Art-6

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"Studies on Polarizability and Effective Pressure of Aqua Guard Water, Aqua Fina Water, Pepsi and Thums up Across Urinary Bladder Membranes of Goat"

P. C. SHUKLA and AALOK SHUKLA

Bio-Physical Laboratory, Chemistry Department
St. Andrews Post Graduate College, Gorakhpur (U. P.) India

Abstract — Water is an integral part of life. Water plays many roles in biological systems. Acid-base balance of the body is primarily maintained by proper urination. Development of pressure, sustenance of pressure and finally release of pressure across urinary bladder membranes is the normal pattern of urination. Passive collection and active expulsion of urine is the primary function of the bladder. Bladder surface should not interact with urine as regards passive collection is concerned. After experiencing certain value of pressure, it begins to interact which finally leads to expulsion of urine with drastic change in polarizability.

Use of aquaguard water, aquafina water and cold drinks (Pepsi ,Thums up etc.) are becoming fashion of the modern society. These liquids differ minutely in their physical properties but interactional behavior is quite significant. Hydrodynamic and electro-osmotic permeability measurements of these liquids have been carried out across urinary bladder membranes. Methodology of non equilibrium thermodynamics have been used to explain the data. It has been found that thumsup produces maximum change in polarizability as compared to other permeants.

Keywords : *Urinary bladder membranes, Hydrodynamic and electro-osmotic permeability measurements, Non equilibrium thermodynamics.*

INTRODUCTION

Water is important to the mechanics of human body. All the cells and organs made up in our entire human anatomy and physiology depend upon water for their

*Author for correspondence. E-mail : pcshuklabpl@yahoo.com

functioning. Water regulates body temperature and metabolism and helps to alleviate constipation by moving food through the intestinal tract and thereby eliminating wastes [1, 2].

Use of aqua guard water, aqua fina water and cold drinks mirinda, mountain dew, pepsi & thums up etc has become fashion of modern society. These liquids differ minutely in their physical properties yet their interactional properties are quite different.

Drop by drop filling of the bladder [3, 4] develops streaming potential which in turn produces streaming current which is nothing but micturition wave. Proper generation of micturition wave is a sign of normal voiding pattern. Interactional properties of liquids in contact with bladder produces change in effective pressure as well as polarizability. Inefficient flushing action of the bladder produces several complications in the human body. [5]

Interactional properties of aqua guard water, aqua fina water, mountain dew and mirinda across urinary bladder membrane have been studied earlier.[6]

Present study is an attempt to analyze interactional behavior of “Pepsi” and “Thums up” across urinary bladder membranes so that a comparative idea of different cold drinks may be made. Methodology of non equilibrium thermodynamics have been made to analyze the data.

Water is the most abundant constituent of the body. It provides the fluid medium within which chemical reaction of the body takes place and substances are transported.

THEORETICAL

Using methodology of non equilibrium thermodynamics, volume flow (Jv) and current flow (I) across the membrane may be expressed as (4)

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

and

$$I = L_{21}(\Delta P) + L_{22}\Delta\psi + L_{212}\Delta P\Delta\psi + 1/2\ L_{222}(\Delta\psi)^2 + 1/2\ L_{211}(\Delta P)^2$$
$$+ 1/2\ L_{2112}(\Delta P)^2\Delta\psi + 1/2\ L_{2122}\ \Delta P\ (\Delta\psi)^2 + 1/6\ L_{2222}(\Delta\psi)^2 + \ldots\ldots$$

where L_{ij}, L_{ijk}, and L_{ijkl} (i,j,k,l = 1, 2) are phenomenological coefficients.

Pressure difference (ΔP) and electrical potential gradient ($\Delta\psi$) are the forces operating in the system.

In situations where the permeant experiences acceleration or retardation inside the membrane, the kinetic energy of center of mass ($\alpha 1$) may be expressed as [6,7]

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

Where L_{111} and L_{1111} are higher order phenomenological coefficients ρ is the density, A is effective cross sectional area of the membrane. The effect of kinetic energy term ($\alpha 1$) is equivalent to velocity head which decreases effective pressure of the membrane.

The polarization term ($\alpha 2$) arising due to oriented solvent at a planner solid/ solution interface inside the membrane may be expressed as [7].

$$\alpha 2 = \frac{-L_{1122}(A)^2}{\alpha 1\rho\ (L_{11})^3} - \frac{3\alpha 1\rho\ (L_{12})^2}{(A)^2}$$

$$= \frac{-L_{1222}(A)^2}{3\rho\ (L_{11})^2 L_{12}\ \alpha 1} - \frac{-\alpha 1\ (L_{12})^2}{2(A)^2} \quad (4)$$

Where L_{1122} and L_{1222} are the higher order phenomenological co-efficients.

Values of phenomenological coefficients are evaluated by using extra polation technique [4].

EXPERIMENTAL

Choice of permeants : Two sets of permeants have been chosen

(1) Aqua guard & Aqua fina water (Pepsi brand)

(2) Colored permeants such as Pepsi and Thums up

Aqua guard water is free from impurities and micro-organism, Aqua fina (Pepsi brand) has zero value of calories, fat, carbohydrates and proteins.

Other permeants used are sweetened carbohydrates, water, contain no fruit but caffeine and have emulsifying and stabilizing agents. These permeants have permitted natural colors, flavors, anti oxidants etc. The amount of sugar differ in each case.

Choice of Membrane :

Membrane chosen for experimental study is urinary bladder membrane of goat. The source of goat bladder obtained is slaughter house situated in several parts of cities. It was chosen due to its easy availability and capacity to withstand high pressure.

The bladder is immediately dipped in dilute brine solution. Care is taken to see that bladder contents some urine. After keeping the urinary bladder in brine for two to three hours it is then treated with formalin alcohol solution. The membrane was isolated and preserved by formalin alcohol (100 parts water, 125 parts 95% alcohol and 10 parts 40% formaldehyde) solution as described earlier [8]. The effective cross sectional area of the membrane is 3.14 cm^2. The membrane is always maintained in wet state by filling the apparatus with a dilute 0.01 molar urea solution. The fixative used does not preserve a particular part of membrane but all parts of structure associated with tissue are fixed. This is evident from electrokinetic studies across membranes [8].

Hydrodynamic permeability is measured by noting the change in liquid level in horizontal capillary tube as described earlier [8]. Variation of hydrostatic pressure is brought about by raising the level of pressure head across one side of the membrane. The difference in height is noted by cathetometer. A plot of volume flow against pressure difference gives permeability co-efficient.

Electro-osmotic permeability [4] was measured by noting the rate of advancement of liquid column as a result of application of an electrical potential across the membrane.

RESULT AND DISCUSSION

We, the humans, are designed alkaline and function acidic. Human body ideally maintains a pH of 7.4 This is alkaline in nature. Alkalinity is defined as equivalent sum of bases that are titrable with strong acid. Effects of having alkaline body leads to (i) High energy level (ii) Deep sleep pattern (iii) Less colds and flue than normal (iv) Totally clam and quiet (v) Immune system is fortified and (vi) Body has good absorption assimilation and digestion. Thus maintaining alkalinity is essential for life, health and vitality.

Pollution, stress and our consumption of highly processed food tend to create acid body. All cellular waste and most internally generated toxins are acidic. As each cell performs its task of respiration, it secretes metabolic waste which are acidic. These wastes are end product of cellular metabolic and must not be allowed to build up. Body goes to great length to neutralize and detoxify these acids before they are in position to act as poison in and around the cell. Each minute of each day, the body's metabolic processes produce enormous quantity of acids even though in order to do that properly, the cells and tissues require a slightly alkaline environment. Biological kidney performs numerous regulatory function in addition to manufacturing important bio-chemicals. Preliminary, the kidney function to [9] (i) remove nitrogenous metabolic waste product (ii) regulates volume of body water (iii) maintain acid-base electrolyte composition (iv) assist in regulation of blood pressure and (v) assist in red blood cell production. Heavy soft drinks consumption offend kidneys and interfere with body's metabolism.

Kidneys imperfections are bound to develop complications in the characteristic of urinary bladder. Constant use of highly acidic material (Table 1) (Pepsi & Thums up) are bound to develop problems in the functioning of bladder. Inefficient functioning of the bladder may lead to residual urine in the bladder which may be a cause of urinary stones.

Urinary process is the development of pressure, sustenance of pressure and finally release of pressure [10] across the bladder membranes. Initially pressure build up is not significant but gradually it acquires special significance. In view of this, hydrodynamic and electro-osmotic permeability measurements are of immense importance.

When different phases come in contact with each other, an interface surface between them occurs. An interface region use to have new properties, new structures, compared to the bulk of solution [11]. To maintain electrical neutrality electrical double layers are formed which are characteristics of all phase boundaries.

TABLE 1.

Physical Properties of Permeants

Sl. No.	Permeant	Density $Kgm^{-3} \times 10^3$	Viscosity $NSM^{-2} \times 10^{-3}$	pH	Absorbance
1.	Aqua guard water	0.9991	0.7958	7.06	–0.002
2.	Aqua fina water	0.9841	0.7900	6.86	–0.001
3.	Pepsi	1.0366	1.0230	3.70	+1.836
4.	Thums up	1.0349	1.0289	3.64	+2.0614

The electrical field of the double layer causes ordering of molecular dipoles, thus increasing the field, which increases the thickness of the double layer. The dividing pressure gradient causes translational movement of molecules and destroys the dipoles orientation. Increasing of pressure gradient decreases thickness of interior layer. Thus the two forces act in opposite directions.

Phenomenological co-effiecient (Table II) are real measure of interactions occurring in the system. They may be positive or negative or changes of sign may also occur. Cross phenomenological coefficients such as L_{112}, L_{1112}, L_{1122} represent net interaction of forces towards an electrical double layer. L_{1112} and L_{1122} are related

TABLE 2.

Values of Phenomenological coefficient for different permeants

System	$L_{11} \times 10^{-3}$ $m^5s^{-1}N^{-1}$	$L_{111} \times 10^{-17}$ $m^7N^{-2}s^{-1}$	$L_{12} \times 10^{-13}$ $M^3s^{-1}Volt^{-1}$	$L_{112} \times 10^{-15}$ $m^5s^{-1}V^{-1}N^{-1}$	$L_{122} \times 10^{-14}$ $M^3s^{-1}V^{-2}$	$L_{1112} \times 10^{-18}$ $M^7s^{-1}V^{-1}N^{-2}$	$L_{1122} \times 10^{-17}$ $m^5s^{-1}V^{-2}N^{-1}$	$L_{1222} \times 10^{-15}$ $M^3s^{-1}V^{-3}$	$\alpha_1 \times 10^{-15}$ $m^{-1}s^2kg^{-1}$	α_2 $m^{-3}v^{-2}J$
Aqua fina	2.40	4.00	2.70	1.41	5.60	−2.86	−2.80	8.4	1.7	−1.17
Aqua guard	1.80	5.10	2.30	−0.52	7.2	−1.63	−7.40	9.6	7.2	−1.66
Pepsi	1.37	4.54	1.90	−0.34	2.0	−1.38	−6.90	4.0	16.0	−1.95
Thums up	0.85	1.97	0.52	−1.05	1.4	−1.02	−5.25	4.8	21.4	−3.85

with relative dominance of force over each other in diverse situations. Higher order phenomenological coefficients are evaluated by extrapolation technique as described earlier [4].

In order to verify if any difference of concentration exists across the membrane, measurements of density, viscosity and refractive index were made before and after the experiments. It was found that no significant change occurs in these properties. Thus a concentration difference across the membrane is ruled out.

Aqua fina water (Pepsi brand) and aqua guard water differ in physical properties very minutely. Similar observations are also true for Pepsi & Thums up as given ion Table 1.

Volume flow is non-linearly related with pressure and electrical potential gradients as shown in Fig. 1 & 2. The values of permeability coefficients i.e L_{11} and L_{12} are evaluated from these graphs. Since urinary process takes place as a result of coupling of pressure and electrical potential, evaluation of phenomenological coefficients as shown in Fig. 3-6 assumes great significance.

All these depend upon nature of permeant and the interaction of membrane.

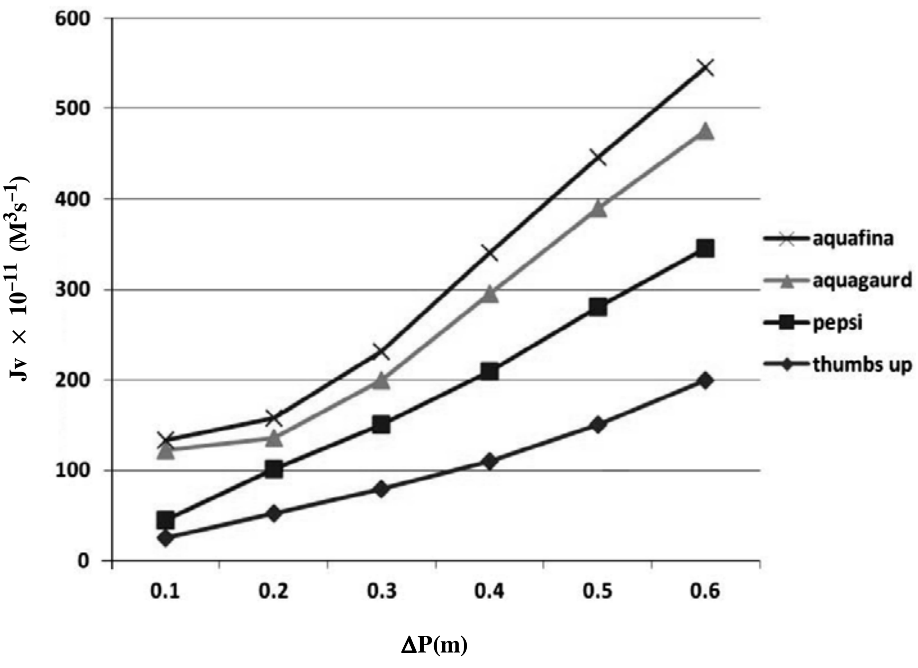

Fig. 1. Dependence of volume flow (Jv) against pressure difference.

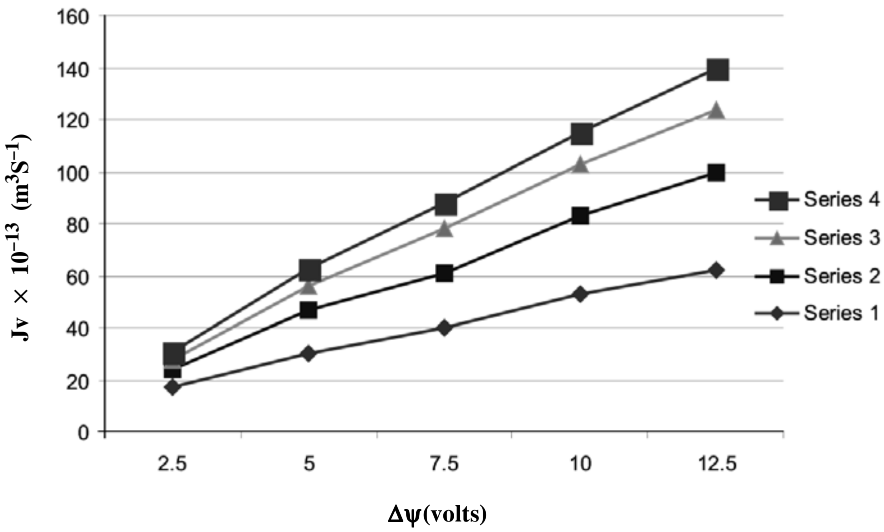

Fig. 2. Dependence of volume flow Jv against electrical potential difference.

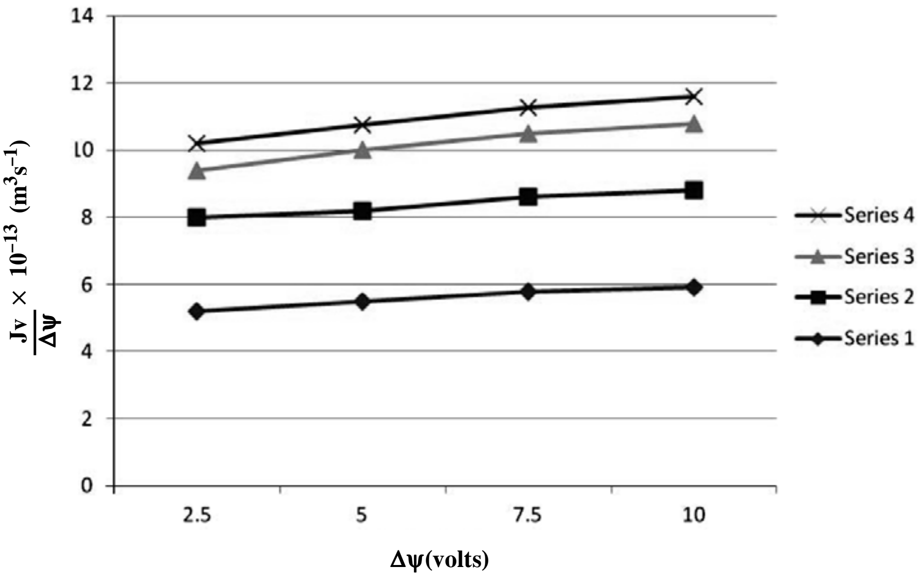

Fig. 3. 0 : A plot Jv/Δψ against Δψ.

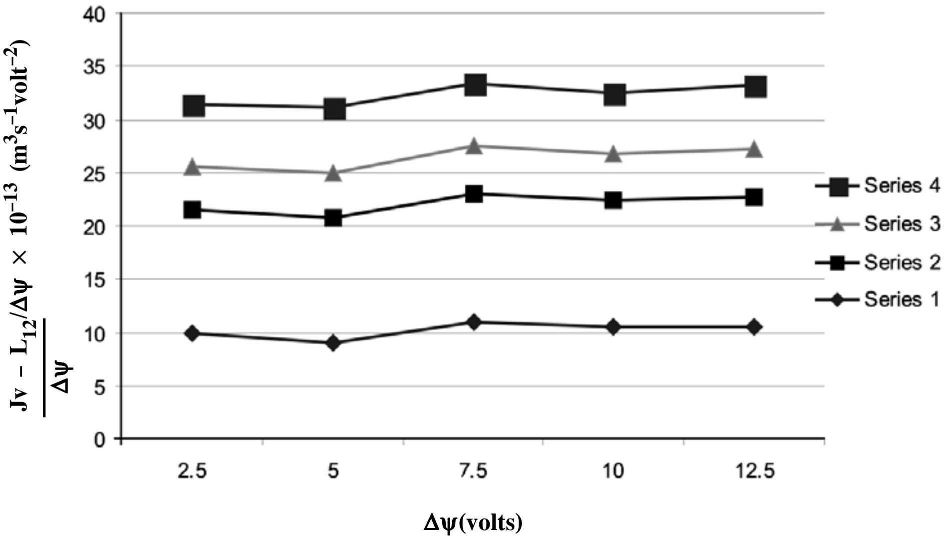

Fig. 4. A plot of ($Jv/\Delta\psi$-L_{12})/$\Delta\psi$ against $\Delta\psi$.

In the case of urine, electro-osmotic permeability is quite high. In other words, interaction of constituents of urine with bladder interface is quite significant. In the case of water and other permeants, interaction becomes quite weak. As a result of which L_{12}, L_{122} decrease with change of permeant. Thus, it may be inferred that effective zeta potential decreases with change of permeant from water to thums up.

In the case of urine, pH is slightly acidic so membrane pH is approximately equal to bulk of solution. In the case of soft drinks, there is vast difference in the value of pH, as a result of which membrane surface pH will not equal to pH of the medium [12] as shown below –

$$pH_m = pH_b + e\ \psi/2.303\ k\ T$$

Where ψ is surface potential, e is electronic charge, k is Boltzmann constant and T is temperature respectively

pH_m denotes membrane surface pH and pH_b is the pH of bulk medium.

When $\psi = 0$, membrane surface pH will be equal to the pH of the medium. If ψ is negative $pH_m < pH_b$ because the charge attracts hydrogen ions close to the membrane surface.

Heavy soft drink consumption offends kidneys and the colours are adsorbed [13] on the bladder surface, elastic behavior of the bladder is greatly affected. Comparing polarizability behavior of aqua guard water, aqua fina water, mirinda,

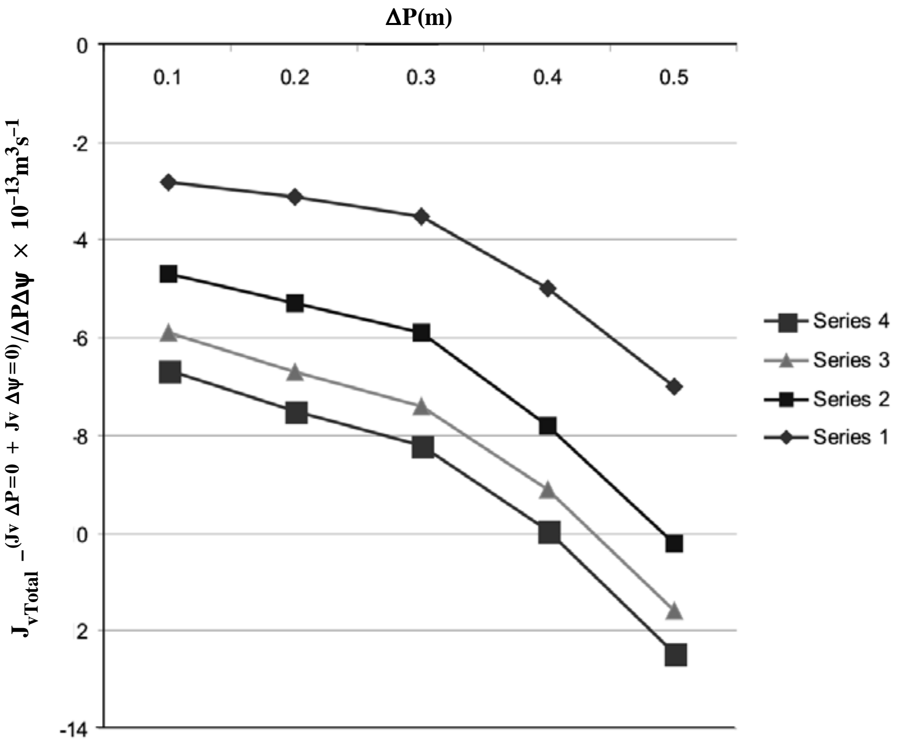

Fig. 5. A plot of $J_{v\ Total}^{-(Jv\ \Delta P=0\ +\ Jv\ \Delta\psi=0)}/\Delta P\Delta\psi$ against ΔP when $\Delta\psi$ is maintained constant.

mountain dew [6] pepsi & thums up, it has been found that thums up produces maximum effect on the bladder surface.

Thus ionic atmosphere around the membrane will be different in the case of soft drinks as compared to water. Interaction of permeant across bladder surface will undergo drastic changes which will have significant effect on the values of phenomenological coefficients.

Soft drinks contain water, sweetening agents, flavors, preservatives etc. Artificial sweetening agents are saccharin, aspertame, sucrolose etc. Diseases love acidity, Consumption of large amounts of soft drinks increases acid levels throughout the body. It causes inflammation of stomach and erosion of stomach lining. Acidity is due to phosphoric acid present in soft drinks. Stomach maintains a very delicate acid-alkaline balance that can be set out of balance by consumption to large amount of soft drinks. Proper digestion is disturbed, when the stomach can not digest food, the person will have indigestion, gassiness or bloating.

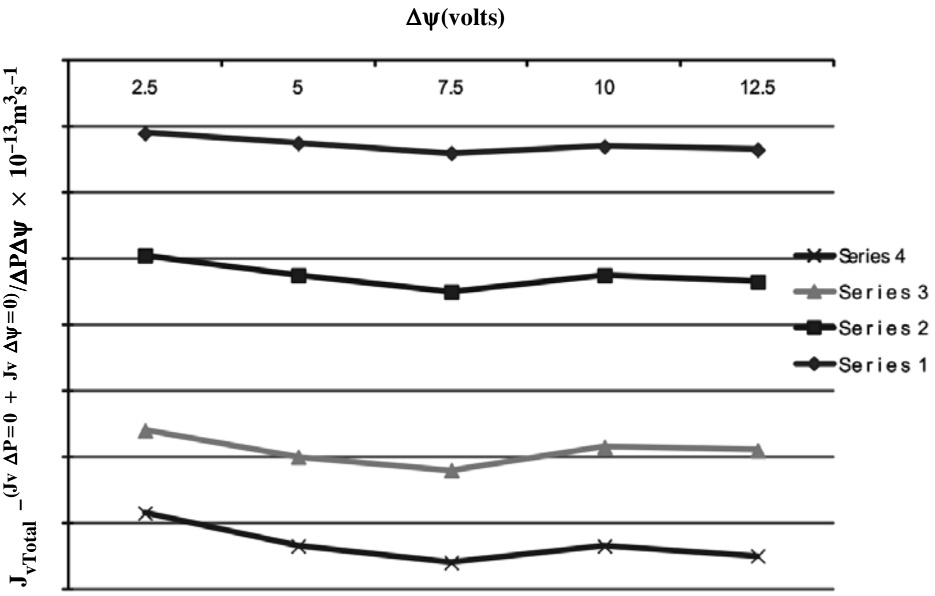

Fig. 6. A plot of $J_{v\ Total}{}^{-(Jv\ \Delta P=0\ +\ Jv\ \Delta\psi=0)}/\Delta P\Delta\psi$ against $\Delta\psi$ when ΔP is maintained constant.

Bubbles and fizz in soft drinks are caused by phosphoric acid and carbon dioxide. The carbon dioxide that is emitted in fizz is consumed when a person drinks a soft drink. Carbon dioxide is waste product and can be harmful when digested.

Body gives response to an acid-base perturbation. It has three components.

(A) First defense - Buffering

(B) Second defense - Respiratory alternations in arterial PCO_2 (what is P ? Is it "p" ?)

(C) Third defense - Renal alternations in HCO_3 excretion.

Buffering Mechanism :

(i) Bi-carbonate - Carbonic acid buffer

(ii) Protein - Proteinate buffer

(iii) Di-hydrogen phosphate (H_2PO_4)and hydrogen phosphate ions(HPO_4.)

These systems try to maintain acid-alkaline balance but too much consumption on a regular basis affects the whole mechanism. It may result change in polarizability of the bladder surface which will have significant effect in the voiding pattern of the whole system.

SUMMARY

Hydrodynamic and electro-osmotic permeability of Aqua fina water, Aqua guard water, Pepsi & Thums up have been carried out across urinary bladder membranes of goat. Methodology of non equilibrium thermodynamics have been used to explain the data. Kinetic energy term (á1) and polarization term (á2) have been computed for all the permeants. Higher value of (á1) and lower value of (á2) produce same effect on the bladder surface. It has been found that thums up produces greater effect on the bladder surface as compared to pepsi and other permeants. In other words, stasis of urine may be expected for thums up as compared to pepsi and other permeants. Such studies are expected to be of very great use in predicting physiological behavior of membrane in diverse situation.

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