

Viscosity Studies of SDS in Aqueous Solutions of Butylated Hydroanisole at Different Temperatures

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Abstract

Viscosities of surfactant sodium dodecyl sulphate in aqueous solutions of antioxidant Butylated Hydroxy Anisole BHA at different temperature ranging from 25°C to 40°C with interval of 5°C have been determined. The viscosity data have been analyzed for the evaluation of A and B viscosity coefficients using Jones–Dole equation. A - coefficients are found to be negligible implying weak ion–ion interactions whereas B – coefficients are found to be positive thereby showing solute–solvent interactions. It can be inferred from these studies that all the BHA can be regarded as structure-makers/promoters due to hydrophobic hydration of the antioxidant or surfactant molecules. Furthermore, the results are correlated to understand the solution behavior of antioxidants in aqueous systems.

Keywords: Viscosity, Antioxidants, Surfactants, Hydrophobic interactions.

Introduction

In recent days, drug-surfactant systems constitute one of the most spectacular branches of the modern science that has seen input from many disciplines including chemistry, physics, biochemistry and biotechnology. It is because of the reason that properties of such systems find useful applications in biological, pharmaceutical and industrial systems. However, due to the availability of new experimental techniques and the production of novel surfactant molecules, these studies continue to carry interest for the researchers in academics to provide systematic understanding of the subject. Drug actions [1,2] i.e. drug reaching the blood stream, its extent of distribution, its binding to the receptors and finally producing the physiological action, all depend on various physico-chemical properties chiefly decided by various interactions e.g. ionic or covalent, charge transfer, hydrogen bonding, ion–dipole interactions, or hydrophobic interactions [3,4]. A systematic knowledge of solution behavior of drugs can be of great significance in order to understand their physiological action which can be achieved with the help of transport property measurements. In this regard, viscometric methods have been successfully used to access the thermodynamic parameters of various biological molecules [5,6]. They also throw light on solute–solvent interactions which correlate with the structure making–breaking property [7] of the solutes and solvents.

In the present communication, an attempt has been made to study viscosity measurements of antioxidants Sodium Dodecyl Sulphate in aqueous solutions of Butylated hydroxy anisole in order to investigate various kinds of interactions that govern the solution behavior of these systems.

Experimental

Material

Butylated hydroxyanisole (BHA) and sodium dodecyl sulfate (SDS) of AR grade and purity >99% were obtained from Merck Chemicals. Double distilled water was used which was freshly prepared using double distillation unit (HARCO & Co.) and had specific conductivity of $\approx(1-4)\times 10^{-7}$ S cm⁻¹ at 25 °C and pH in the range of 6.5–7.0.

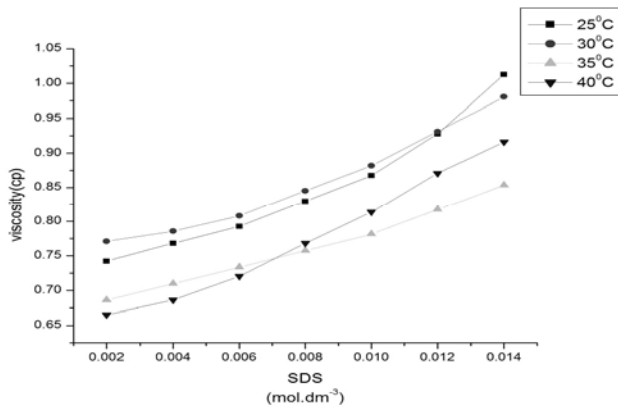
Apparatus and methods

The viscosity η measurements for various solutions were carried out by Ubbelohde viscometer and a sealable pycnometer of capacity 25 cm³ obtained from (HARCO & Co.). The flow time of water was approximately 460 s at 25°C and a constant volume of solution through the capillary was measured. The precision achieved in viscosity measurement was $\pm 0.01\%$. Every time the Ubbelohde viscometer was placed vertically in water thermostat (HARCO & Co.) having a digital temperature controller of accuracy $\pm 0.05^\circ\text{C}$. In all the above mentioned methodologies, the concentration of BHA was fixed at (0.03 – 0.02) mol dm⁻³ within the range limit of the ADI dose 0–0.5 mg/kg adult body weight (i.e. 60 kg) [8] and SDS with concentration ranging from 1 to 14 mmol dm⁻³. The overall accuracy of the present viscosity measurements was estimated to be $\pm 0.2\%$. The viscometer was calibrated by measuring viscosity of purified solvents such as DMSO [9] ($\eta_0=1.989$ cP), AN [10] ($\eta_0=0.341$ cP) and PC [10] ($\eta_0=2.526$ cP) etc. The temperature was maintained constant at ± 0.1 °C by circulating thermostat through a double walled vessel containing the solution.

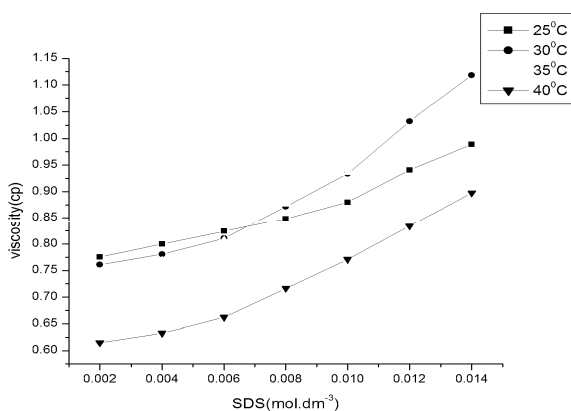
Result and Discussion

Information with respect of the solution behavior of antioxidant molecules is obtained from the contribution of these molecules to the viscosity of a solution which also supports the observations obtained from the conductance measurements in our previous studies [11-13].

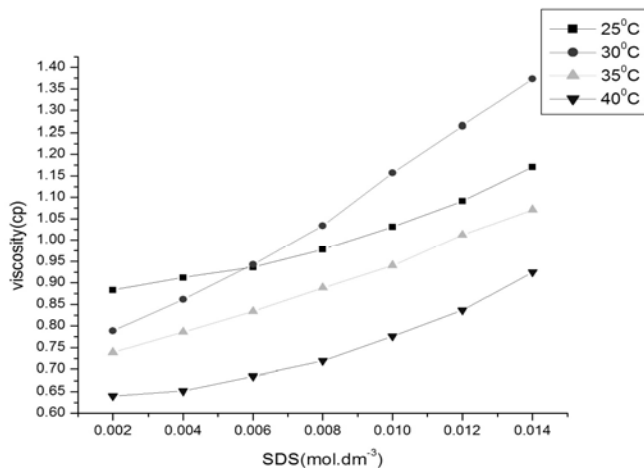
Examination of the behavior of viscosity of the solution as a function of concentration, nature of solute/solvent system may be interpreted in terms of structural changes. The viscosity of SDS/BHA solution is important in its own right, as it is a fundamental transport property necessary for the prediction and evaluation of other properties such as electrical conductance. Figure 1 (a, b and c) indicates the effect of viscosity on the concentration of SDS in aqueous media containing BHA which illustrates that there is a regular increase with increase in concentration of SDS. With increase in temperature, decrease in viscosity was observed from 25°C to 40°C with interval of 5°C.



(a)



(b)



(c)

Figure 1 (a,b,c). Viscosity coefficient (η) as a function of SDS in $0.001 \text{ mol.dm}^{-3}$, $0.002 \text{ mol.dm}^{-3}$ and $0.003 \text{ mol.dm}^{-3}$ BHA at different temperatures.

A considerable change in the values indicated the temperature dependence. Similar observations are noticed at other concentration of BHA with SDS i.e. 0.002 and $0.003 \text{ mol.dm}^{-3}$. From viscosity data A and B coefficients [14] were calculated [Table 1] with the help of Jones Dole equation as :

$$\eta_r = \eta/\eta_0 = 1 + AC^{1/2} + BC \text{ or}$$

$$(\eta_r - 1)/C^{1/2} = \Psi = A + BC^{1/2}$$

where $\eta_r = (\eta/\eta_0)$, and η and η_0 are viscosities of solution and solvent system respectively, C is the molar concentration. In this equation, A signifies solute-solute interaction. However, B accounts for the contribution arising from the size of solute, molar volume of the solvent in addition to the contribution due to solute-solvent interactions and estimates the order or disorder introduced by the addition of solute into solvent.

Table 1. A and B coefficients in aqueous solution of 0.001 mol.dm³, 0.002 mol.dm³ and 0.003 mol.dm³ BHA at different temperatures.

Temp. (°C)	A Values			B values		
	0.001	0.002	0.003	0.001	0.002	0.003
25	-0.998	-1.1267	-1.5789	33.927	28.43	34.727
30	-1.2062	-2.2708	-2.6161	29.272	51.42	80.724
35	-0.2342	-1.7471	-1.6772	21.513	46.14	48.129
40	-1.7878	-2.0747	-2.2699	42.755	50.81	48.083

The values of A were negative whereas B -coefficient were found to be positive. Since A is a measure of ionic interaction, it is evident that there is a weak ion-ion interaction, which is indicated by the smaller magnitude of A values. B -coefficient is known as a measure of solute-solvent interaction and is directly dependent on the size, shape and charge of the solute molecules. Thus, B values reflect the net structural effects of the solute and solvent molecules. The positive behaviour of B -coefficient suggests the existence of strong solute-solvent interaction and temperature dependent changes as shown in Figure 2.

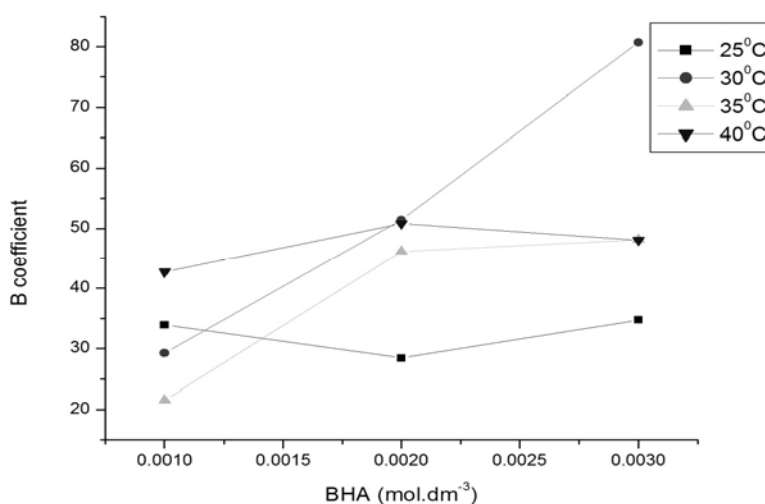


Figure 2. B coefficient as function of BHA at different temperatures.



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