



Thermophysical properties and taste behavior of L-serine/L-valine in aqueous glucose, sucrose and lactose solutions at different temperatures

Ashwani Kumar, Ruby Rani, Balwinder Saini¹, Rajinder K. Bamezai^{*}

Department of Chemistry, University of Jammu, Jammu 180006, J & K, India

ARTICLE INFO

Article history:

Received 8 March 2017

Received in revised form 22 May 2017

Accepted 1 June 2017

Available online 2 June 2017

Keywords:

Density

Speed of sound

Saccharides

Apparent molar volume

Hydration number

Taste behavior

ABSTRACT

The volumetric and compressibility properties of L-serine and L-valine in the concentration range (0.0 to 0.2) mol kg⁻¹ in water and various saccharides (0.1 glucose, 0.1 sucrose and 0.1 lactose) mol dm⁻³ have been studied over a temperature range of (293.15 to 313.15) K. The experimental data is used to obtain the apparent molar volume (V_ϕ), limiting apparent molar volume (V_ϕ°), limiting apparent molar transfer volume ($\Delta t V_\phi^\circ$), as well as apparent molar compressibility ($K_{s,\phi}$), limiting apparent molar compressibility ($K_{s,\phi}^\circ$), limiting apparent molar transfer compressibility ($\Delta t K_{s,\phi}^\circ$), limiting partial molar expansibility (ϕ_E°), coefficient of thermal expansion (α), hydration number (n_H) and taste behavior of amino acids. The results have been interpreted in terms of solute-solute and solute-solvent interactions. As the taste behavior is divided into four basic taste qualities in different ranges, so an effort has also been made to compare the taste behavior of the two amino acids in water and in aqueous solution of saccharides.

© 2017 Elsevier B.V. All rights reserved.

1. Introduction

The interactions of saccharides with proteins have been an intense field of research as it finds applications in number of biochemical processes like immunology, biosynthesis, medicine, pharmacology, etc. Amino acids, being the basic structural units of proteins, make up the major content of human body in playing a vital role. So, the thermodynamic study of these compounds in aqueous and mixed aqueous saccharide solutions can provide valuable information on solute-solute and solute-solvent interactions [1–4]. The physiological importance of amino acids can also be gauged from the fact that they are delicate to the gustatory system, therefore, every amino acid makes a contribution of varying degree towards the taste of foods [5,6]. Both L-Serine and L-valine have common α -amino and carboxyl groups. Apart from it, L-serine has a side chain hydroxyl group, classifying it as a polar and non-essential amino acid, where as L-valine has a side chain isopropyl variable group, making it a non-polar and essential amino acid. The later cannot be synthesized in human body and thus must be obtained from the diet. Saccharide solutions are often used in various food related industries to control the water activity, pH and to monitor the growth of microorganisms that are contaminated [7,8]. The addition of cosolute (saccharide) to the system (amino acid + water) can drastically affect the

interactions between amino acids and water molecules and, accordingly, the structural order of the water molecule may increase or decrease. Further, a better understanding of the mechanism of taste chemoreception can be monitored by studying the parameters on solute-water interactions and particularly, the changes involved in the hydration layer of the solute, through a number of studies on the molar volumes of savor molecules [9–16]. Therefore, physicochemical data determining the hydration behavior of saccharides is required for a better understanding of protein stabilization, taste chemoreception and antidesiccation mechanisms [17].

Although, a detailed study of thermophysical properties of amino acids are known [18–22], however, volumetric and compressibility studies along with taste behavior of amino acids (L-serine and L-valine) with some saccharides (glucose, sucrose and lactose) in the aqueous medium seem to be scarce. This led us to study the thermodynamic behavior of L-serine and L-valine in the concentration range (0.0 to 0.2) mol kg⁻¹ in water and in various aqueous solution of saccharides (0.1 glucose, 0.1 sucrose and 0.1 lactose) mol dm⁻³ at $T = (293.15, 298.15, 303.15, 308.15 \text{ and } 313.15) \text{ K}$, i.e., as a function of concentration and temperature, from density and speed of sound data. The derived parameters like apparent molar volume, limiting apparent molar volume, transfer volume, as well as apparent molar compressibility, limiting apparent molar compressibility, transfer compressibility, partial molar expansibilities, thermal expansion coefficient and hydration number are obtained from the experimental results. These evaluated parameters are found to be helpful to understand the interactions between aqueous saccharides and the two amino acids. Additionally, an effort is also made to compare their taste behavior.

^{*} Corresponding author.

E-mail address: rkb10@rediffmail.com (R.K. Bamezai).

¹ School of Physical Sciences, Lovely Professional University, Phagwara (Punjab) 144402, India.

2. Experimental

2.1. Source and purity of chemicals

The chemicals along with their mass fraction purity used in the present work are: L-serine, L-valine, α -lactose monohydrate (all >99.8%), D-(+)-glucose, sucrose (both >99.5%). All these chemicals are obtained from Sigma Aldrich, India and used after keeping them over anhydrous calcium chloride in a vacuum desiccator overnight at room temperature, except α -lactose monohydrate which was used as such. All the solutions are prepared in freshly prepared triple distilled water on molality basis. Specific conductance of the triple distilled water used for the preparation of aqueous solutions was found to be $<1 \times 10^{-6} \text{ S cm}^{-1}$.

2.2. Apparatus and procedure

The stock solutions of glucose, sucrose and lactose (each being 0.1 mol dm^{-3}) were used as solvent to prepare L-serine and L-valine solutions of nine different molal concentrations (ranging from 0.0 to 0.2) mol kg^{-1} . An electronic single pan five digit analytical balance (Model: Mettler AE-240) with a precision of $\pm 0.01 \text{ mg}$ was used to measure the mass. All the solutions were prepared with precaution and stored in special airtight bottles to avoid their exposure to air and evaporation. A vibrating-tube density meter (Model: DMA 5000 M, Anton Paar, Austria) with an uncertainty of $\pm 5 \times 10^{-2} \text{ kg m}^{-3}$ was used to measure the density of solutions. A density calibration was performed first with triply distilled water followed by dry air at 293.15 K at atmospheric pressure before each series of measurement. The density, being extremely sensitive to temperature, was controlled to $\pm 1 \times 10^{-3} \text{ K}$ by built-in Peltier system. The speed of sound of solutions was measured using a single-crystal variable-path multi-frequency ultrasonic interferometer (Model: M-82S, Mittal Enterprises, India) having stainless steel sample cell (with a digital micrometer) operating at

a fixed frequency of 2 MHz. The uncertainty in speed measurement was found to be within $\pm 0.5 \text{ m s}^{-1}$. The temperature of solutions was maintained to an accuracy of $\pm 0.02 \text{ K}$ using an electronic controlled thermostatic water bath (Model: TIC-4000N, Thermotech, India).

3. Results and discussion

3.1. Volumetric studies

The experimental values of densities and speeds of sound of amino acids (L-serine and L-valine) in the concentration range (0.000, 0.025, 0.050, 0.075, 0.100, 0.125, 0.150, 0.175 and 0.200) mol kg^{-1} in water and aqueous solution of saccharides (0.1 glucose, 0.1 sucrose and 0.1 lactose) mol dm^{-3} at $T = (293.15, 298.15, 303.15, 308.15 \text{ and } 313.15) \text{ K}$ are listed in supplementary Table S1 as supporting information. The densities of amino acids in solutions (representative 3-D plot, shown in Fig. 1, of density versus molality of L-serine and L-valine in aqueous solution of 0.1 mol dm^{-3} lactose) increase with the increase in the concentration of respective amino acids but decreases with the rise of temperature.

The apparent molar volume (V_ϕ) has been obtained from the density values using Eq. (1).

$$V_\phi = \frac{1000(\rho_o - \rho)}{m\rho\rho_o} + \frac{M}{\rho} \quad (1)$$

where M and m are the molar mass and molality of solute (amino acids), ρ and ρ_o are the densities of the solution (amino acid + saccharide + water) and solvent (saccharide + water), respectively. The data presented in Table 1 reveals that apparent molar volume increases as the temperature and concentration of L-serine/L-valine increase. However, a marginal increase in this value is noticed in moving from aqueous solution of sucrose to lactose monohydrate at all temperatures and concentrations. This may probably be

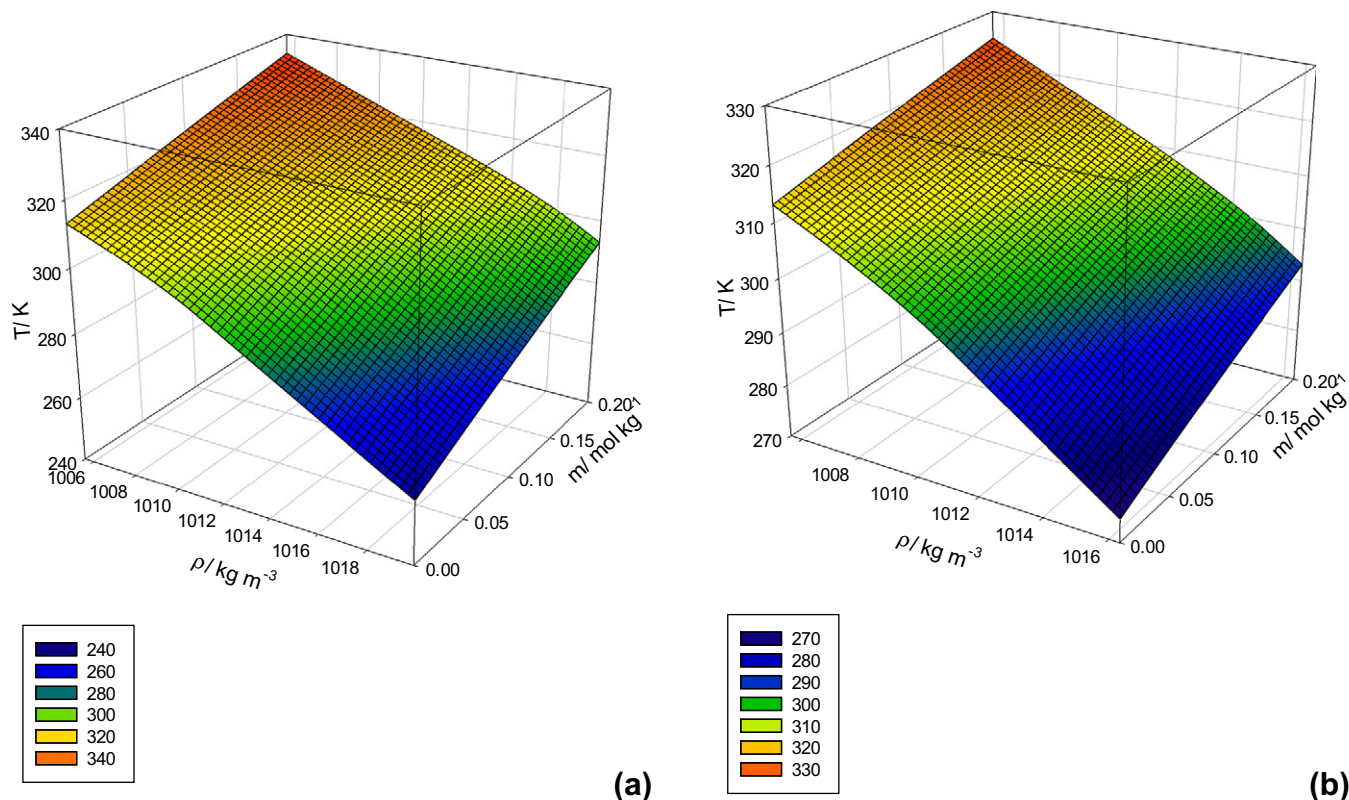


Fig. 1. Plot of density (ρ) against molality (m) for (a) L-serine, (b) L-valine in aqueous solution of lactose at (293.15, 298.15, 303.15, 308.15 and 313.15) K.

Download English Version:

<https://daneshyari.com/en/article/5408324>

Download Persian Version:

<https://daneshyari.com/article/5408324>

[Daneshyari.com](https://daneshyari.com)