JOURNAL OF CHEMICAL & ENGINEERING DATA

SHORT ARTICLE

pubs.acs.org/jced

Densities, Speeds of Sound, and Refractive Indices of Binary Mixtures of Decan-1-ol with Anisole, *o*-Cresol, *m*-Cresol, and *p*-Cresol at T = (298.15, 303.15, and 308.15) K

Subhash C. Bhatia,* Ruman Rani,* and Rachna Bhatia

Department of Chemistry, Kurukshetra University, Kurukshetra 136 119, Haryana, India

S *Supporting Information*

ABSTRACT: Densities, speeds of sound, and refractive indices of binary mixtures of decan-1-ol with 2-methylphenol (*o*-cresol), 3-methylphenol (*m*-cresol), 4-methylphenol (*p*-cresol), and methyl phenyl ether (anisole) were measured over the entire range of composition from T = (298.15 to 308.15) K and at a pressure of 0.1 MPa. The experimental values of densities were used to calculate the excess molar volumes of the binary liquid mixtures. Excess molar volumes have been fitted to the Redlich−Kister polynomial equation to derive the binary coefficients and the standard errors between the experimental and the calculated quantities. The excess molar volumes are negative over the entire composition range for the binary mixtures of decan-1-ol with *m*-cresol and *p*-cresol and give an s-shaped curve with *o*-cresol at the high mole fraction region of *o*-cresol. For the binary mixtures of decan-1-ol with anisole, the excess molar volume is positive.

INTRODUCTION

Information about the physical properties of the pure liquids and the liquid mixtures containing aromatic hydrocarbon and higher alcohols and their dependence on composition and temperature is a very important basic data required for extraction and separation processes in petrochemical industry. Systematic studies of thermodynamic properties of binary liquid mixtures of higher alcohols and aromatic hydrocarbons are important to study the nature of molecular interaction and physicochemical behavior of these binary mixtures,[1−5] but the review of the literature on the thermodynamic, acoustic, and optical properties of binary mixtures containing 1-alcohols with aromatic hydrocarbon reveals that the databases are limited, so it seems to be very useful in this area of research to carry out systematic investigations involving the physical properties of the binary mixtures containing 1-alcohols with aromatic hydrocarbons. In an attempt to explore the nature of interactions occurring between the decan-1-ol with isomeric cresols and anisole, the densities, speeds of sound, and refractive indices of binary mixtures of decan-1-ol with *o*-cresol, *m*-cresol, *p*-cresol, and anisole have been measured over the entire range of composition at T = (298.15, 303.15, and 308.15) K and at atmospheric pressure. From the experimental data, excess molar volumes were calculated. The calculated excess functions have been fitted to the Redlich−Kister polynomial equation to derive the binary coefficients and the standard errors between the experimental and the calculated quantities.

EXPERIMENTAL SECTION

Chemicals. Decan-1-ol (CAS Registry No.: 112-30-1 with a mass fraction purity of 0.995), *o*-cresol (CAS Registry No.: 96-66-2 with a mass fraction purity of 0.997), *m*-cresol (CAS Registry No.: 2301-01-7 with a mass fraction purity of 0.997), *p*-cresol (CAS Registry No.: 128-37-0 with a mass fraction purity of 0.990), and anisole (CAS Registry No.: 100-63-3 with a mass fraction purity of 0.995) were obtained from SD Fine Chemicals, Ltd., India and were used after double distillation and partially degassed with a vacuum pump under nitrogen atmosphere. The purity of these solvents was ascertained by comparing the measured density, refractive index, and speed of sound of the components at T = 298.15 K with the available literature[6−13] shown in the Table 1.

Measurements. All liquid mixtures are prepared by weighing appropriate amounts of pure liquids on an electronic balance (Afcoset, ER-120A, India) with a precision of ± 0.1 mg by syringing each component into airtight stopper bottles to minimize evaporation losses. The accuracy of the mole fraction was $\pm\, 1 \cdot 10^{-4}$.

Densities, ρ, and speeds of sound, u, of the pure liquids and their mixtures were measured with a density and sound speed analyzer apparatus (Anton Paar DSA 5000, Austria-Europe) with precision in densities and speeds of sound better than $\pm\, 2 \cdot 10^{-6}\ \mathrm{g \cdot cm^{-3}}$ and $\pm\, 0.01\ \mathrm{m \cdot s^{-1}}$, respectively, and the temperature was kept constant within ± 0.001 K using the Peltier method. The uncertainty in experimental measurements has been found to be lower than $\pm\, 10^{-4}\ \mathrm{g \cdot cm^{-3}}$ for the density and $\pm\, 1\ \mathrm{m \cdot s^{-1}}$ for the speed of sound. Before each series of measurements, the calibration of the apparatus was carried

Special Issue: John M. Prausnitz Festschrift

Received: April 14, 2010
Accepted: July 8, 2010
Published: July 21, 2010

dx.doi.org/10.1021/je100362p | *J. Chem. Eng. Data* 2011, 56, 1669–1674

out at working temperature by measuring densities of double-distilled water,[8] benzene,[9] and toluene[9] and speeds of sound of double-distilled water,[11] benzene,[7] and toluene[7] at working temperature, and these values are reported in Table 1.

Refractive indices, n_D, were measured with a thermostatic Abbe refractometer (Erma, A-302A, India) using sodium-D line with an error less than ± 0.0001 units at (298.15 to 308.15) K. The temperature in the refractometer was regulated by using a circulation pump connected with a constant temperature water bath with ± 0.01 °C stability. The uncertainty in refractive indices measurements has been found to be ± 0.0002 units. Calibration of the instrument was carried out at working temperature by measuring the refractive indices of double-distilled water,[8] benzene,[8] and toluene,[7] and these values are reported in Table 1.

Table 1. Comparison of Experimental Densities ρ, Speeds of Sound u, and Refractive Indices n_D of Pure Components with Available Literature Values at T = 298.15 K

	$\rho \cdot 10^{-3}/\text{kg} \cdot \text{m}^{-3}$		$u/\text{m} \cdot \text{s}^{-1}$		n_D	
component	exp.	lit.	exp.	lit.	exp.	lit.
decan-1-ol	0.8265	0.8264[6]	1379	1380[10]	1.4346	1.4345[12]
anisole	0.9891	0.9892[7]	1407	1408[7]	1.5150	1.5141[13]
o-cresol	1.0423		1505		1.5440	1.5442[8]
m-cresol	1.0300	1.0302[8]	1481		1.5380	1.5396[8]
p-cresol	1.0301		1486		1.5370	1.5391[8]
benzene	0.8737	0.8737[9]	1299	1299[7]	1.4979	1.4979[8]
toluene	0.8622	0.8622[9]	1305	1305[7]	1.4938	1.4941[7]
water	0.9971	0.9971[8]	1497	1497[11]	1.3331	1.3326[8]

Table 2. Densities ρ, Excess Molar Volume V^E, Speeds of Sound u, and Refractive Indices n_D for Binary Liquid Mixtures at T = (298.15 to 308.15) K

	$\rho \cdot 10^{-3}$	$V^E \cdot 10^6$	u			$\rho \cdot 10^{-3}$	$V^E \cdot 10^6$	u	
x	$\text{kg} \cdot \text{m}^{-3}$	$\text{m}^3 \cdot \text{mol}^{-1}$	$\text{m} \cdot \text{s}^{-1}$	n_D	x	$\text{kg} \cdot \text{m}^{-3}$	$\text{m}^3 \cdot \text{mol}^{-1}$	$\text{m} \cdot \text{s}^{-1}$	n_D
				$T/\text{K} = 298.15$					
				x Anisole + $(1 - x)$ Decan-1-ol					
0.0000	0.8265	0.000	1379	1.4346	0.5440	0.8899	0.420	1369	1.4632
0.0817	0.8340	0.089	1377	1.4376	0.6071	0.9001	0.419	1370	1.4683
0.1440	0.8400	0.156	1375	1.4403	0.6699	0.9111	0.405	1372	1.4739
0.2047	0.8463	0.217	1374	1.4430	0.7359	0.9238	0.371	1376	1.4804
0.2730	0.8538	0.278	1372	1.4463	0.8171	0.9411	0.300	1382	1.4896
0.3484	0.8628	0.336	1370	1.4503	0.9100	0.9637	0.177	1393	1.5016
0.4099	0.8706	0.374	1369	1.4539	0.9464	0.9735	0.119	1398	1.5067
0.4874	0.8814	0.407	1369	1.4591	1.0000	0.9892	0.000	1407	1.5150
				x *o*-Cresol + $(1 - x)$ Decan-1-ol					
0.0000	0.8265	0.000	1379	1.4346	0.5545	0.9144	−0.141	1421	1.4772
0.0861	0.8375	−0.108	1385	1.4394	0.6165	0.9277	−0.106	1428	1.4841
0.1516	0.8464	−0.163	1389	1.4435	0.6875	0.9443	−0.062	1438	1.4928
0.2077	0.8543	−0.194	1393	1.4473	0.7538	0.9613	−0.025	1448	1.5018
0.2717	0.8639	−0.211	1397	1.4519	0.8245	0.9814	0.006	1461	1.5124
0.3340	0.8738	−0.216	1402	1.4567	0.8811	0.9991	0.020	1474	1.5218
0.4103	0.8867	−0.201	1408	1.4631	0.9410	1.0198	0.020	1489	1.5325
0.4797	0.8995	−0.177	1414	1.4696	1.0000	1.0423	0.000	1505	1.5440
				x *m*-Cresol + $(1 - x)$ Decan-1-ol					
0.0000	0.8265	0.000	1379	1.4346	0.5447	0.9086	−0.230	1415	1.4743
0.0818	0.8364	−0.088	1384	1.4390	0.6205	0.9241	−0.206	1422	1.4823
0.1443	0.8444	−0.141	1388	1.4427	0.6951	0.9408	−0.171	1431	1.4909
0.2191	0.8546	−0.189	1393	1.4475	0.7472	0.9535	−0.144	1437	1.4976
0.2700	0.8619	−0.214	1396	1.4510	0.8163	0.9716	−0.103	1447	1.5071
0.3513	0.8744	−0.237	1401	1.4571	0.8738	0.9882	−0.069	1457	1.5158
0.4154	0.8850	−0.244	1405	1.4623	0.9325	1.0066	−0.032	1469	1.5256
0.4864	0.8975	−0.241	1410	1.4687	1.0000	1.0301	0.000	1481	1.5380
				x *p*-Cresol + $(1 - x)$ Decan-1-ol					
0.0000	0.8265	0.000	1379	1.4346	0.5566	0.9112	−0.265	1420	1.4756
0.0790	0.8361	−0.096	1385	1.4388	0.6321	0.9269	−0.239	1428	1.4838
0.1424	0.8443	−0.159	1389	1.4425	0.7041	0.9433	−0.204	1436	1.4923
0.2213	0.8551	−0.217	1394	1.4476	0.7628	0.9578	−0.170	1444	1.4999

Table 1. Continued

x	$\rho \cdot 10^{-3}$ $\mathrm{kg \cdot m^{-3}}$	$V^{\mathrm{E}} \cdot 10^{6}$ $\mathrm{m^{3} \cdot mol^{-1}}$	u $\mathrm{m \cdot s^{-1}}$	n_{D}	x	$\rho \cdot 10^{-3}$ $\mathrm{kg \cdot m^{-3}}$	$V^{\mathrm{E}} \cdot 10^{6}$ $\mathrm{m^{3} \cdot mol^{-1}}$	u $\mathrm{m \cdot s^{-1}}$	n_{D}
0.2915	0.8653	−0.253	1399	1.4525	0.8229	0.9738	−0.129	1453	1.5083
0.3611	0.8762	−0.274	1404	1.4579	0.8793	0.9901	−0.090	1462	1.5168
0.4180	0.8857	−0.282	1408	1.4626	0.9382	1.0087	−0.043	1474	1.5263
0.4915	0.8987	−0.278	1414	1.4692	1.0000	1.0302	0.000	1486	1.5370
T/K = 303.15									
x Anisole + (1 − x) Decan-1-ol									
0.0000	0.8231	0.000	1362	1.4326	0.5440	0.8859	0.438	1351	1.4610
0.0817	0.8305	0.095	1360	1.4356	0.6071	0.8960	0.436	1352	1.4662
0.1440	0.8365	0.165	1358	1.4380	0.6699	0.9069	0.421	1354	1.4718
0.2047	0.8427	0.229	1356	1.4407	0.7359	0.9195	0.385	1357	1.4785
0.2730	0.8501	0.293	1354	1.4439	0.8171	0.9367	0.310	1362	1.4877
0.3484	0.8590	0.353	1352	1.4480	0.9100	0.9591	0.183	1373	1.5000
0.4099	0.8668	0.393	1351	1.4516	0.9464	0.9689	0.122	1378	1.5054
0.4874	0.8774	0.426	1351	1.4568	1.0000	0.9844	0.000	1387	1.5140
x o-Cresol + (1 − x) Decan-1-ol									
0.0000	0.8231	0.000	1362	1.4327	0.5545	0.9105	−0.188	1404	1.4744
0.0861	0.8340	−0.114	1368	1.4374	0.6165	0.9237	−0.155	1411	1.4813
0.1516	0.8428	−0.176	1372	1.4414	0.6875	0.9402	−0.109	1421	1.4900
0.2077	0.8508	−0.213	1376	1.4451	0.7538	0.9571	−0.068	1431	1.4989
0.2717	0.8603	−0.237	1380	1.4495	0.8245	0.9769	−0.028	1444	1.5095
0.3340	0.8701	−0.247	1384	1.4543	0.8811	0.9944	−0.005	1456	1.5188
0.4103	0.8830	−0.240	1390	1.4606	0.9410	1.0147	0.008	1472	1.5295
0.4797	0.8957	−0.221	1397	1.4669	1.0000	1.0369	0.000	1487	1.5410
x m-Cresol + (1 − x) Decan-1-ol									
0.0000	0.8231	0.000	1362	1.4326	0.5447	0.9049	−0.227	1398	1.4714
0.0818	0.8330	−0.087	1367	1.4369	0.6205	0.9204	−0.202	1406	1.4793
0.1443	0.8409	−0.141	1371	1.4405	0.6951	0.9370	−0.168	1414	1.4880
0.2191	0.8511	−0.188	1376	1.4451	0.7472	0.9497	−0.141	1421	1.4946
0.2700	0.8584	−0.213	1379	1.4486	0.8163	0.9678	−0.100	1431	1.5042
0.3513	0.8708	−0.234	1384	1.4545	0.8738	0.9843	−0.067	1441	1.5130
0.4154	0.8814	−0.241	1388	1.4597	0.9325	1.0027	−0.031	1453	1.5227
0.4864	0.8939	−0.237	1393	1.4658	1.0000	1.0261	0.000	1465	1.5350
x p-Cresol + (1 − x) Decan-1-ol									
0.0000	0.8231	0.000	1362	1.4326	0.5566	0.9076	−0.263	1403	1.4728
0.0790	0.8326	−0.094	1368	1.4366	0.6321	0.9232	−0.237	1411	1.4809
0.1424	0.8408	−0.156	1372	1.4403	0.7041	0.9395	−0.203	1419	1.4894
0.2213	0.8515	−0.213	1377	1.4452	0.7628	0.9540	−0.169	1427	1.4969
0.2915	0.8618	−0.248	1382	1.4501	0.8229	0.9700	−0.128	1437	1.5052
0.3611	0.8726	−0.270	1386	1.4553	0.8793	0.9863	−0.090	1446	1.5137
0.4180	0.8821	−0.278	1391	1.4599	0.9382	1.0049	−0.043	1458	1.5232
0.4915	0.8951	−0.274	1397	1.4665	1.0000	1.0263	0.000	1471	1.5340
T/K = 308.15									
x Anisole + (1 − x) Decan-1-ol									
0.0000	0.8197	0.000	1346	1.4305	0.5440	0.8818	0.457	1333	1.4582
0.0817	0.8269	0.107	1343	1.4330	0.6071	0.8919	0.456	1334	1.4632
0.1440	0.8329	0.181	1341	1.4354	0.6699	0.9027	0.441	1335	1.4688
0.2047	0.8390	0.247	1339	1.4380	0.7359	0.9152	0.404	1338	1.4754
0.2730	0.8464	0.313	1337	1.4413	0.8171	0.9322	0.327	1343	1.4848
0.3484	0.8552	0.372	1335	1.4452	0.9100	0.9546	0.193	1353	1.4969
0.4099	0.8629	0.412	1334	1.4488	0.9464	0.9642	0.129	1358	1.5023

Table 1. Continued

x	$\rho\cdot10^{-3}$ $\mathrm{kg\cdot m^{-3}}$	$V^E\cdot10^6$ $\mathrm{m^3\cdot mol^{-1}}$	u $\mathrm{m\cdot s^{-1}}$	n_D	x	$\rho\cdot10^{-3}$ $\mathrm{kg\cdot m^{-3}}$	$V^E\cdot10^6$ $\mathrm{m^3\cdot mol^{-1}}$	u $\mathrm{m\cdot s^{-1}}$	n_D
0.4874	0.8735	0.445	1333	1.4540	1.0000	0.9797	0.000	1367	1.5110
				x *o*-Cresol + $(1-x)$ Decan-1-ol					
0.0000	0.8197	0.000	1346	1.4305	0.5545	0.9066	−0.230	1387	1.4712
0.0861	0.8306	−0.126	1351	1.4351	0.6165	0.9197	−0.198	1394	1.4779
0.1516	0.8393	−0.193	1355	1.4389	0.6875	0.9361	−0.155	1404	1.4864
0.2077	0.8472	−0.234	1359	1.4425	0.7538	0.9528	−0.115	1414	1.4952
0.2717	0.8567	−0.264	1363	1.4469	0.8245	0.9725	−0.075	1427	1.5057
0.3340	0.8665	−0.278	1367	1.4515	0.8811	0.9898	−0.046	1439	1.5149
0.4103	0.8793	−0.275	1373	1.4576	0.9410	1.0098	−0.020	1454	1.5256
0.4797	0.8919	−0.259	1379	1.4638	1.0000	1.0316	0.000	1470	1.5370
				x *m*-Cresol + $(1-x)$ Decan-1-ol					
0.0000	0.8197	0.000	1346	1.4305	0.5447	0.9012	−0.223	1382	1.4685
0.0818	0.8295	−0.086	1351	1.4346	0.6205	0.9167	−0.198	1389	1.4764
0.1443	0.8374	−0.139	1354	1.4382	0.6951	0.9333	−0.165	1398	1.4850
0.2191	0.8476	−0.186	1359	1.4427	0.7472	0.9458	−0.138	1404	1.4916
0.2700	0.8548	−0.210	1362	1.4460	0.8163	0.9639	−0.097	1415	1.5013
0.3513	0.8672	−0.232	1367	1.4518	0.8738	0.9804	−0.065	1425	1.5101
0.4154	0.8777	−0.238	1371	1.4569	0.9325	0.9988	−0.030	1437	1.5198
0.4864	0.8902	−0.234	1377	1.4630	1.0000	1.0221	0.000	1450	1.5320
				x *p*-Cresol + $(1-x)$ Decan-1-ol					
0.0000	0.8197	0.000	1346	1.4305	0.5566	0.9038	−0.254	1386	1.4699
0.0790	0.8292	−0.092	1351	1.4344	0.6321	0.9195	−0.229	1394	1.4779
0.1424	0.8373	−0.153	1355	1.4379	0.7041	0.9358	−0.195	1403	1.4863
0.2213	0.8480	−0.209	1360	1.4428	0.7628	0.9502	−0.163	1411	1.4938
0.2915	0.8582	−0.242	1365	1.4475	0.8229	0.9662	−0.124	1420	1.5021
0.3611	0.8690	−0.263	1370	1.4526	0.8793	0.9825	−0.087	1430	1.5106
0.4180	0.8784	−0.270	1374	1.4572	0.9382	1.0010	−0.042	1442	1.5201
0.4915	0.8914	−0.266	1380	1.4636	1.0000	1.0224	0.000	1455	1.5310

RESULTS AND DISCUSSION

The experimental data of density, ρ, speed of sound, u, refractive index, n_D, and excess molar volume, V^E, for binary liquid mixtures at $T = (298.15 \text{ to } 308.15)$ K and $p = 0.1$ MPa are reported in Table 2.

The excess molar volumes, V^E, were calculated from the densities of the pure liquids and their mixtures using the following equation:

$$V^E = \sum_{i=1}^{2} x_i M_i(\rho^{-1} - \rho_i^{-1}) \tag{1}$$

where ρ_i is the density of the pure component i, ρ is the density of the mixture, and x_i and M_i are the mole fraction and the molecular weight (decan-1-ol = 158.2811, *o*-cresol = 108.1392, *m*-cresol = 108.1392, *p*-cresol = 108.1392, and anisole = 108.14) of the component i of the system, respectively.

The experimental results of V^E were fitted to the Redlich–Kister equation of the type:[14]

$$Y(x) = x(1-x)\sum_{k=1}^{n} A_k(1-2x)^{k-1} \tag{2}$$

where k is the number of estimated parameters and A_k the polynomial coefficients were obtained by fitting the equation to the experimental results by least-squares regression method. The standard deviations, σ, for V^E were calculated using the relation

$$\sigma(Y) = \left[\sum_{i}^{n}\{Y(x)_{\text{exp}} - Y(x)_{\text{cal}}\}^2/(N-n)\right]^{1/2} \tag{3}$$

where $Y(x)_{\text{exp}}$, $Y(x)_{\text{cal}}$, N, and n are values of the experimental and calculated property, the number of data points, and the number of parameter of the fitting equation, respectively. The polynomial coefficients and the standard deviation between the experimental and the calculated values of V^E are given in Table 3.

The excess molar volumes are plotted in Figure 1 over the entire composition range at $T = 298.15$ K. The results shown in Figure 1 reveal that, for (*m*-cresol + decan-1-ol) and (*p*-cresol + decan-1-ol), $V^E < 0$ over the whole composition range. For the mixture (*o*-cresol + decan-1-ol), the V^E curve becomes slightly s-shaped, that is, $V^E < 0$ with the exception of the mole fraction after $x \approx 0.82$. In this region the V^E values are close to zero or even positive. For the mixture of anisole with decan-1-ol, $V^E > 0$ over the whole composition range. Generally, the mixtures of decan-1-ol with isomeric cresols show a contraction of volume ($V^E < 0$); that is, the packing of the molecules and molecular interaction in the mixture is more compact as compared to the pure components, but in the case of *o*-cresol at $x \approx 0.82$ the steric hindrance factor dominates, which opposes the close proximity of the constituent molecules, that is, $V^E \geq 0$. In case of (anisole +

Table 3. Coefficients A_i of the Redlich−Kister Equation and Standard Deviations σ for the Excess Molar Volume V^E for Binary Liquid Mixtures at T = (298.15 to 308.15) K

T/K	A_1	A_2	A_3	σ
		x Anisole + (1 − x) Decan-1-ol		
298.15	1.6392	0.5592	0.0670	0.0031
303.15	1.7131	0.5550	0.0616	0.0032
308.15	1.7905	0.5527	0.1569	0.0027
		x *o*-Cresol + (1 − x) Decan-1-ol		
298.15	−0.6725	0.9666	0.1870	0.0019
303.15	−0.8539	0.8666	0.2147	0.0026
308.15	−1.0068	0.7326	0.0292	0.0009
		x *m*-Cresol + (1 − x) Decan-1-ol		
298.15	−0.9565	0.3412	0.1302	0.00163
303.15	−0.9429	0.3498	0.1286	0.00164
308.15	−0.9298	0.3540	0.1334	0.00162
		x *p*-Cresol + (1 − x) Decan-1-ol		
298.15	−1.1100	0.3039	0.0682	0.0012
303.15	−1.0977	0.2873	0.0712	0.0013
308.15	−1.0634	0.2913	0.0541	0.0009

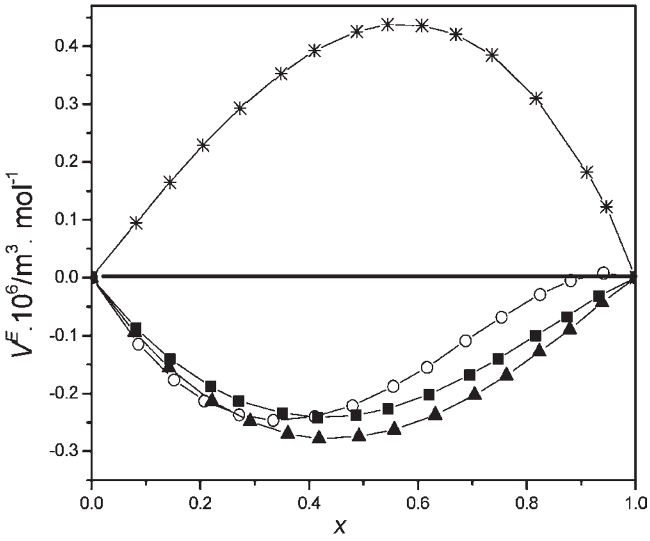

Figure 1. Excess molar volume, V^E, plotted against mole fraction, x, for [x isomeric cresols and anisole + (1 − x) decan-1-ol] systems at T = 298.15 K: ○, *o*-cresol; ■, *m*-cresol; ▲, *p*-cresol; and ∗, anisole.

decan-1-ol), $V^E > 0$; this is mainly due to the weak intermolecular force of attraction and mainly dispersion forces between anisole and decan-1-ol molecules.

The magnitude of the maximum value of V^E for (anisole + decan-1-ol) binary mixtures increases slightly with the increase of temperature from T = (298.15 to 308.15) K, and the minimum value of V^E for the (*m*-cresol + decan-1-ol) and (*p*-cresol + decan-1-ol) binary mixtures becomes more positive with the increase of temperature from T = (298.15 to 308.15) K, except for the (*o*-cresol + decan-1-ol) binary mixture where the V^E value at the minimum becomes more negative with the increase of temperature from T = (298.15 to 308.15) K.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information. The values of isentropic compressibility, κ_S, deviation in isentropic compressibility, $\Delta\kappa_S$, molar isentropic compression, $K_{S,m}$, deviation in molar isentropic compression, $\Delta K_{S,m}$, and the deviation in the speeds of sound, Δu, for the investigated systems at T = (298.15 to 308.15) K. The values of heat capacity, C_p, and isobaric coefficient of thermal expansion, α, for pure components in the temperature range (298.15 to 308.15) K. Two additional figures. This material is available free of charge via the Internet at http://pubs.acs.org.

■ AUTHOR INFORMATION

Corresponding Author

*E-mail: bhatiasc2@rediffmail.com, rumanjangra58@gmail.com.

■ ACKNOWLEDGMENT

Authors are grateful to the Kurukshetra University authorities for providing the necessary facilities to carry out the research work and for the award of University Research Fellowship to one of the authors.

■ REFERENCES

(1) Bhatia, S. C.; Bhatia, R.; Dubey, G. P. Thermodynamic and Sonochemical Behaviour of Binary Mixtures of Decan-1-ol with Halohydrocarbons at (293.15 and 313.15). *J. Chem. Thermodyn.* **2010**, *42*, 114–127.

(2) Bhatia, S. C.; Bhatia, R.; Dubey, G. P. Studies of Thermodynamic Properties of Binary Mixtures of Hexan-1-ol with Halogenated Compounds at 308.15 and 313.15 K. *J. Chem. Thermodyn.* **2009**, *41*, 1132–1144.

(3) Bhatia, S. C.; Bhatia, R.; Dubey, G. P. Studies on Transport and Thermodynamic Properties of Binary Mixtures of Octan-ol with Chloroform, 1,2-Dichloroethane and 1,1,2,2-Tetrachloroethane at 298.15 and 308.15 K. *J. Mol. Liq.* **2009**, *144*, 163–171.

(4) Kiyohara, O.; Benson, G. C. Ultrasonic Speeds and Isentropic Compressibilities of *n*-Alkanol + *n*-Heptane mixtures at 298.15 K. *J. Chem. Thermodyn.* **1979**, *11*, 861–873.

(5) Benson, G. C.; Kiyohara, O. Evaluation of Excess Isentropic Compressibilities and Isochoric Heat Capacities. *J. Chem. Thermodyn.* **1979**, *11*, 1061–1064.

(6) Heintz, A.; Schmittecker, B.; Wanger, D.; Lichtenthaler, R. N. Excess Volumes of Binary 1-Alkanol/Hexane Mixtures at Temperatures between 283.15 and 323.15 K. *J. Chem. Eng. Data* **1986**, *31*, 487–492.

(7) Al-Jimaz, A. S.; Al-Kandary, J. A.; Abdul-Latif, A.-H. M. Densities, Viscosities, and Refractive Indices of Binary Mixtures of Anisole with Benzene, Methylbenzene, Ethylbenzene, Propylbenzene, and Butylbenzene at (293.15 and 303.15) K. *J. Chem. Eng. Data* **2006**, *51* (1), 99–103.

(8) Riddick, J. A.; Bunger, W. B.; Sakano, F. K. *Oraganic Solvents, Physical Properties and Method of Purification*, 4th ed.; Wiley-Interscience: New York, 1986.

(9) Dubey, G. P.; Kumar, K. Volumetric and Viscometric Properties of Binary Liquids Mixtures of Ethylene Glycol Monomethyl Ether + 1-Hexanol, 1-Octanol, and 1-Decanol at Temperatures of T = (293.15, 298.15, 303.15, and 308.15) K. *J. Chem. Eng. Data* **2010**, *55*, 1700–1703.

(10) Dubey, G. P.; Sharma, M. Acoustic, Thermodynamic, Viscometric and Volumetric Studies in Binary Systems of 1-Decanol with *n*-Hexane, *n*-Octane and *n*-Decane with respect to Temperature. *J. Mol. Liq.* **2008**, *143*, 109–114.

(11) Zafarani-Moattar, M. T.; Samadi, F.; Sadeghi, R. Volumetric and Ultrasonic Studies of the System (Water + Polypropylene Glycol 400) at Temperatures from (283.15 to 313.15) K. *J. Chem. Thermodyn.* **2004**, *36*, 871–875.

(12) Ortega, J. Densities and Refractive Indices of Pure Alcohols as a Function of Temperature. *J. Chem. Eng. Data* **1982**, *27*, 312–317.

(13) Al-Jimaz, A. S.; Al-Kandary, J. A.; Abdul-latif, A.-H. M.; Al-Zanki, A. M. Physical Properties of {a Anisole + n-Alkanes} at Temperatures between (293.15 and 303.15) K. *J. Chem. Thermodyn.* **2005**, *37*, 631–642.

(14) Redlich, O.; Kister, A. T. Algebric Representation of Thermodynamic Properties and Classification of Solution. *Ind. Eng. Chem.* **1948**, *40*, 345–348.