# Density and Speed of Sound of Binary Mixtures of *N*-Methylacetamide with Ethyl Acetate, Ethyl Chloroacetate, and Ethyl Cyanoacetate in the Temperature Interval (303.15 to 318.15) K

**Satyanarayana Nallani,* Sathyanarayana Boodida, and Savitha J. Tangeda**

Department of Chemistry, Kakatiya University, Warangal-506 009, India

The excess isentropic compressibilities are computed by measuring the density and speed of sound of binary mixtures of *N*-methylacetamide with ethyl acetate, ethyl chloroacetate, and ethyl cyanoacetate over the entire range of volume fraction in the temperature range of (303.15 to 318.15) K. The experimental results are fitted to a Redlich−Kister type polynomial equation. Estimated coefficients and standard deviation values are also presented.

## Introduction

The variation of density, speed of sound, and isentropic compressibility of binary liquid mixtures of protic, aprotic, and associating liquids with changing volume fraction of one of the components has been investigated by some researchers. The trends of changes, either positive or negative, have been interpreted by these workers in terms of differences in size of the molecules and the strength of specific and nonspecific interactions taking place between the components of the mixtures.[1−4] In our laboratory, we had investigated the ultrasonic, transport, and volumetric properties for the binary mixtures of *N*-methylacetamide (NMA) with aromatic ketones and observed that the chemical forces were acting between the unlike molecules.[5,6]

As a part of our research program of measuring the physicochemical properties of binary mixtures of NMA with nonaqueous solvents, a study has been made on NMA + ethyl acetate, + ethyl chloroacetate, and + ethyl cyanoacetate over the entire range of volume fraction in the temperature interval of (303.15 to 318.15) K. Ethyl acetate was chosen because of its importance in polymer processing industries as a plasticizer.[7] Due to its insecticidal activity, ethyl chloroacetate was chosen as a solvent in organic synthesis.[8] Ethyl cyanoacetate was used as a solvent in pharmaceuticals, and NMA was used as an intermediary for the synthesis of active ingredients in pharmaceuticals, agrochemicals, and pesticides. Detailed investigations on transport and acoustic properties of such mixtures are scarce in the literature.[9−11] This prompted us to undertake a study on the measurements of density $\rho$ and speed of sound $u$ at $T$ = (303.15 to 318.15) K. Using these data, excess isentropic compressibilities $\Delta\kappa_S$ have been calculated. These results have been fitted to the Redlich−Kister type equation to derive the binary coefficients.[12]

## Experimental Section

***Materials.*** High-purity and analytical grade sample of ethyl acetate with purity of 99.5 %, procured from S. D. Fine Chemicals Ltd., India, was used after a single distillation. Ethyl chloroacetate 99 % (GC), ethyl cyanoacetate 98 % (GC), and NMA 99 % (GC) were purchased from Sigma-Aldrich Chemicals Pvt. Ltd., St. Louis, MO. These samples were used without further purification. The purities of the solvents were further ascertained by GLC and comparing their densities and speeds of sound at $T$ = 298.15 K, which agreed reasonably with the corresponding literature values (Table 1).

**Table 1. Comparison of Experimental Density $\rho$/kg·m$^{-3}$ and Speed of Sound $u$/m·s$^{-1}$ of Pure Liquids at $T$ = 298.15 K with Literature Data**

| | $\rho \times 10^{-3}$/kg·m$^{-3}$ | | $u$/m·s$^{-1}$ | |
|---|---|---|---|---|
| component | expt | lit | expt | lit |
| *N*-methylacetamide | 0.94591[a] | 0.94600[18] | 1362[a] | 1360[5] |
| ethyl acetate | 0.89456 | 0.89455[18] | 1145 | 1144[4] |
| ethyl chloroacetate | 1.15603 | 1.15600[21] | 1249 | 1249[8] |
| ethyl cyanoacetate | 1.05642 | 1.05640[18] | 1385[a] | |

[a] At $T$ = 308.15 K.

***Apparatus and Procedure.*** Binary mixtures were prepared by mass in air-tight glass bottles.[13] The mass measurements were performed on a Dhona 100 DS, India, single pan analytical balance with a precision of $0.01 \times 10^{-6}$ kg. The required properties were measured within 1 day of the mixture. The uncertainty in mole fraction was estimated to be less than $\pm 1 \times 10^{-4}$.

Densities of pure liquids and their mixtures were determined using a $1 \times 10^{-5}$ m$^3$ double-arm pycnometer as described by Nikam et al.[14] The density values from triplicate replication at each temperature were reproducible within $\pm 2 \times 10^{-2}$ kg·m$^{-3}$. The uncertainty in density values was found to be $\pm 4 \times 10^{-2}$ kg·m$^{-3}$.

Speed of sound values were measured by using a single-crystal variable-path interferometer (Mittal Enterprises, India) operating at 2 MHz, which was calibrated with water and benzene.[12] The detailed procedure was described in our previous papers.[15,16] The uncertainty in speeds of sound values was found to be 0.2 %. The isentropic compressibilities were calculated from

$$\kappa_S = 1/u^2\rho \qquad (1)$$

where $u$ is speed of sound and $\rho$ is density. The uncertainty in excess isentropic compressibility was found to be $0.4 \times 10^{-11}$ m$^2$·N$^{-1}$.

* Corresponding author. Tel: +91-870-2461434. Fax: +91-870-2438800. E-mail: ns_narayana@yahoo.com.

10.1021/je060343y CCC: $37.00 
Published on Web 01/25/2007

**Table 2. Values of Density $\rho$, Speed of Sound $u$, Isentropic Compressibility $\kappa_S$, and Deviations in Isentropic Compressibility $\Delta\kappa_S$ as a Function of Volume Fraction $\Phi_1$ for Binary Mixtures of *N*-Methylacetamide (1) with Esters (2) from $T$ = (303.15 to 318.15) K**

| $\phi_1$ | $\rho \times 10^{-3}$ kg·m$^{-3}$ | $u$ m·s$^{-1}$ | $\kappa_S \times 10^{11}$ m$^2$·N$^{-1}$ | $\Delta\kappa_S \times 10^{11}$ m$^2$·N$^{-1}$ | $\phi_1$ | $\rho \times 10^{-3}$ kg·m$^{-3}$ | $u$ m·s$^{-1}$ | $\kappa_S \times 10^{11}$ m$^2$·N$^{-1}$ | $\Delta\kappa_S \times 10^{11}$ m$^2$·N$^{-1}$ | $\phi_1$ | $\rho \times 10^{-3}$ kg·m$^{-3}$ | $u$ m·s$^{-1}$ | $\kappa_S \times 10^{11}$ m$^2$·N$^{-1}$ | $\Delta\kappa_S \times 10^{11}$ m$^2$·N$^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T$ = 303.15 K | | | | | | | | | | | | | | |
| Ethyl Acetate (2) | | | | | | | | | | | | | | |
| 0.0000 | 0.8889 | 1119 | 89.92 | 0.00 | 0.3991 | 0.91749 | 1223 | 72.83 | −3.64 | 0.7437 | 0.93768 | 1306 | 62.53 | −2.33 |
| 0.0538 | 0.89387 | 1132 | 87.32 | −0.79 | 0.4982 | 0.92367 | 1248 | 69.56 | −3.58 | 0.9463 | 0.94819 | 1354 | 57.56 | −0.47 |
| 0.1843 | 0.90306 | 1167 | 81.25 | −2.46 | 0.594 | 0.9293 | 1271 | 66.63 | −3.27 | 1.0000 | 0.9513 | 1367 | 56.22 | 0.00 |
| 0.2972 | 0.91076 | 1197 | 76.59 | −3.31 | 0.6955 | 0.93503 | 1295 | 63.82 | −2.66 | | | | | |
| Ethyl Chloroacetate (2) | | | | | | | | | | | | | | |
| 0.0000 | 1.13929 | 1229 | 58.07 | 0.00 | 0.2903 | 1.08592 | 1272 | 56.92 | −0.61 | 0.7118 | 1.00688 | 1329 | 56.26 | −0.50 |
| 0.0547 | 1.12833 | 1238 | 57.84 | −0.14 | 0.4356 | 1.05931 | 1293 | 56.50 | −0.77 | 0.8656 | 0.97731 | 1350 | 56.17 | −0.30 |
| 0.1540 | 1.11027 | 1252 | 57.47 | −0.32 | 0.5321 | 1.04112 | 1305 | 56.37 | −0.71 | 1.0000 | 0.9513 | 1367 | 56.22 | 0.00 |
| 0.2473 | 1.09379 | 1265 | 57.11 | −0.51 | 0.6203 | 1.02432 | 1317 | 56.30 | −0.62 | | | | | |
| Ethyl Cyanoacetate (2) | | | | | | | | | | | | | | |
| 0.0000 | 1.0514 | 1397 | 48.74 | 0.00 | 0.3672 | 1.01895 | 1386 | 51.08 | −0.41 | 0.7307 | 0.98097 | 1375 | 53.95 | −0.26 |
| 0.0529 | 1.04811 | 1396 | 48.98 | −0.16 | 0.4502 | 1.01093 | 1384 | 51.66 | −0.44 | 0.8795 | 0.96497 | 1370 | 55.20 | −0.12 |
| 0.1860 | 1.03606 | 1391 | 49.86 | −0.27 | 0.5435 | 1.00123 | 1380 | 52.42 | −0.38 | 1.0000 | 0.9513 | 1367 | 56.22 | 0.00 |
| 0.2745 | 1.02782 | 1389 | 50.44 | −0.36 | 0.5664 | 0.99875 | 1379 | 52.63 | −0.35 | | | | | |
| $T$ = 308.15 K | | | | | | | | | | | | | | |
| Ethyl Acetate (2) | | | | | | | | | | | | | | |
| 0.0000 | 0.8826 | 1098 | 94.01 | 0.00 | 0.3988 | 0.91143 | 1208 | 75.25 | −3.99 | 0.7434 | 0.93286 | 1296 | 63.80 | −2.69 |
| 0.0537 | 0.88758 | 1114 | 90.87 | −1.16 | 0.4979 | 0.91794 | 1234 | 71.49 | −4.09 | 0.9488 | 0.94396 | 1348 | 58.32 | −0.57 |
| 0.1841 | 0.89686 | 1149 | 84.52 | −2.68 | 0.5937 | 0.92393 | 1259 | 68.30 | −3.73 | 1.0000 | 0.9459 | 1362 | 56.99 | 0.00 |
| 0.2969 | 0.90458 | 1180 | 79.46 | −3.56 | 0.6952 | 0.93002 | 1284 | 65.19 | −3.09 | | | | | |
| Ethyl Chloroacetate (2) | | | | | | | | | | | | | | |
| 0.0000 | 1.1325 | 1212 | 60.07 | 0.00 | 0.2902 | 1.08037 | 1256 | 58.68 | −0.49 | 0.7118 | 1.00205 | 1318 | 57.49 | −0.39 |
| 0.0547 | 1.12326 | 1221 | 59.74 | −0.17 | 0.4356 | 1.05383 | 1277 | 58.18 | −0.55 | 0.8656 | 0.97228 | 1342 | 57.15 | −0.25 |
| 0.1540 | 1.10523 | 1235 | 59.28 | −0.31 | 0.5320 | 1.03602 | 1291 | 57.92 | −0.51 | 1.0000 | 0.9459 | 1362 | 56.99 | 0.00 |
| 0.2473 | 1.0882 | 1249 | 58.88 | −0.43 | 0.6202 | 1.01938 | 1304 | 57.70 | −0.46 | | | | | |
| Ethyl Cyanoacetate (2) | | | | | | | | | | | | | | |
| 0.0000 | 1.0465 | 1385 | 49.83 | 0.00 | 0.3675 | 1.01263 | 1375 | 52.23 | −0.23 | 0.7309 | 0.97466 | 1367 | 54.90 | −0.17 |
| 0.0529 | 1.04191 | 1384 | 50.12 | −0.09 | 0.4504 | 1.00444 | 1373 | 52.79 | −0.27 | 0.8796 | 0.95876 | 1365 | 55.98 | −0.15 |
| 0.1862 | 1.02963 | 1380 | 50.97 | −0.19 | 0.5438 | 0.99468 | 1371 | 53.48 | −0.25 | 1.0000 | 0.9459 | 1362 | 56.99 | 0.00 |
| 0.2747 | 1.02142 | 1378 | 51.60 | −0.20 | 0.5666 | 0.99226 | 1370 | 53.68 | −0.28 | | | | | |
| $T$ = 313.15 K | | | | | | | | | | | | | | |
| Ethyl Acetate (2) | | | | | | | | | | | | | | |
| 0.0000 | 0.8759 | 1081 | 97.66 | 0.00 | 0.3976 | 0.90715 | 1188 | 78.17 | −4.35 | 0.7431 | 0.92967 | 1274 | 66.23 | −3.14 |
| 0.0534 | 0.88097 | 1097 | 94.32 | −1.31 | 0.4966 | 0.91379 | 1214 | 74.28 | −4.48 | 0.9460 | 0.94122 | 1322 | 60.81 | −0.83 |
| 0.1833 | 0.8913 | 1132 | 87.49 | −3.19 | 0.5924 | 0.92009 | 1238 | 70.91 | −4.19 | 1.0000 | 0.9436 | 1334 | 59.59 | 0.00 |
| 0.2958 | 0.89984 | 1161 | 82.45 | −3.96 | 0.6941 | 0.92671 | 1263 | 67.63 | −3.61 | | | | | |
| Ethyl Chloroacetate (2) | | | | | | | | | | | | | | |
| 0.0000 | 1.1259 | 1198 | 61.93 | 0.00 | 0.2895 | 1.07453 | 1239 | 60.66 | −0.59 | 0.7111 | 0.99715 | 1296 | 59.74 | −0.52 |
| 0.0545 | 1.11523 | 1207 | 61.58 | −0.22 | 0.4347 | 1.04813 | 1259 | 60.23 | −0.68 | 0.8652 | 0.9685 | 1317 | 59.57 | −0.34 |
| 0.1535 | 1.09823 | 1220 | 61.15 | −0.42 | 0.5312 | 1.03046 | 1271 | 60.03 | −0.65 | 1.0000 | 0.9436 | 1334 | 59.59 | 0.00 |
| 0.2466 | 1.08214 | 1233 | 60.78 | −0.57 | 0.6194 | 1.01419 | 1283 | 59.86 | −0.62 | | | | | |
| Ethyl Cyanoacetate (2) | | | | | | | | | | | | | | |
| 0.0000 | 1.0408 | 1368 | 51.36 | 0.00 | 0.3667 | 1.00736 | 1356 | 54.03 | −0.35 | 0.7303 | 0.97138 | 1343 | 57.10 | −0.27 |
| 0.0528 | 1.0363 | 1366 | 51.69 | −0.11 | 0.4497 | 0.99941 | 1353 | 54.64 | −0.42 | 0.8793 | 0.95639 | 1337 | 58.49 | −0.10 |
| 0.1857 | 1.02428 | 1362 | 52.60 | −0.29 | 0.5430 | 0.99026 | 1349 | 55.48 | −0.35 | 1.0000 | 0.9436 | 1334 | 59.59 | 0.00 |
| 0.2741 | 1.01597 | 1359 | 53.29 | −0.32 | 0.5659 | 0.98792 | 1348 | 55.71 | −0.30 | | | | | |
| $T$ = 318.15 K | | | | | | | | | | | | | | |
| Ethyl Acetate (2) | | | | | | | | | | | | | | |
| 0.0000 | 0.8696 | 1058 | 102.83 | 0.00 | 0.3968 | 0.90246 | 1172 | 80.62 | −5.68 | 0.7418 | 0.92521 | 1261 | 67.98 | −3.95 |
| 0.0533 | 0.87513 | 1074 | 99.03 | −1.58 | 0.4958 | 0.90937 | 1198 | 76.57 | −5.61 | 0.9458 | 0.93726 | 1309 | 62.31 | −1.13 |
| 0.1828 | 0.8861 | 1113 | 91.18 | −4.03 | 0.5916 | 0.91567 | 1223 | 72.98 | −5.21 | 1.0000 | 0.9399 | 1319 | 61.17 | 0.00 |
| 0.2951 | 0.89479 | 1144 | 85.33 | −5.20 | 0.6934 | 0.92212 | 1249 | 69.48 | −4.46 | | | | | |
| Ethyl Chloroacetate (2) | | | | | | | | | | | | | | |
| 0.0000 | 1.1199 | 1177 | 64.42 | 0.00 | 0.2892 | 1.06623 | 1212 | 63.88 | 0.39 | 0.7108 | 0.99068 | 1272 | 62.44 | 0.32 |
| 0.0544 | 1.10919 | 1187 | 63.95 | −0.29 | 0.4344 | 1.04002 | 1231 | 63.43 | 0.42 | 0.8650 | 0.96331 | 1296 | 61.83 | 0.22 |
| 0.1533 | 1.09085 | 1202 | 63.42 | −0.51 | 0.5308 | 1.02275 | 1244 | 63.18 | 0.48 | 1.0000 | 0.9399 | 1319 | 61.17 | 0.00 |
| 0.2464 | 1.07398 | 1207 | 63.94 | 0.32 | 0.6191 | 1.00706 | 1257 | 62.81 | 0.39 | | | | | |
| Ethyl Cyanoacetate (2) | | | | | | | | | | | | | | |
| 0.0000 | 1.0347 | 1359 | 52.31 | 0.00 | 0.3663 | 1.00185 | 1348 | 54.91 | −0.65 | 0.7299 | 0.96683 | 1332 | 58.34 | −0.44 |
| 0.0527 | 1.03052 | 1358 | 52.61 | −0.16 | 0.4492 | 0.99413 | 1345 | 55.59 | −0.70 | 0.8791 | 0.95207 | 1324 | 59.91 | −0.19 |
| 0.1854 | 1.01859 | 1356 | 53.42 | −0.53 | 0.5425 | 0.98518 | 1341 | 56.46 | −0.66 | 1.0000 | 0.9399 | 1319 | 61.17 | 0.00 |
| 0.2737 | 1.01048 | 1352 | 54.16 | −0.58 | 0.5654 | 0.98297 | 1340 | 56.67 | −0.65 | | | | | |

In all measurements, the temperature stability was controlled within ± 0.01 K using a constant temperature bath (INSREF model IRI-016 C, India) by circulating water from the thermostat. For all the properties, three readings were

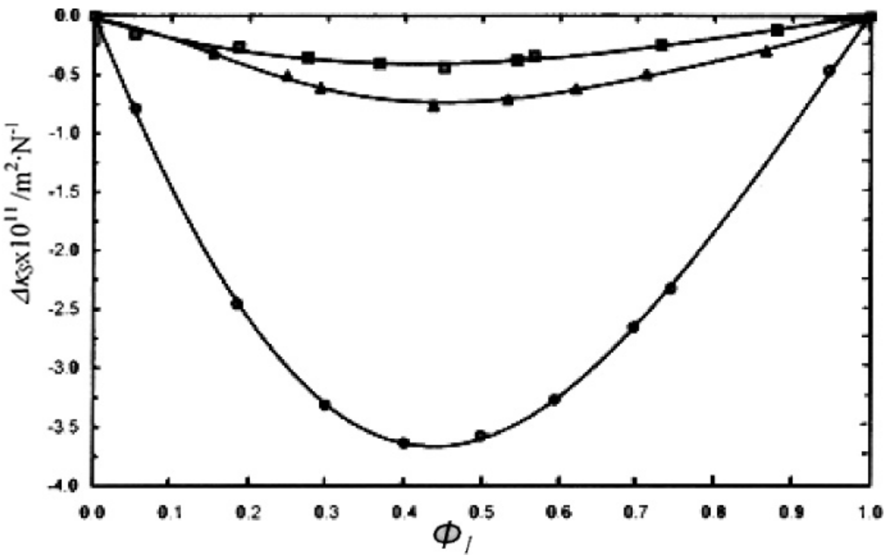

**Figure 1.** Variation of deviation in isentropic compressibility $\Delta\kappa_S$ with volume fraction $\Phi_1$ of the binary mixtures of *N*-methylacetamide (1) with ○, ethyl acetate; △, ethyl chloroacetate; □, ethyl cyanoacetate at $T = 303.15$ K.

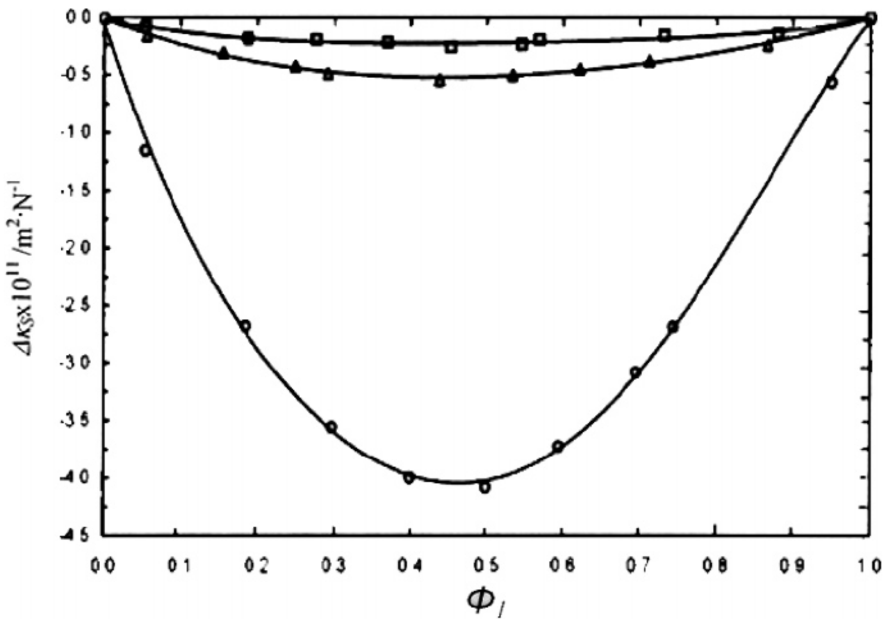

**Figure 2.** Variation of deviation in isentropic compressibility $\Delta\kappa_S$ with volume fraction $\Phi_1$ of the binary mixtures of *N*-methylacetamide (1) with ○, ethyl acetate; △, ethyl chloroacetate; □, ethyl cyanoacetate at $T = 308.15$ K.

taken for each composition; the average of these values is given in Table 2.

## Results and Discussion

The excess isentropic compressibilities have been evaluated using

$$\Delta\kappa_S = \kappa_S - (\Phi_1\kappa_{S1} + \Phi_2\kappa_{S2}) \qquad (2)$$

where $\Phi$ is the volume fraction of pure components and was calculated from the individual pure molar volumes, $V_i$, with the relation

$$\Phi_i = x_iV_i/(\Sigma x_iV_i) \qquad (3)$$

and $\kappa_{S1}$, $\kappa_{S2}$, and $\kappa_S$ are the isentropic compressibilities of the pure components and observed isentropic compressibility of liquid mixture, respectively.

Graphical representation of $\Delta\kappa_S$ values as a function of mole fraction of NMA over the range of temperatures studied is given in Figures 1 to 4. The excess isentropic compressibility is fitted to a Redlich−Kister polynomial equation:[12]

$$\Delta\kappa_S = \Phi_1(1 - \Phi_1)\Sigma A_j(1 - 2\Phi_1)^j \qquad (4)$$

where $j = 0, 1, 2$, etc. and $A_0$, $A_1$, $A_2$, etc. are adjustable parameters. These parameters are evaluated by fitting $\Delta\kappa_S/\Phi_1(1 - \Phi_1)$ into eq 4 by the method of least-squares. A best fit was obtained with five adjustable parameters. These values of parameters along with the standard deviation $\sigma(\Delta\kappa_S)$ as defined by

$$\sigma(\Delta\kappa_S) = [\Sigma(\Delta\kappa_{S\ obs} - \Delta\kappa_{S\ calc})^2/(n - m)]^{1/2} \qquad (5)$$

are recorded in Table 3 for all liquid mixtures. Here $n$ is total number of experimental points, and $m$ is the number of parameters.

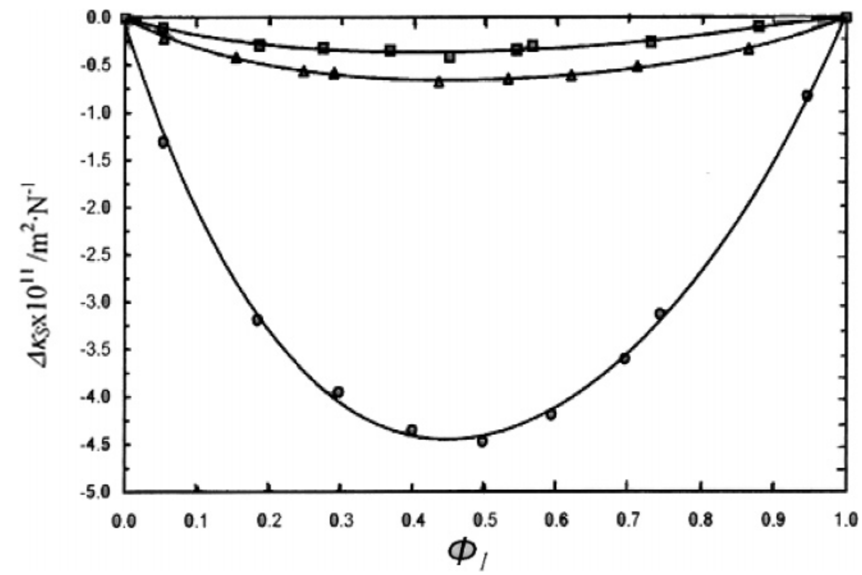


**Figure 3.** Variation of deviation in isentropic compressibility $\Delta\kappa_S$ with volume fraction $\Phi_1$ of the binary mixtures of *N*-methylacetamide (1) with ○, ethyl acetate; △, ethyl chloroacetate; □, ethyl cyanoacetate at $T$ = 313.15 K.

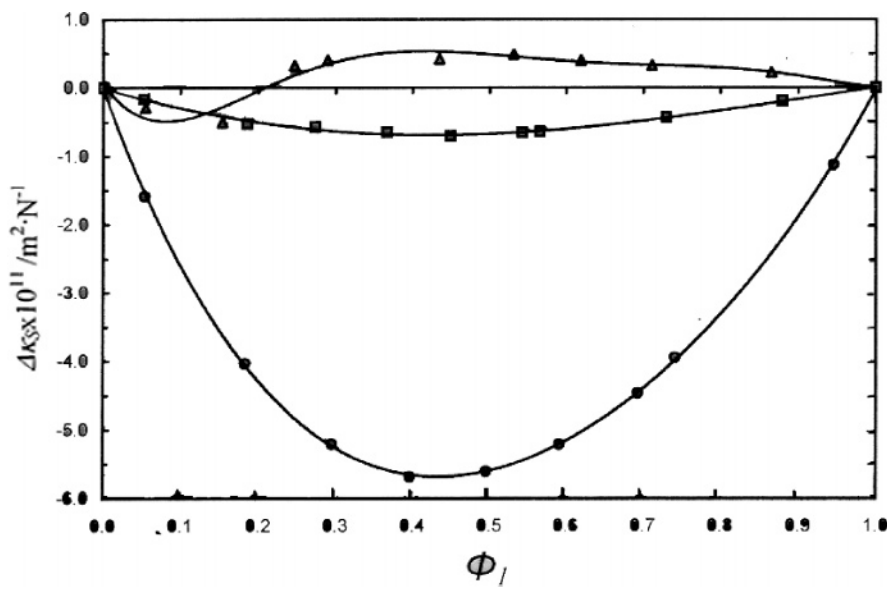


**Figure 4.** Variation of deviation in isentropic compressibility $\Delta\kappa_S$ with volume fraction $\Phi_1$ of the binary mixtures of *N*-methylacetamide (1) with ○, ethyl acetate; △, ethyl chloroacetate; □, ethyl cyanoacetate at $T$ = 318.15 K.

**Table 3. Values of the Parameters of Equation 4 and Standard Deviation σ for the Binary Mixtures of *N*-Methylacetamide (1) with Esters (2) at Various Temperatures**

| binary system | function | $T$/K | $A_0$ | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $\sigma$ |
|---|---|---|---|---|---|---|---|---|
| ethyl acetate (2) | $\Delta\kappa_S \times 10^{-11}$/m$^2$·N$^{-1}$ | 303.15 | −14.30 | 4.26 | −0.18 | −0.90 | 3.23 | 0.06 |
| | | 308.15 | −16.32 | 2.09 | 5.30 | 5.09 | −8.07 | 0.23 |
| | | 313.15 | −17.76 | 2.21 | −0.58 | 3.95 | −4.52 | 0.19 |
| | | 318.15 | −22.51 | 5.02 | −1.38 | 0.26 | −4.77 | 0.13 |
| ethyl chloroacetate (2) | $\Delta\kappa_S \times 10^{-11}$/m$^2$·N$^{-1}$ | 303.15 | −3.02 | 0.93 | 2.89 | −1.85 | −3.78 | 0.08 |
| | | 308.15 | −2.17 | 0.61 | 1.17 | −0.71 | −2.98 | 0.09 |
| | | 313.15 | −2.70 | 0.45 | 0.51 | −0.15 | −2.61 | 0.07 |
| | | 318.15 | 2.17 | −1.30 | −4.74 | 8.29 | | 1.13 |
| ethyl cyanoacetate (2) | $\Delta\kappa_S \times 10^{-11}$/m$^2$·N$^{-1}$ | 303.15 | −1.66 | 0.47 | 1.65 | 0.51 | −3.13 | 0.14 |
| | | 308.15 | −0.96 | 0.40 | 0.35 | −0.71 | −1.91 | 0.09 |
| | | 313.15 | −1.45 | 0.61 | −0.11 | | | 0.14 |
| | | 318.15 | −2.70 | 0.95 | 0.27 | | | 0.16 |

The system NMA + ethyl acetate, NMA + ethyl cyanoacetate, and NMA + ethyl chloroacetate show negative $\Delta\kappa_S$ values over the entire range of mole fraction and over the range of temperatures studied (Figures 1 to 4). In the case of the NMA + ethyl chloroaceate system, the positive $\Delta\kappa_S$ values exhibit sigmoidal trend with an inversion of sign at $x$ = 0.3 and temperature 318.15 K.

NMA is a dipolar protic solvent, with a very high dielectric constant (191.3) that is attributed to the liquid being highly structured with polymeric chains linked by hydrogen bonding.[17]

On the other hand, the molecules of esters have relatively low values of dielectric constants (5−20).[18] In the present investigation, negative $\Delta\kappa_S$ values obtained over the range of temperatures studied for all mixtures (Figures 1 to 4) are attributed to chemical forces operating between unlike molecules of the binary mixtures.[19,20]

## Conclusions

New experimental data of density and speed of sound for the system of NMA with ethyl acetate, ethyl chloroacetate, and ethyl cyanoacetate were measured over the whole range of composition from the temperature range of (303.15 to 318.15) K. The excess isentropic compressiblities of these systems are correlated using the Redlich−Kister type polynomial equation. Estimated coefficients and standard deviation values are also presented. The results show that the volume reduction factors are dominating in all the systems over the entire range of temperatures studied.

### Acknowledgment

B.S. thanks the University Grants Commission, New Delhi, India, for the award of Senior Research Fellowship (Awardee Letter F. 17-80/98(SA-I)). We thank the editor of the Journal, Dr. K. N. Marsh, for his persistent encouragement in shaping the manuscript to the suitable format of the Journal.

## Literature Cited

(1) Tangeda, S. J.; Nallani, S. N. Densities and viscosities of binary liquid systems of acetonitirle with aromatic ketones at 308.15 K. *Indian J. Chem.* **2005**, *44A*, 1365−1371.
(2) Naidu, B. V. K.; Rao, K. C.; Subha, M. C. S. Densities, viscosities, and excess properties for binary mixtures of some glycols and polyglycols in *N*-methylacetamide at 308.15 K. *J. Chem. Eng. Data* **2003**, *48*, 625−627.
(3) Rao, A. S.; Naidu, B. V. K.; Rao, K. C. Ultrasonic velocity study of binary liquid mixtures of *N*-methylacetamide with poly(ethylene glycols) at 35 °C. *J. Acoust. Soc. Ind.* **2000**, *28*, 301−304.
(4) Tejraj, M. A.; Banerjee, K. Density, viscosity, refractive index, and speed of sound in binary mixtures of acrylonitrile with methyl acetate, ethyl acetate, *n*-propyl acetate, *n*-butyl acetate, and 3-methylbutyl-2-acetate in the temperature interval (298.15−308.15) K. *J. Chem. Eng. Data* **1998**, *43*, 514−518.
(5) Tangeda, S. J.; Nallani, S. N. Ultrasonic studies of binary mixtures of some aromatic ketones with *N*-methylacetamide at 308.15 K. *J. Chem. Eng. Data* **2005**, *50*, 89−91.
(6) Tangeda, S. J.; Nallani, S. N. Density and viscosity of binary liquid systems of *N*-methylacetamide with aromatic ketones at 308.15 K. *J. Chem. Thermodyn.* **2006**, *38*, 272−277.
(7) Tejraj, M. A.; Phayde, H. T. S.; Khinnavar, R. S.; Bindu, G. K. Densities, refractive indices, speeds of sound, and shear viscosities of diethylene glycol dimethyl ether with ethyl acetate, methyl benzoate, ethyl benzoate, and diethyl succinate in the temperature range from 298.15 to 318.15 K. *J. Chem. Eng. Data* **1994**, *39*, 251−260.
(8) Nayak, J. N.; Aralaguppi, M. I.; Tejraj, M. A. Density, viscosity, refractive index, and speed of sound for the binary mixtures of ethyl chloroacetate with *n*-alkanes ($C_6$ to $C_{12}$) at (298.15, 303.15, and 308.15) K. *J. Chem. Eng. Data* **2001**, *46*, 891−896.
(9) Chandrasekhar, G.; Venkatesu, P.; Rao, M. V. P. Excess molar volumes and speed of sound of ethyl acetate, and butyl acetate with 2-alkoxyethanols at 308.15 K. *J. Chem. Eng. Data* **2000**, *45*, 590−593.
(10) Nayak, J. N.; Aralaguppi, M. I.; Tejraj, M. A. Density, viscosity, refractive index, and speed of sound in the binary mixtures of ethyl chloroacetate + cyclohexanone, + chlorobenzene, + bromobenzene, or + benzyl alcohol at (298.15, 303.15, and 308.15) K. *J. Chem. Eng. Data* **2003**, *48*, 628−631.
(11) Liu, C. Y.; Ku, H. C.; Tu, C. H. Densities and viscosities of five alkyl esters with nitroethane systems at (293.15, 303.15, and 313.15) K. *J. Chem. Eng. Data* **1999**, *44*, 360−364.
(12) Redlich, O.; Kister, A. T. Algebriac representation of thermodynamic properties and the classification of solutions. *Ind. Eng. Chem.* **1948**, *40*, 345−348.
(13) Tangeda, S. J.; Nallani, S. N. Ultrasonic studies on binary mixtures of some aromatic ketones with acrylonitrile at 308.15 K. *Indian J. Pure Appl. Phys.* **2005**, *43*, 591−595.
(14) Nikam, P. S.; Mahale, T. R.; Hasan, M. Densities and viscosities for ethyl acetate + pentan-1-ol, + hexan-1-ol, + 3,5,5-trimethylhexan-1-ol, + heptan-1-ol + octan-1-ol, and + decan-1-ol at (298.15, 303.15, and 308.15) K. *J. Chem. Eng. Data* **1998**, *43*, 436−440.
(15) Boodida, S. N.; Tangeda, S. J.; Nallani, S. N. Acoustic studies on binary mixtures of *N*-methylacetamide with some chloroethanes and chloroethenes at 308.15 K. *Indian J. Pure Appl. Phys.* **2006**, *44*, 587−591.
(16) Boodida, S. N.; Tangeda, S. J.; Nallani, S. N. Ultrasonic studies on binary mixtures of some aromatic ketones with acetonitrile at $T$ = 308.15 K. *J. Chem. Thermodyn.* **2006**, *38*, 1438−1442.
(17) Boodida, S. N.; Bachu, R. K.; Tangeda, S. J.; Nallani, S. N. Densities and viscosities of binary liquid mixtures of *N*-methylacetamide with some chloroethanes and chloroethenes at $T$ = 308.15 K. *J. Chem. Thermodyn.* (in press).
(18) Riddick, J. A.; Bunger, W. B.; Sakano, T. K. *Techniques of Chemistry, Organic Solvents: Physical Properties and Methods of Purifications*; John Willey & Sons: New York, 1986; Vol. II.
(19) Jose, M. R.; Jose, M. G.; Ana, I. S. Density, refractive index, speed of sound at 298.15 K, and vapor−liquid equilibria at 101.3 kPa for binary mixtures of ethyl acetate + ethyl lactate and methyl acetate + ethyl lactate. *J. Chem. Eng. Data* **2006**, *51*, 1294−1299.
(20) Sharaj, L. O.; Navin, B. P. Speeds of sound, isentropic compressibilities, and excess volumes of binary mixtures of acrylonitrile with organic solvents. *J. Chem. Eng. Data* **2000**, *45*, 225−230.
(21) Schuflan, L.; Jacobs, M. B. *The Handbook of Solvents*; D. Van Nostrand Company: New York, 1953.

Received for review August 1, 2006. Accepted November 12, 2006.

JE060343Y