

Table 1 — Densities (ρ) and speeds of sound (u) of diglycine in aqueous solutions of sulphathiazole drug at different temperature (T)

m_A (mol kg ⁻¹)	T (K)									
	288.15		293.15		298.15		303.15		308.15	
	$\rho \cdot 10^{-3}$ (kg m ⁻³)	u (m s ⁻¹)	$\rho \cdot 10^{-3}$ (kg m ⁻³)	u (m s ⁻¹)	$\rho \cdot 10^{-3}$ (kg m ⁻³)	u (m s ⁻¹)	$\rho \cdot 10^{-3}$ (kg m ⁻³)	u (m s ⁻¹)	$\rho \cdot 10^{-3}$ (kg m ⁻³)	u (m s ⁻¹)
0.001 m_B sulphathiazole + diglycine										
0.00000	0.999217	1466.56	0.998312	1482.90	0.997145	1497.10	0.995738	1509.56	0.994117	1520.23
0.00218	0.999314	1466.69	0.998408	1483.07	0.997239	1497.34	0.995831	1509.85	0.994208	1520.58
0.00569	0.999492	1467.28	0.998586	1483.72	0.997410	1498.31	0.996001	1510.97	0.994376	1521.82
0.00847	0.999652	1468.06	0.998746	1484.55	0.997564	1499.59	0.996154	1512.49	0.994527	1523.39
0.01000	0.999748	1468.63	0.998842	1485.12	0.997656	1500.48	0.996245	1513.58	0.994618	1524.48
0.005 m_B sulphathiazole + diglycine										
0.00000	0.999728	1467.17	0.998818	1483.45	0.997640	1497.67	0.996233	1509.99	0.994607	1520.60
0.00212	0.999821	1467.28	0.99891	1483.61	0.997730	1497.89	0.996321	1510.25	0.994692	1520.90
0.00499	0.999961	1467.64	0.999049	1484.00	0.997866	1498.33	0.996455	1510.74	0.994823	1521.44
0.00801	1.000126	1468.26	0.999215	1484.65	0.998027	1498.99	0.996614	1511.41	0.994978	1522.18
0.01073	1.000293	1469.02	0.999379	1485.41	0.998187	1499.73	0.996773	1512.16	0.995135	1522.96
0.01 m_B sulphathiazole + diglycine										
0.00000	1.000315	1468.52	0.999398	1484.50	0.998217	1498.74	0.996802	1510.71	0.995166	1521.69
0.00220	1.000409	1468.63	0.999491	1484.62	0.998307	1498.94	0.996891	1510.95	0.995252	1521.98
0.00516	1.000552	1468.76	0.999633	1484.78	0.998446	1499.20	0.997028	1511.27	0.995384	1522.40
0.00839	1.000730	1468.88	0.999811	1484.95	0.99862	1499.47	0.997198	1511.61	0.99555	1522.89
0.01003	1.000829	1468.93	0.999910	1485.04	0.998718	1499.60	0.997294	1511.78	0.995644	1523.16

m_A is the molality diglycine in water - drug solvent systems; m_B is the molality of drug in water; Standard uncertainties, U, are $U(T) = \pm 0.01$ K, $U(p) = \pm 0.01$ MPa, $U(\rho) = \pm 1.5 \times 10^{-1}$ kg·m⁻³, and $U(u) = \pm 5 \times 10^{-2}$ m·s⁻¹

Table 2 — Apparent molar volume V_ϕ , and apparent molar isentropic compression $K_{\phi,s}$, of diglycine in aqueous solutions of sulphathiazole drug at different temperatures

m_A (mol kg ⁻¹)	T(K)									
	$V_\phi \cdot \times 10^6$ (m ³ mol ⁻¹)					$K_{\phi,s} \cdot \times 10^6$ (m ³ mol ⁻¹ GPa ⁻¹)				
	288.15	293.15	298.15	303.15	308.15	288.15	293.15	298.15	303.15	308.15
0.001 m_B sulphathiazole + diglycine										
0.00218	87.65	88.15	89.12	89.65	90.65	-17.6	-27.4	-44.3	-55.5	-68.4
0.00569	83.79	84.00	85.64	86.04	86.82	-63.5	-71.6	-108.0	-125.0	-138.0
0.00847	80.75	80.90	82.71	83.11	83.89	-98.3	-105.0	-159.0	-184.0	-193.0
0.01000	79.00	79.12	81.06	81.51	82.17	-119.0	-123.0	-186.0	-217.0	-224.0
0.005 m_B sulphathiazole + diglycine										
0.00212	88.26	88.77	89.77	90.79	92.30	-12.2	-25.4	-39.7	-48.6	-56.3
0.00499	85.42	85.85	86.91	87.77	89.06	-41.6	-49.2	-59.3	-67.2	-74.2
0.00801	82.41	82.56	83.86	84.66	85.98	-70.9	-76.4	-81.4	-85.4	-93.0
0.01073	79.43	79.82	81.17	81.87	83.05	-96.7	-98.9	-99.9	-102.0	-108.0
0.01 m_B sulphathiazole + diglycine										
0.00220	89.37	89.87	91.29	91.82	93.28	-10.0	-17.2	-31.6	-40.0	-50.1
0.00516	86.16	86.58	87.80	88.44	90.08	-12.0	-18.0	-33.4	-42.6	-56.1
0.00839	82.61	82.88	84.12	85.01	86.51	-14.1	-18.9	-35.4	-44.9	-62.2
0.01003	80.82	81.05	82.19	83.13	84.60	-14.8	-19.2	-36.2	-46.2	-65.8

where $M/\text{kg mol}^{-1}$ is the molar mass of diglycine and ρ , ρ_0 , β_s and $\beta_{s,0}$ are the densities in kg m⁻³ and coefficient of molar isentropic compression of solution and the solvent (drug+water) in Pa⁻¹ and m_A is the molality of solute in kg mol⁻¹, that is,

diglycine in solutions. The coefficient of molar isentropic compression has been calculated by the following Laplace-Newton's equation

$$\beta_s = (1/u^2 \rho) \quad \dots (3)$$

Since, for diglycine, a linear dependence of both the apparent molar volumes (V_ϕ) and the apparent molar isentropic compression ($K_{s,\phi}$) on the molality (m_A) was observed over the concentration range studied. Furthermore, both the values show an increase with the chain length i.e., from glycine³⁶ to diglycine at all the temperatures. Due to the presence of polar groups both on drug as well as on diglycine, the structure enhancing ability of peptide in the solution are improved.

The apparent molar volumes at infinite dilution (V_ϕ^0) and limiting apparent molar isentropic compression ($K_{s,\phi}^0$) are obtained by the linear regression analysis of the V_ϕ and $K_{s,\phi}$ data using the following equation

$$Y_\phi = Y_\phi^0 + S_Q m_A \quad \dots (4)$$

where Y_ϕ^0 (denotes V_ϕ^0 or $K_{s,\phi}^0$) is the limiting value of the apparent partial molar property that is equal to the infinite dilution partial molar property and S_Q (denotes S_V or S_K) is the experimental or limiting slope indicative of solute-solute interactions. The V_ϕ^0 or $K_{s,\phi}^0$ at infinite dilution and S_V or S_K with standard errors obtained by the least square fitting of V_ϕ and $K_{s,\phi}$ data using Eqn.(4) are summarized in Table 3.

The V_ϕ and $K_{s,\phi}$ were found to be a linear function of m_A , in the concentration range studied. The V_ϕ and $K_{s,\phi}$ data have been used to see the effect of temperature and drug concentration on solute-solvent interactions occurring in the ternary mixtures of the present study. Table 3 reveals that diglycine studied here has large positive V_ϕ^0 values and negative $K_{s,\phi}^0$ (Ref 17) values in aqueous sulphathiazole solutions (except at lower temperature and at lower sulphathiazole concentrations), which indicates

Table 3 — Partial molar properties, V_ϕ^0 ($\text{m}^3 \text{mol}^{-1}$), $K_{\phi,s}^0$ ($\text{m}^3 \text{mol}^{-1} \text{GPa}^{-1}$) and their corresponding slopes, S_V ($\text{m}^3 \text{kg mol}^{-3/2}$) and S_K ($\text{kg m}^3 \text{mol}^{-2} \text{GPa}^{-1}$) of diglycine in aqueous solutions of sulphathiazole drug at different temperatures

Properties	T(K)				
	288.15	293.15	298.15	303.15	308.15
Diglycine in water					
$V_\phi^0 \cdot \times 10^6$	74.14(± 0.02) [24]	74.63(± 0.03)*	75.24(± 0.05) [24]	75.57(± 0.03)*	76.21(± 0.02) [24]
$S_V \cdot \times 10^6$	5.37(± 0.17)	5.40(± 0.02)	5.44(± 0.13)	5.32(± 0.02)	5.22(± 0.14)
$K_{s,\phi}^0 \cdot \times 10^6$	-43.58(± 0.22) [22]	-41.64(± 0.25)*	-39.64(± 0.20) [22]	-37.54(± 0.18)*	-35.57(± 0.01) [22]
$S_K \cdot \times 10^6$	2.30(± 1.11)	6.74(± 1.04)	7.94(± 1.13)	8.46(± 0.64)	8.49(± 0.72)
0.001 m _B sulphathiazole + diglycine					
$V_\phi^0 \cdot \times 10^6$	90.06(± 0.03)	90.62(± 0.07)	91.41(± 0.09)	91.93(± 0.03)	92.99(± 0.05)
$S_V \cdot \times 10^6$	-1103.64(± 5.31)	-1151.6(± 10.26)	-1030.3(± 13.64)	-1041.63(± 4.26)	-1080.56(± 6.93)
$K_{s,\phi}^0 \cdot \times 10^6$	10.42(± 0.73)	-1.21(± 0.92)	-4.76(± 0.48)	-9.37(± 2.11)	-24.97(± 0.37)
$S_K \cdot \times 10^6$	-12911.2(± 101.1)	-12230.8(± 128.2)	-18156.3(± 67.07)	-20363.1(± 292.9)	-19874.2(± 51.6)
0.005 m _B sulphathiazole + diglycine					
$V_\phi^0 \cdot \times 10^6$	90.48(± 0.124)	91.00(± 0.08)	92.38(± 0.10)	92.96(± 0.03)	94.50(± 0.10)
$S_V \cdot \times 10^6$	-1022.13(± 17.29)	-1044.98(± 11.09)	-1042.48(± 13.97)	-1035.39(± 4.31)	-1068.5(± 14.5)
$K_{s,\phi}^0 \cdot \times 10^6$	8.00(± 0.86)	-6.97(± 0.75)	-24.66(± 0.52)	-35.93(± 0.63)	-43.9(± 0.86)
$S_K \cdot \times 10^6$	-9803(± 119.2)	-8588.09(± 103.8)	-7027.6(± 72.04)	-6176.75(± 87.81)	-6030.6(± 119.7)
0.01 m _B sulphathiazole + diglycine					
$V_\phi^0 \cdot \times 10^6$	91.78(± 0.01)	92.37(± 0.03)	93.82(± 0.04)	94.21(± 0.08)	95.74(± 0.07)
$S_V \cdot \times 10^6$	-1092.78(± 2.20)	-1128.93(± 5.05)	-1159.15(± 5.98)	-1103.27(± 12.14)	-1106.51(± 10.10)
$K_{s,\phi}^0 \cdot \times 10^6$	-8.71(± 0.21)	-16.64(± 0.07)	-30.32(± 106)	-38.38(± 0.17)	-45.74(± 0.20)
$S_K \cdot \times 10^6$	-622.8(± 29.6)	-260.24(± 10.88)	-594.08(± 14.98)	-782.68(± 25.27)	-1986.12(± 31.70)

*Obtained through extrapolation; Expanded uncertainties, $U_{\text{exp.}}$ are $U_{\text{exp.}}(V_\phi^0) = \pm 0.05 \cdot 10^{-6} \text{ m}^3 \text{mol}^{-1}$, and $U_{\text{exp.}}(K_{\phi,s}^0) = \pm 0.04 \cdot 10^{-6} \text{ m}^3 \text{mol}^{-1} \text{GPa}^{-1}$; Corresponding references are given in the square bracket

the presence of strong dipeptide – drug-water²² interactions. The V_{ϕ}^0 values increase from glycine³⁶ to diglycine with the order of the increase of the molar mass or peptide linkage. Further, the values increase with increasing temperature and also with increase in the concentration of sulphathiazole. This signifies that solute-solvent interaction increases^{30,35} both with an increase in the concentration of sulphathiazole and temperature. This is due to the reduction in the electrostriction surrounding the zwitterion. This interaction results from the release of some water molecules from the loose solvation shell of the solute (diglycine) in the bulk solution. As a result, there is expansion in volume of the solution. That is, the maximum structure-breaking effect of diglycine takes place in higher concentrations of sulphathiazole and at higher temperature. Moreover, $K_{s,\phi}^0$ values are negative for diglycine but higher in magnitude than glycine³⁶ in aqueous sulphathiazole solutions. The negative $K_{s,\phi}^0$ values indicate that water molecules around the solute are less compressible than water present in the bulk. This feature is similar to that observed for diglycine in aqueous solutions of saccharides or cyclodextrin^{17,22,24,30}. The experimental S_V values in Table 3 for diglycine in sulphathiazole are found to be negative but smaller than the V_{ϕ}^0 values, suggesting that solute-solute interactions are weaker than solute-solvent interaction in the system under study.

Partial molar properties of transfer

The transfer partial molar volume of transfer ($\Delta_{tr}V_{\phi}^{\circ}$) and partial molar isentropic compression of transfer ($\Delta_{tr}K_{s,\phi}^{\circ}$) of diglycine from water to aqueous solutions of sulphathiazole drug have been determined as

$$\Delta_{tr}Y_{\phi}^{\circ} = Y_{\phi}^{\circ}(\text{in aqueous sulphathiazole solution}) - Y_{\phi}^{\circ}(\text{in water}) \quad \dots (5)$$

The experimental values V_{ϕ}^0 and $K_{s,\phi}^0$ for diglycine

in water have been taken from our previous works^{22,24}. Table 4 and Figs. 2 and 3 show that $\Delta_{tr}V_{\phi}^{\circ}$ are positive and $\Delta_{tr}K_{s,\phi}^{\circ}$ are also positive (except for diglycine at higher concentrations of sulphathiazole and at higher temperatures). The $\Delta_{tr}V_{\phi}^{\circ}$ value can further be explained on the basis of cosphere overlap model^{37,38}. According to this model ionic-hydrophilic and hydrophilic - hydrophilic group interactions contribute positively, whereas hydrophilic-

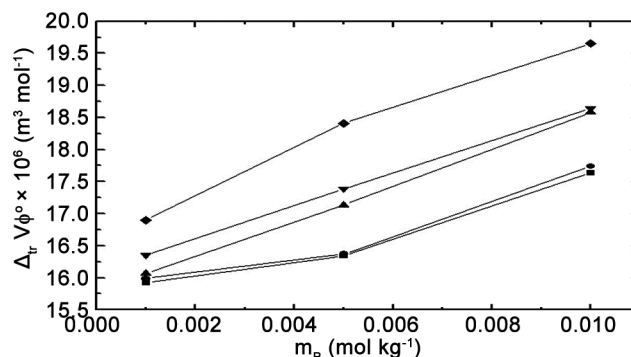



Fig. 2 — Plot of transfer partial molar volume, $\Delta_{tr}V_{\phi}^{\circ}$ at infinite dilution versus molality of sulphathiazole drug at T= (■, 288.15 K; ●, 293.15 K; ▲, 298.15 K; ▼, 303.15 K; ○, 308.15 K)

Fig. 3 — Plot of transfer partial molar isentropic compression, $\Delta_{tr}K_{s,\phi}^{\circ}$ at infinite dilution versus molality of sulphathiazole drug at T= (■, 288.15 K; ●, 293.15 K; ▲, 298.15 K; ▼, 303.15 K; ○, 308.15 K)

Table 4 — Transfer partial molar volumes, $\Delta_{tr}V_{\phi}^{\circ}$ and transfer partial molar isentropic compressions, $\Delta_{tr}K_{\phi,s}^{\circ}$ of diglycine in aqueous solutions of sulphathiazole drug at different temperatures

m_B (mol kg ⁻¹)	T(K)									
	$\Delta_{tr}V_{\phi}^{\circ} \times 10^6$ (m ³ mol ⁻¹)					$\Delta_{tr}K_{\phi,s}^{\circ} \times 10^6$ (m ³ mol ⁻¹ GPa ⁻¹)				
	288.15	293.15	298.15	303.15	308.15	288.15	293.15	298.15	303.15	308.15
	Sulphathiazole + diglycine									
0.001	15.92	15.99	16.07	16.36	16.90	54.00	40.43	35.04	28.17	10.6
0.005	16.34	16.37	17.14	17.39	18.41	51.58	34.67	15.14	1.61	-8.33
0.01	17.64	17.74	18.58	18.64	19.65	34.87	25.00	9.48	-0.84	-10.17

hydrophobic and hydrophobic-hydrophobic group interactions contribute negatively to the $\Delta_{tr}V_{\phi}^{\circ}$ values. It can be seen in Table 4 and Fig. 2 that the positive transfer volume $\Delta_{tr}V_{\phi}^{\circ}$ for diglycine increases with increasing concentration of drug and at all of the temperatures. It may be concluded that in the ternary solutions, the increased concentrations of drug lead to greater ionic-hydrophilic and hydrophilic-hydrophilic interactions between NH_3^+ and COO^- group of

diglycine and sulfuric()group of sulpha drugs that are not influenced by the hydrophilic-hydrophobic interactions. Thus, it promotes the structure making ability of solute in the solution due to hydrophilic interactions between them.

The $\Delta_{tr}K_{s,\phi}^{\circ}$ values decrease both with increase in concentration of sulphathiazole drug and temperature. The positive value $\Delta_{tr}K_{s,\phi}^{\circ}$ indicates the dominance of the charged end groups NH_3^+ and COO^- . The interactions between sulphathiazole drug and zwitterionic centre of diglycine increase with drug concentration. Increase in the concentration of drug leads to electrostriction decreases and structure making tendency of the ions increases². That is, the release of water molecules to solvent bulk occurs due to disruption of hydration sphere of the charged end centers of diglycine and sulphathiazole drug. As a result, it leads to large decrease in the compressibility with increase in sulphathiazole concentration. Thus, $K_{s,\phi}^{\circ}$ values are negative and $\Delta_{tr}K_{s,\phi}^{\circ}$ values are positive.

The pair and triplet interaction coefficients estimated from $\Delta_{tr}V_{\phi}^{\circ}$ and $\Delta_{tr}K_{s,\phi}^{\circ}$ values as given by McMillan *et al.*³⁹ and Millero *et al.*⁴⁰ by using the following equation,

$$\Delta_{tr}Y_{\phi}^{\circ}(\text{water to aqueous cosolute solution}) = 2Y_{AB}m_B + 3Y_{ABB}m_B^2 \quad \dots (6)$$

where, the constants Y_{AB} and Y_{ABB} are pairwise and triplet interaction coefficients. Here A denotes diglycine, B denotes the cosolute (drugs), and m_B is the molality of the cosolute. The $\Delta_{tr}Y_{\phi}^{\circ}$ values have been fitted to Eqn. (6) to obtain Y_{AB} and Y_{ABB} . The corresponding parameters V_{AB} and V_{ABB} for volumes and K_{AB} and K_{ABB} for isentropic compressions, estimated from $\Delta_{tr}V_{\phi}^{\circ}$ and $\Delta_{tr}K_{s,\phi}^{\circ}$ respectively, are listed in Table 5. The pair wise interaction coefficients V_{AB} are positive for sulpha drug at all temperatures whereas triplet interaction coefficient V_{ABB} is negative except at 288.15 K for diglycine. Positive values for V_{AB} strengthen our viewpoint that

ionic/hydrophilic-hydrophilic interactions dominate over hydrophobic-ionic interactions between solute and cosolute molecules. The values of V_{AB} for diglycine increase with increase in temperature. The pairwise interaction coefficient K_{AB} corresponding to the isentropic compression is positive except at 308.15 K and it decreases with increase in temperature.

Apparent molar expansibilities

The temperature variation of V_{ϕ}° can be expressed as

$$V_{\phi}^{\circ} = a + b(T - T_m) + c(T - T_m)^2 \quad \dots (7)$$

where T_m represents the midpoint temperature of the range used ($T_m = 298.15$ K). Least-square fitting of Eqn. (7) was done to obtain a, b and c parameters. Differentiation of Eqn. (7) with respect to temperature at constant pressure was done to calculate partial molar isobaric expansions

$$E_2^{\circ} = (\partial V_{\phi}^{\circ} / \partial T)_P = b + 2c(T - T_m) \quad \dots (8)$$

It follows from Eqn. (8) that the quantity $b + 2c(T - T_m)$ is equivalent to E_2° . The calculated values of partial molar expansion (E_2°) at different temperatures are included in Table 6.

Table 5 — Pair, Y_{AB} and triplet, Y_{ABB} interaction coefficients of diglycine in aqueous solutions of sulphathiazole at different temperatures

Temp. (K)	$V_{AB} \times 10^9$ ($\text{m}^3 \text{mol}^{-2}$ kg)	$V_{ABB} \times 10^{11}$ ($\text{m}^3 \text{mol}^{-3}$ kg^2)	$K_{AB} \times 10^9$ ($\text{m}^3 \text{mol}^{-2} \text{kg}$ GPa^{-1})	$K_{ABB} \times 10^{11}$ ($\text{m}^3 \text{mol}^{-3} \text{kg}^2$ GPa^{-1})
Sulphathiazole + diglycine				
288.15	3.15	-1.54	11.0	-6.31
293.15	3.15	-1.54	7.68	-4.36
298.15	3.26	-1.58	4.58	-2.81
303.15	3.32	-1.62	2.20	-1.56
308.15	3.49	-1.70	-0.30	-1.67

Table 6 — Partial molar expansions, E_2° at infinite dilution and isobaric thermal expansion coefficient, α_2 of diglycine in aqueous solutions of sulphathiazole at different temperatures

m_B (mol kg^{-1})	$E_2^{\circ} \times 10^6$ ($\text{m}^3 \text{mol}^{-1} \text{K}^{-1}$)				
	288.15	293.15	298.15	303.15	308.15
Sulphathiazole + diglycine					
0.001	-0.018	0.015	0.049	0.083	0.117
0.005	0.056	0.080	0.103	0.127	0.150
0.010	0.087	0.094	0.100	0.107	0.113
α_2 (K)					
Sulphathiazole + diglycine					
0.001	-0.00021	0.00017	0.00054	0.00090	0.00012
0.005	0.00062	0.00088	0.00112	0.00136	0.00159
0.010	0.00095	0.00102	0.00107	0.00113	0.00118

The E_2^0 values for any solute thought to be sensitive measure of solute-solvent interaction⁴¹. From Table 6, it has been seen that at each temperature E_2^0 values in aqueous drug solution are increasing regularly with rise in temperature, and with the concentration of sulphathiazole drug except at higher temperatures and higher concentrations. It may be noted that E_2^0 values are positive favouring the solute-solute interactions. The effect is that electrostricted water may be released from the loose solvation layer of diglycine. Removal of water molecules favours diglycine-drug or drug-drug interactions, indicating the value of partial molar expansibility gives information regarding the size of the solute and its hydrophobicity. The values of V_ϕ^0 and E_2^0 are further used to calculate the isobaric thermal expansion coefficient, α_2 using following relation⁴²

$$\alpha_2 = E_2^0/V_\phi^0 \quad \dots (9)$$

The α_2 value increases with increase in temperature as well as with increase in concentration of sulphathiazole drug (except at higher concentration and higher temperature) indicating that dipeptide - drug- water interaction increases as concentration of sulphathiazole drug increases. The calculated values of α_2 are included in Table 6.

Hydration Number

The partial molar volume of the peptide can be examined by a simple model⁴⁰

$$V_\phi^0(\text{peptide}) = V_\phi^0(\text{int}) + V_\phi^0(\text{elect}) \quad \dots (10)$$

where $V_\phi^0(\text{elect})$ is the electrostriction partial molar volume due to the hydration of the peptide and can be estimated from experimentally measured values of $V_\phi^0(\text{peptide})$, and $V_\phi^0(\text{int})$ is the intrinsic partial molar volume of the peptide and has been calculated from the following expressions⁴⁰

$$V_\phi^0(\text{int}) = (0.7/0.6) V_\phi^0(\text{cryst}) \quad \dots (11)$$

$$V_\phi^0(\text{int}) = (0.7/0.634) V_\phi^0(\text{cryst}) \quad \dots (12)$$

where $V_\phi^0(\text{cryst}) (= M/d_{\text{cryst}})$ is the crystal molar volume and M its molar mass, 0.7 is the packing density for molecules in organic crystals and 0.634 is the packing density for random packing spheres. The values of $V_\phi^0(\text{int})$ for the peptide were estimated from Eqn. (11) and (12) using d_{cryst} values for diglycine

determined by single crystal X-ray diffraction is 1.534 g cm^{-3} taken from the references^{43,44}.

The change in volume due to electrostriction can be related to the number of water molecules n_H hydrated to the diglycine by⁴⁵⁻⁴⁷

$$n_H = -V_\phi^0(\text{elect})/(V_{\phi,e}^0 - V_{\phi,b}^0) \quad \dots (13)$$

where $V_{\phi,e}^0$ is the molar volume of electrostricted water and $V_{\phi,b}^0$ is the molar volume of bulk water ($18.069 \times 10^{-6} \text{ m}^3 \text{ mol}^{-1}$ at 298.15 K). The reported value^{35,38} of $(V_{\phi,e}^0 - V_{\phi,b}^0)$ is $\approx -3.3 \times 10^{-6} \text{ m}^3 \text{ mol}^{-1}$ at 298.15 K. Further, the number of water molecules n_H hydrated to the diglycine were calculated by using the method given by Millero *et al.*^{40,48}

$$n_H = -K_{\phi,s}^0(\text{elect})/V_{\phi,b}^0 K_{s,b}^0 \quad \dots (14)$$

The values of n_H calculated from Eqn. (13) and (14) using the $V_\phi^0(\text{elect})$ and $K_{s,\phi}^0(\text{elect})$ values determined are listed in Table 7. It can be seen that the n_H values calculated from partial molar volume data decrease with an increase in the concentration of sulphathiazole drug³⁰. Similar results are observed between diglycine and sulpha drugs in aqueous solutions⁴⁴. Again, this indicates that an increase in solute-cosolute interaction occurs with increase in concentration of antibiotic drug. This suggests that the interactions between the hydrophilic group of drugs and the charged end centers/polar groups of peptide become stronger with increase in the sulphathiazole concentrations. The values for the diglycine from compressibility data in the presence of sulphathiazole are less than in water and increases with the concentration of sulphathiazole. It again indicates the increase in the solute-cosolute interaction with increasing sulphathiazole drug concentrations as the number of solvent (water) molecules around solute goes on decreasing. Subsequently, solute-solvent

Table 7 — Hydration number, n_H of diglycine in aqueous solutions of sulphathiazole at 298.15 K

m_B (mol kg ⁻¹)	Hydration number (n_H)		
	From volume		From compressibility
	Using Eqn. 11	Using Eqn. 12	Using Eqn. 14
0.000	7.65	6.02	4.91
0.001	2.75	1.12	0.58
0.005	2.50	0.82	3.04
0.010	2.02	0.39	3.74

interaction decreases. This clearly shows that sulphathiazole drug have a dehydrating effect on diglycine in aqueous solutions. Also, we can classify diglycine as a structure- maker in aqueous solution of sulphathiazole.

Conclusions

In this paper, we have presented the volumetric and acoustic properties of diglycine in aqueous sulphathiazole drug solutions at different temperatures. The apparent molar volume values are positive and apparent molar isentropic compression values are negative in aqueous drug solutions, indicating the presence of strong solute-solvent interactions. The transfer volumes of peptide from water to aqueous drug solutions are positive, suggesting that ionic-hydrophilic and hydrophilic - hydrophilic group interactions play a dominant role in these systems. Positive value of partial molar expansibility and pair wise interaction coefficient indicate the presence of strong solute-solute interaction. These results also confirm the structure making behaviour of diglycine in aqueous drug solution. Hydration number calculated from values of partial molar volume decreases with increase in concentration of sulphathiazole drug, indicating an increase in solute-solvent interactions. Therefore, such a study has great importance in future for formulation development in the pharmaceutical industry, drug delivery and physiological action.

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