

STUDY ON PHYSICAL PROPERTIES OF URINE-OXALIC ACID MIXTURE

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Physical properties namely density, viscosity, surface tension and pH of oxalic acid-urine system have been Determined. The results may be summarized as (i) Density decreases with increase in concentration of oxalic acid in urine-oxalic acid mixture (ii) Surface tension first increases and then decreases with increase of oxalic acid (iii) Viscosity of urine-oxalic acid mixture increases and then decreases with increase in concentration of oxalic acid but viscosity of urine-oxalic acid mixture is lower than that of urine (iv) pH decreases with increase of concentration of oxalic acid in urine. (v) Temperature of mixing increases with increase of concentration of oxalic acid in urine. Since oxalic acid is well known for its stone forming tendency, its occurrence in urine in different proportions bears special significance. In view of these, physical properties measurements have been used to explain unusual behaviour of urine-oxalic acid system and interaction of urine with bladder interface.

Key words: Urine-oxalic acid, Physical properties, Density, Viscosity.

Introduction

Urine is a multicomponent system (Oser 1979). The composition of the constituents depends upon the diet taken. Variation of the composition sometimes leads to alarming situations (West *et al* 1974). Physical properties (such as density, viscosity, surface tension, pH and temperature of mixing) change with change of composition. However, the change is not of same type for every constituent. Increase of glucose in the urine is a symptom of diabetic mellitus whereas that of oxalic acid leads to formation of urinary calculi in the bladder (Wyker and Gillinwater 1977). Physical properties are the measures of structural changes and so such studies are quite useful in understanding interaction of urine with urinary bladder interface. Since urinary process is explained in terms of pressure (Guyton 1981) and electrical potential (Shukla and Misra 1987; Shukla *et al* 1989 a & b), chances of adsorption of some constituents with urinary bladder interface can not be ruled out. During the adsorption process, capillaries may be filled which are not completely emptied at the same pressure on desorption (Daniel and Alberty 1967). pH which is a measure of acidity, predicts adsorption tendency of cations and anions on a heterogeneous membranes surface. It is also likely that at a given pH both cationic and anionic groups are active. Most membrane systems have only one type of group active at a physiological pH (Lakshminaranaiarh 1984; Smith *et al* 1985). Physical properties of the oxalic acid-urine system have been measured to investigate the unusual behaviour of the system.

Experimental

Density, viscosity, surface tension, temperature of mixing and pH were measured by keeping the corresponding appa-

ratus in a thermostat set at $35 \pm 0.1^\circ\text{C}$. Measurements of density were carried out with the help of pycnometer, while that of viscosity with Ostwald viscometer. Surface tension was measured by drop weight method (Rastogi *et al* 1996) using stalgmometer while pH was measured by pH meter (Shukla *et al* 1991). For measurement of temperature of mixing, a thermometer with an accuracy of 0.1°C was used. Urine-oxalic acid mixture was prepared by mixing the two on 1: 1 basis. Urine of normal healthy individual was taken and was used as such without any delay. The mean values of several measurements of proper ties are given in Table 1-3. Solvent used was pure deionized water.

Results and Discussion

Transported behaviour (Shukla and Misra 1994) of urine depends upon its constituents. Various constituents of urine effect the bladder membrane interface and thus produce changes in the behaviour of the membrane surface. Continuous presence of acidic urine in the bladder ruptures the bladder mucosal layer and leads to the ineffective functioning of the bladder. Thus, physical properties are useful in describing membrane solution interactions. Urinary bladder has two primary functions i.e. passive collection and active expulsion of urine. In the case of passive collection, urine is stored in the bladder which it collects through drop by drop filling. In this case, it is not expected to develop any sort of interaction with the bladder wall. While in the case of active expulsion, urine has to interact with the bladder wall and micturition wave needs to be developed through the interactions of bladder and urine present. The physical properties of the permeants (Urine) influence both these properties.

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The results of the measurements for urine-oxalic acid mixture system may be summarized as follows:-

- (1) Density decreases with increase in concentration of oxalic acid in urine-oxalic acid mixture.
- (2) Viscosity of urine-oxalic acid mixture increases and then decreases with increase in concentration of oxalic acid but viscosity of urine-oxalic acid mixture remains lower than that of urine.
- (3) Surface tension first increases and then decreases with increase of oxalic acid in urine.
- (4) pH decreases with increase of concentration of oxalic acid in urine.
- (5) Temperature of mixing increases with increase of concentration of oxalic acid in urine.

The above experimental observations may be examined in terms of interaction of solute with membrane interface. Since urinary bladder membranes remain in contact with these solutions, its behaviour under varying conditions of permeants deserves considerations. The urine transport may be related with the electrokinetic phenomenon (Shukla and Misra 1994). Electrokinetic studies of aqueous oxalic solutions (Shukla and Misra 1991) and urine-oxalic acid mixture (Shukla and Misra 1992) gives following informations:

(i) Mode of electro osmotic transport of oxalic acid solution and urine solutions are quite different. Urine has a tendency to flow from outer side to inner side whereas oxalic acid has the reverse trend. This is explained in terms of composition of ions in inner and outer Helmholtz planes. The term inner side denotes the portion which remains in touch with urine and outside just the reverse.

(ii) Since urinary bladder is concerned with expulsion of urine, energy conversion maxima is lower in case of urine-oxalic acid mixture than urine, i.e., urine-oxalic acid mixture requires higher energy for expulsion than urine.

(iii) Increase of oxalic acid in urine tends to reduce polarization power of the urinary bladder membrane which ultimately leads to formation of urinary calculi in the urinary bladder itself.

Although the whole process is quite complex, and urine usually undergoes changes in its composition, measurements of physical properties may be of some help in analysing the changes taking place.

Increase of density and viscosity with increase of concentration suggests greater degree of interaction of solute with solvent urine. Increasing concentration of oxalic acid in urine leads to nucleation and finally crystal growth.

Table 1(a)

Density and viscosity of aqueous oxalic acid solutions

S.No.	Composition of solution	Density (gm cm ⁻³)	Viscosity η (poise)
1.	Water (pure)	1.0193	0.7225
2.	0.002 M Oxalic acid	1.0194	0.7085
3.	0.004 M Oxalic acid	1.0195	0.7105
4.	0.006 M Oxalic acid	1.0196	0.7281
5.	0.008 M Oxalic acid	1.0197	0.7499
6.	0.010 M Oxalic acid	1.0198	0.7628

Table 1(b)

Density and viscosity of aqueous oxalic acid-urine mixture system

S.No.	Composition of solution	Density (gm cm ⁻³)	Viscosity η (poise)
1.	Urine	1.0454	0.7595
2.	0.002 M Oxalic acid	1.0194	0.7082
3.	Urine + 0.002 M Oxalic acid	1.0321	0.7041
4.	Urine + 0.004 M Oxalic acid	1.0318	0.6653
5.	Urine + 0.006 M Oxalic acid	1.0308	0.6721
6.	Urine + 0.008 M Oxalic acid	1.0305	0.7199
7.	Urine + 0.010 M Oxalic acid	1.0303	0.7276

Table 2(a)

Surface tension and pH value of aqueous oxalic acid solutions

S.No.	Composition of solution	Surface tension γ (dyne cm ⁻¹)	pH values
1.	Water (pure)	70.38	-
2.	0.002 M Oxalic acid	68.78	3.77±0.02
3.	0.004 M Oxalic acid	69.79	4.41±0.01
4.	0.006 M Oxalic acid	70.81	4.60±0.02
5.	0.008 M Oxalic acid	71.88	4.88±0.02
6.	0.010 M Oxalic acid	72.97	4.96±0.02

Table 2(b)

Surface tension and pH value of aqueous oxalic acid-urine mixture system

S.No.	Composition of solution	Surface tension γ (dyne cm ⁻¹)	pH values
1.	Urine	65.83	4.49±0.01
2.	0.002 M Oxalic acid	68.78	3.77±0.02
3.	0.002 M Oxalic acid + Urine	71.68	3.64±0.02
4.	0.004 M Oxalic acid + Urine	70.79	4.14±0.02
5.	0.006 M Oxalic acid + Urine	68.63	4.67±0.02
6.	0.008 M Oxalic acid + Urine	67.87	4.73±0.02
7.	0.010 M Oxalic acid + Urine	67.00	5.10±0.02

Table 3

Temperature of mixing of aqueous oxalic acid-urine mixture system

S.No.	Composition of mixture	$\Delta T^{\circ}\text{C}$
1.	Urine	-
2.	0.002 M Oxalic Acid + Urine	0.2
3.	0.004 M Oxalic Acid + Urine	0.3
4.	0.006 M Oxalic Acid + Urine	0.4
5.	0.008 M Oxalic Acid + Urine	0.6
6.	0.010 M Oxalic Acid + Urine	0.7

Surface tension measurements show that urine tolerates some concentration of oxalic acid and when its surface tension starts decreasing, chances of adsorption (Daniel and Alberty 1967) on the surface become quite probable. These measurements are also quite important as measurement of interfacial tension is related with potential difference across the interface (Bockris and Reddy 1977). Since surface tension decreases with increase of concentration, electrical potential will also decrease. Electrical potential across the interface is found to be proportional to electro osmosis and streaming potential and these may be correlated with micturition phenomenon (Shukla and Misra 1987). Generation of lesser electrical potential across the interface produces lesser micturition waves and so complete expulsion of urine containing varying amounts of oxalic acid is ruled out and chances of residual urine in bladder and ineffective functioning of bladder become bright.

At the membrane solution interface, the polar groups of the membrane constituents (phospholipids and proteins) exist at physiological pH in different states of ionization depending on pKa of the groups concerned. Groups or sites on the membrane surface in general are of weak acid or weak base type and so their ionization depends upon the pH of the medium in which they exist. The surface potential will alter the pH value at the surface. When surface potential is zero (Lakshminaraniaiah 1984), membrane surface pH will be equal to the pH of the medium. If surface potential is negative, pH of the membrane will be less than pH of the bulk phase. Thus, pH of the medium decides chances of adsorption.

Mixing of oxalic acid in the urine predicts exothermic reaction. Solubility in such case decreases with increase in concentration. Decrease of solubility suggests poor miscibility which shows chances of recrystallization.

Thus physical properties are of immense use in understanding the interaction of urine with urinary bladder interface.

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