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Volumetric and compressibility behavior of L-valine in aqueous poly ethylene glycol solutions at $T = (298.15, 308.15$ and $318.15)$ K

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ABSTRACT

The density and sound velocity measurements were carried out on L-valine (2-amino-3-methyl butanoic acid) in pure water and in aqueous solutions of 0.02 w/w of PEG400, PEG2000 and PEG6000 at T = (298.15, 308.15 and 318.15) K at ambient pressure. From these experimental data, the values of the apparent molar volume, isentropic compressibility and apparent molar isentropic compressibility were evaluated and fitted to the Redlich – Mayer equation from which the corresponding infinite dilution molar properties were obtained. Furthermore, the effect of molar mass PEG and temperature on the volumetric and comperssibility properties of the mentioned systems have been studied. The results show that the structure and molar mass of the polymer don't affect on the values of apparent molar volume, isentropic compressibility and apparent molar isentropic compressibility.

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1. Introduction

Study of the stability of proteins, in aqueous solutions is greatly influenced by the addition of various solutes to solutions. Due to highly complex structure of proteins, amino acids are commonly used in molecular interaction studies instead of them [1–6]. Therefore, to gain a better knowledge about the nature of these interactions, studies of physicochemical properties of amino acids in aqueous solutions are vital [1–3,7]. Although there are several literatures which aimed the studying of the compressibility and volumetric properties of aqueous amino acid – PEG solutions [8–11], detailed knowledge on the thermodynamic properties of these systems is scarce. As a continuation of our research group works about studying of excess molar volume, partial molar volume and apparent molar volume of binary and ternary mixtures containing organic solvent [12–16], in this present work we did a comprehensive study of volumetric and compressibility properties at different temperatures (298.15, 308.15 and 318.15) K for binary system (L-valine in water) and ternary aqueous systems (L-valine in aqueous solutions of 0.02 *w*/w of the PEG400, PEG2000 and PEG6000).

2. Experimental section

2.1. Materials

PEGS and L-valine (≥99% w/w) were obtained from Merck and used without further purification. Double distilled and deionized water was used for the preparation of the solutions.

2.2. Method

All the solutions were prepared by mass on an electronic balance (Sartorius AG.GK 1203, Germany) accurate to within $\pm 10^{-4}$g by considering one specific molality, the experiments were carried out for all temperature studied. The density and sound velocity of the solutions were measured at different temperatures with a digital vibrating-tube analyzer (Anton Paar DSA 5000) with proportional temperature control that kept the samples at working temperature within $\pm 10^{-3}$ K. The calibration of the instrument was made with degassed and double distilled water and dry air at atmospheric pressure according to the instruction manual of the instrument. The experimental uncertainties of density and sound velocity measurements were $\pm 3.10^{-5}$ g·cm^{-3} and $\pm 3.10^{-1}$ m·s^{-1}, respectively.

3. Results and discussion

In order to gain a better understanding of various interactions existing in the amino acid + water + polymer systems, we performed

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the volumetric and compressibility studied on the solutions of L-valine in pure water and in aqueous solutions of 0.02 w/w of PEG400, PEG2000 and PEG6000 by accurate measurements of density and sound velocity at different temperatures as a function of molality. The experimental density, d, and sound velocity, u, data for the investigated systems are reported in Table 1.

Table 1
Experimental density $d/(g\cdot cm^{-3})$ and sound velocity $u/(m\cdot s^{-1})$of L-valine in water and in aqueous solutions of 0.02 w/w of PEG400, PEG2000 and PEG6000 at different temperatures as function of the molality.

$m/(mol\cdot kg^{-1})$	$T = 298.15\ K$		$T = 308.15$ K		$T = 318.15$ K	
	$d/(g\cdot cm^{-3})$	$u/(m\cdot s^{-1})$	$d/(g\cdot cm^{-3})$	$u/(m\cdot s^{-1})$	$d/(g\cdot cm^{-3})$	$u/(m\cdot s^{-1})$
	L- valine in water					
0.0171	0.997522	1498.64	0.994427	1521.45	0.988352	1537.93
0.0214	0.997630	1499.01	0.994600	1521.73	0.988581	1538.21
0.0309	0.997876	1499.98	0.994855	1522.62	0.989868	1539.02
0.0385	0.998078	1500.70	0.995049	1523.32	0.990181	1539.65
0.0515	0.998436	1502.00	0.995402	1524.53	0.990612	1540.76
0.0684	0.998861	1503.58	0.995819	1525.96	0.990506	1542.06
0.0861	0.999335	1505.33	0.996286	1527.56	0.991533	1543.53
0.1105	0.999998	1507.74	0.996940	1529.75	0.992395	1545.54
0.1564	1.001206	1512.40	0.998126	1534.10	0.993341	1549.60
0.1976	1.002284	1516.16	0.999184	1537.46	0.994266	1552.60
0.2229	1.002831	1518.20	0.999722	1539.31	0.994976	1554.31
0.2704	1.004102	1522.89	1.000970	1543.59	0.996167	1558.23
0.3109	1.004999	1526.21	1.001851	1546.63	0.997754	1561.02
0.3477	1.005994	1529.90	1.002827	1549.99	0.997894	1564.10
	L-Valine in aqueous solution of 2% w/w PEG400					
0.0128	1.000342	1508.73	0.997231	1529.97	0.993324	1545.10
0.0171	1.000468	1509.17	0.997355	1530.40	0.993294	1545.49
0.0222	1.000594	1509.70	0.997476	1530.84	0.993535	1545.88
0.0389	1.001051	1511.81	0.997929	1532.87	0.993998	1547.92
0.0683	1.001829	1514.20	0.998691	1534.98	0.994751	1549.68
0.0840	1.002228	1515.81	0.999084	1536.48	0.995137	1551.13
0.1123	1.002952	1518.34	0.999796	1538.74	0.995843	1553.14
0.1282	1.003372	1519.88	1.000209	1540.16	0.996026	1554.44
0.1731	1.004521	1524.30	1.001337	1544.23	0.997361	1558.22
0.1919	1.004958	1526.75	1.001765	1546.56	0.997425	1560.56
0.2273	1.005903	1529.24	1.002693	1548.72	0.998241	1562.31
0.2620	1.006781	1532.49	1.003552	1551.65	0.999547	1565.00
0.3078	1.007956	1537.06	1.004707	1555.86	1.000687	1565.87
0.3498	1.008963	1540.59	1.005692	1559.03	1.001657	1571.71
	L-Valine in aqueous solution of 2% w/w PEG2000					
0.0128	1.000641	1508.99	0.997289	1530.21	0.992178	1545.29
0.0169	1.000766	1509.43	0.997627	1530.64	0.992351	1545.71
0.0213	1.000905	1509.94	0.997764	1531.10	0.992551	1546.13
0.0299	1.001112	1510.72	0.997966	1531.81	0.992695	1546.78
0.0376	1.001310	1511.47	0.998162	1532.48	0.993116	1547.40
0.0515	1.001677	1513.15	0.998521	1534.13	0.993544	1549.03
0.0688	1.002113	1514.45	0.998948	1535.21	0.993976	1549.90
0.0861	1.002571	1516.59	0.999321	1537.23	0.994303	1551.81
0.1122	1.003240	1518.58	1.000057	1538.99	0.995459	1553.37
0.1552	1.004406	1522.90	1.001201	1542.95	0.996009	1557.02
0.1911	1.005298	1526.21	1.002075	1545.94	0.997034	1559.74
0.2267	1.006222	1529.67	1.002986	1549.09	0.998638	1562.62
0.2633	1.007131	1533.26	1.003876	1552.43	0.997992	1565.72
0.3073	1.008192	1537.13	1.004918	1555.95	0.999936	1568.92
0.3542	1.009359	1541.46	1.006065	1559.87	1.001723	1572.44

$m/(mol\cdot kg^{-1})$	$T = 298.15\ K$		$T = 308.15$ K		$T = 318.15$ K	
	$d/(g\cdot cm^{-3})$	$u/(m\cdot s^{-1})$	$d/(g\cdot cm^{-3})$	$u/(m\cdot s^{-1})$	$d/(g\cdot cm^{-3})$	$u/(m\cdot s^{-1})$
	L-Valine in aqueous solution of 2% w/w PEG6000					
0.0135	1.000706	1509.11	0.997188	1530.35	0.991533	1545.45
0.0210	1.000906	1509.79	0.997491	1530.97	0.992220	1546.04
0.0380	1.001350	1511.42	0.998020	1532.48	0.992642	1547.46
0.0673	1.002106	1514.22	0.998925	1534.99	0.994705	1549.70
0.0779	1.002404	1515.53	0.999233	1536.30	0.994953	1550.97
0.0858	1.002606	1516.14	0.999431	1536.77	0.995163	1551.35
0.1113	1.003248	1518.98	1.000055	1539.43	0.995813	1553.84
0.1274	1.003682	1520.05	1.000488	1540.32	0.996258	1554.56
0.1541	1.004388	1522.69	1.001154	1542.76	0.996585	1556.85
0.1910	1.005271	1525.96	1.002015	1545.71	0.997696	1559.53
0.2155	1.005961	1528.50	1.002729	1548.03	0.998480	1561.62
0.2617	1.007105	1532.77	1.003777	1552.04	0.998653	1565.35
0.3053	1.008179	1536.75	1.004901	1555.56	1.000456	1568.54
0.3547	1.009396	1541.29	1.006084	1559.70	1.001108	1572.30

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