric acid	
	α_1 $m^{-1}s^2kg^{-1}$	α_2 $m^3v^{-2}J$		α_1 $m^{-1}s^2kg^{-1}$	α_2 $m^3v^{-2}J$
Urine+.002 M oxalic	+ 12.79	- 9.66	Urine+.002M uric acid	+ 20.78	- 29.78
Urine+.004 M oxalic	- 8.00	+ 8.01	Urine+.004M uric acid	+ 5.96	+ 11.62
Urine+.006 M oxalic	- 6.07	+ 38.53	Urine+.006M uric acid	+ 0.79	+ 32.76

From table 1 & 2 it can easily be inferred that stone forming permeants undergo drastic changes in polarizability with increase in concentration. In other words voiding tendency undergoes drastic changes and effective pressure required for excretion is found to be much less than required. Energy conversion maxima also supports this view[15].

High uric acid levels in urine[16] may be due to –

(i)Cancers

(ii)Disorders that affect the bone marrow

(iii)High purine diet

(iv)Gout

(v)Farconi syndrome.

and low levels in urine may be due to (i) long term alcohol use and lead poisoning. Stasis and sluggish flow of urine may be a factor in stone formation in Lacking any flushing action, beginning stones are not washed away but instead may grow.

Thus, it may safely be inferred that stone forming crystalloids have poor voiding tendency as compared to other permeates.

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