Density, Speed of Sound, and Refractive Index for Binary Mixtures Containing Cycloalkanes with *o*-Xylene, *m*-Xylene, *p*-Xylene, and Mesitylene at $T = (298.15$ and 313.15) K

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Experimental physical properties (densities, speeds of sound, and refractive indices) and their derived and excess properties (excess molar volumes, isentropic compressibility, and excess molar isentropic compressibility) of binary systems containing cycloalkanes with aromatics (cyclopentane (1), or cyclohexane (1), or methylcyclohexane (1), or cyclooctane + *o*-xylene (2), + *m*-xylene (2), + *p*-xylene (2), or + mesitylene (2)) at $T = (298.15$ and 313.15) K and at atmospheric pressure were determined over the whole composition range. The excess properties of all the studied binary systems were satisfactorily fitted to the Redlich−Kister equation.

Introduction

The extraction of benzene, toluene, ethylbenzene, and xylenes from refinery products such as naphtha, kerosene, and fuel jets is very important to the petrochemical industry. Because of this, the information about the physical properties of pure liquids and liquid mixtures containing aromatic and aliphatic compounds and their dependence with composition and temperature is very important basic data.

As a part of our work of research concerning the study of the behavior of cycloalkanes and alkanes with aromatic compounds,[1,2] here new experimental density, speed of sound, and refractive index data at $T = (298.15$ and 313.15) K under atmospheric pressure of binary systems containing cycloalkanes (1) with aromatic compounds (2) [cyclopentane (1), or cyclohexane (1), or methylcyclohexane (1), or cyclooctane + *o*-xylene (2), + *m*-xylene (2), + *p*-xylene (2), or mesitylene (1,3,5-trimethylbenzene) (2)] are presented. The experimental results were used to calculate excess molar volumes, isentropic compressibilities, and excess molar isentropic compressibilities. The studied binary systems are available in the literature,[3−8] but a review of the literature shows that only one binary system (*p*-xylene (1) + cyclohexane (2)[3]) has been measured at $T = (298.15$ and 313.15) K.

Experimental Section

Chemicals. Cyclopentane (CAS number 287-92-3), cyclohexane (CAS number 110-82-7), methylcyclohexane (CAS number 108-87-2), *o*-xylene (CAS number 95-47-6), *p*-xylene (CAS number 106-42-3), *m*-xylene (CAS number 108-38-3), and mesitylene (CAS number 108-67-8) were supplied by Fluka, all of them with a mass fraction greater than 0.99, except for cyclohexane which had a mass fraction greater than 0.999. Cyclooctane (CAS number 292-64-8) was supplied by Sigma-Aldrich with a mass fraction greater than 0.99. They were degassed ultrasonically and dried over molecular sieves type 0.4 nm, supplied by Aldrich, and kept in an inert argon atmosphere. Table 1 shows a comparison between experimental and literature[9−12] data of pure components at $T = 298.15$ K.

Apparatus and Procedure. Samples were prepared by syringing known masses of the pure liquids into stoppered bottles. For weight measurements, a Mettler AX-205 Delta Range balance with a precision of $\pm 10^{-5}$ g was used. Good mixing was ensured by stirring. All samples were prepared immediately prior to measurements to avoid variations in composition due to evaporation of solvent.

Densities and speeds of sound were measured using an Anton Paar DSA-48 digital vibrating-tube densimeter. The uncertainty in experimental measurements has been found to be lower than $\pm 10^{-4}$ g·cm^{-3} for the density and ± 1 m·s^{-1} for the speed of sound. The apparatus was calibrated by air and water, according to the manual instruction. The calibration was checked with pure liquids shown in Table 1.

To measure refractive indices of pure components and their mixtures, an automatic refractometer (Abbemat-HP, Dr. Kernchen) with an uncertainty in the experimental measurements of $\pm 4 \cdot 10^{-5}$ was used.

Results and Discussion

The experimental data of density, speed of sound, refractive index, isentropic compressibility, excess molar volume, and excess molar isentropic compressibility for the binary systems (cyclopentane (1), or cyclohexane (1), or methylcyclohexane (1), or cyclooctane + *o*-xylene (2), + *m*-xylene (2), + *p*-xylene (2), + mesitylene (2)) at $T = (298.15$ and 313.15) K, under atmospheric pressure, are reported in Tables 2 and 3. The excess molar volumes were calculated by the following equations

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

where ρ and ρ_i are the density of the mixture and the density of the pure components, respectively; M_i is the molar mass of the pure components; and x_i represents the mole fraction of the component *i*.

The speed of sound, *u*, is related to the isentropic compressibility, κ_s, by the Laplace equation

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$$\kappa_s = -V_m^{-1}(\partial V_m/\partial p)_S = \rho^{-1}u^{-2} = V_m/(M_m u^2) \quad (2)$$

where V_m is the molar volume and M_m is the molar mass of the mixture.

To achieve agreement with the other thermodynamic quantities, it is appropriate to shift from the volume-intensive κ_s to the mole-intensive quantity $K_{S,m}$[13,14]

$$K_{S,m} = -(\partial V_m/\partial p)_S = V_m\kappa_s = V_m^2/(M_m u^2) \quad (3)$$

where $K_{S,m}$ is the molar isentropic compressibility.

Experimental values for the speed of sound are reported in Tables 2 and 3, together with derived values of the isentropic compressibility and its excess, $K^E_{S,m}$. The excess molar isentropic compressibility $K^E_{S,m}$ is calculated by the following equation

$$K^E_{S,m} = K_{S,m} - K^{id}_{S,m} \quad (4)$$

where $K^{id}_{S,m}$ is defined by the approach developed by Benson and Kiyohara[15]

$$K^{id}_{S,m} = \sum_i x_i\left[K^*_{S,i} + T\frac{(E^*_{p,i})^2}{C^*_{p,i}}\right] - T\left[\frac{(\sum_i x_i E^*_{p,i})^2}{\sum_i x_i C^*_{p,i}}\right] \quad (5)$$

where $K^*_{S,i}$ is the product of the molar volume V^*_i and the isentropic compressibility $\kappa^*_{S,i}$of the pure component i. The molar isobaric expansion of pure component i, $E^*_{p,i}$, is the product of the molar volume and the isobaric expansibility $\alpha^*_{p,i}$[$\alpha^*_{p,i} = -(1/\rho)((\partial\rho/\partial T))_P$], and $C^*_{p,i}$ is the molar isobaric heat capacity of

Table 1. Comparison of Experimental Density Pure Component Data and Refractive Index with Literature Values at T = 298.15 K and Literature Data of Heat Capacity, $C^*_{p,i}$, and Isobaric Expansibility, $\alpha^*_{p,i}$, at T = 298.15 K

	ρ/(g·cm^{-3})		n_D		$C^*_{p,i}$	$\alpha^*_{p,i}$
component	exptl	lit.	exptl	lit.	lit.	lit.
cyclopentane	0.7400	0.74045[a]	1.40292	1.40363[a]	119.78[b]	0.00135[b]
cyclohexane	0.7739	0.77389[a]	1.42360	1.42354[a]	162.07[b]	0.00092[b]
methylcyclohexane	0.7650	0.76506[a]	1.42062	1.42058[a]	192.63[b]	0.00138[b]
cyclooctane	0.8315	0.83151[c]	1.45598	1.45624[d]	250.11[b]	0.00090[b]
o-xylene	0.8754	0.87594[a]	1.50262	1.50295[a]	189.25[b]	0.00093[b]
m-xylene	0.8598	0.86001[a]	1.49466	1.49464[a]	182.66[b]	0.00096[b]
p-xylene	0.8566	0.85661[a]	1.49312	1.49325[a]	197.74[b]	0.00098[b]
mesitylene	0.8611	0.86111[a]	1.49693	1.49684[a]	208.31[b]	0.00093[b]

[a] From ref 9. [b] From ref 10. [c] From ref 11. [d] From ref 12.

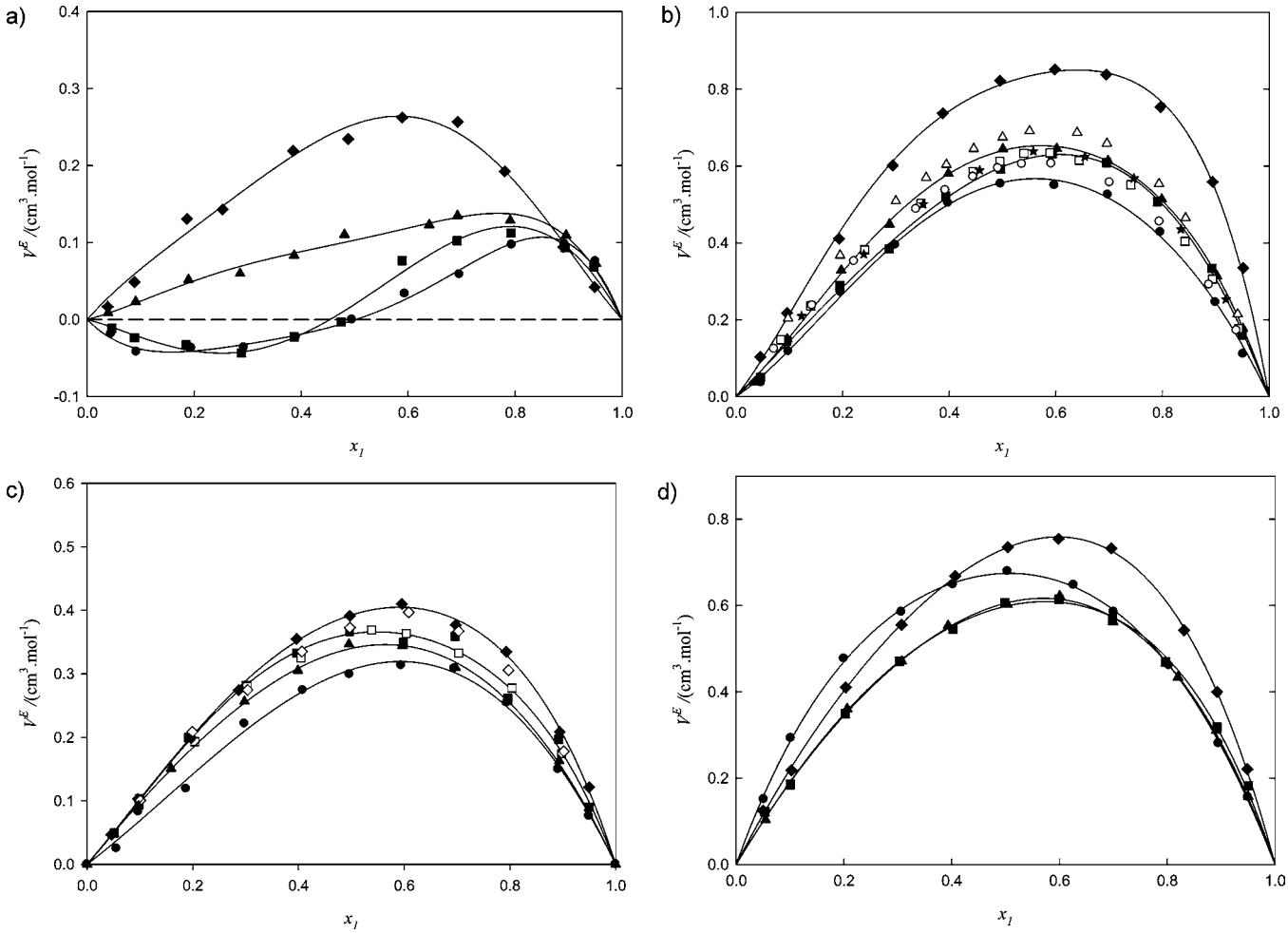

Figure 1. Excess molar volumes, V^E, from the Redlich−Kister equation plotted against mole fraction for the binary mixtures at T = 298.15 K: cycloalkane (1) + aromatic (2); for (a) cyclopentane, (b) cyclohexane, (c) methylcyclohexane, and (d) cyclooctane. Closed symbols correspond to experimental data: ●, *o*-xylene; ▲, *m*-xylene; ■, *p*-xylene; and ◆, mesitylene. Open symbols and ★ correspond to literature data.[3,5,6]

Table 2. Densities (ρ), Refractive Indices (n_D), Speeds of Sound (u), Isentropic Compressibility ($K_{S,m}$), Excess Molar Volumes (V^E), and Excess Molar Isentropic Compressibility ($K^E_{S,m}$) of the Binary Mixtures at 298.15 K

x_1	ρ / g·cm^{-3}	n_D	u / m·s^{-1}	$K_{S,m}$ / m^3·TPa^{-1}·mol^{-1}	V^E / cm^3·mol^{-1}	$K^E_{S,m}$ / m^3·TPa^{-1}·mol^{-1}
			Cyclopentane (1) + *o*-Xylene (2)			
0.0000	0.8754	1.50262	1350	0.07607	0.000	0.00000
0.0450	0.8707	1.49951	1342	0.07656	−0.019	−0.00006
0.0924	0.8657	1.49549	1336	0.07694	−0.042	−0.00027
0.1949	0.8541	1.48698	1319	0.07807	−0.037	−0.00040
0.2932	0.8425	1.47910	1304	0.07918	−0.036	−0.00049
0.3903	0.8304	1.47003	1289	0.08035	−0.023	−0.00052
0.4954	0.8166	1.46059	1273	0.08169	0.000	−0.00047
0.5940	0.8029	1.45070	1259	0.08301	0.034	−0.00037
0.6958	0.7881	1.43935	1244	0.08438	0.059	−0.00025
0.7939	0.7730	1.42832	1231	0.08573	0.097	−0.00011
0.8926	0.7573	1.41649	1217	0.08708	0.098	0.00003
0.9503	0.7479	1.40949	1210	0.08779	0.076	0.00004
1.0000	0.7400	1.40292	1204	0.08837	0.000	0.00000
			Cyclopentane (1) + *m*-Xylene (2)			
0.0000	0.8598	1.49466	1321	0.08235	0.000	0.00000
0.0391	0.8561	1.49183	1315	0.08260	0.009	0.00002
0.0908	0.8511	1.48818	1308	0.08297	0.023	0.00008
0.1894	0.8412	1.48065	1296	0.08356	0.052	0.00007
0.2859	0.8312	1.47341	1284	0.08416	0.060	0.00009
0.3868	0.8201	1.46504	1272	0.08482	0.083	0.00015
0.4808	0.8092	1.45745	1260	0.08550	0.110	0.00026
0.6394	0.7898	1.44242	1241	0.08653	0.123	0.00033
0.6923	0.7829	1.43668	1235	0.08690	0.135	0.00039
0.7909	0.7697	1.42686	1224	0.08750	0.129	0.00040
0.8952	0.7550	1.41504	1214	0.08804	0.110	0.00031
0.9514	0.7469	1.40888	1208	0.08824	0.073	0.00016
1.0000	0.7400	1.40292	1204	0.08837	0.000	0.00000
			Cyclopentane (1) + *p*-Xylene (2)			
0.0000	0.8566	1.49312	1310	0.08436	0.000	0.00000
0.0462	0.8525	1.49015	1305	0.08446	−0.011	−0.00009
0.0885	0.8487	1.48707	1300	0.08463	−0.024	−0.00008
0.1848	0.8396	1.48001	1289	0.08497	−0.033	−0.00013
0.2886	0.8293	1.47236	1277	0.08533	−0.044	−0.00018
0.3869	0.8188	1.46445	1266	0.08580	−0.023	−0.00011
0.4744	0.8090	1.45737	1256	0.08622	−0.003	−0.00004
0.5886	0.7951	1.44669	1244	0.08690	0.077	0.00018
0.6913	0.7822	1.43720	1233	0.08737	0.102	0.00024
0.7923	0.7689	1.42618	1223	0.08783	0.112	0.00029
0.8935	0.7550	1.41575	1213	0.08817	0.093	0.00022
0.9471	0.7474	1.40916	1208	0.08832	0.069	0.00016
1.0000	0.7400	1.40292	1204	0.08837	0.000	0.00000
			Cyclopentane (1) + Mesitylene (2)			
0.0000	0.8611	1.49693	1336	0.09075	0.000	0.00000
0.0383	0.8578	1.49446	1332	0.09065	0.017	−0.00001
0.0884	0.8533	1.49105	1325	0.09060	0.049	0.00006
0.1869	0.8439	1.48398	1311	0.09057	0.131	0.00026
0.2531	0.8375	1.47925	1302	0.09045	0.143	0.00030
0.3849	0.8235	1.46883	1283	0.09036	0.219	0.00052
0.4879	0.8119	1.45960	1269	0.09020	0.234	0.00061
0.5891	0.7995	1.45045	1255	0.09009	0.262	0.00074
0.6926	0.7860	1.44030	1241	0.08986	0.257	0.00076
0.7807	0.7740	1.43111	1229	0.08964	0.192	0.00074
0.8901	0.7579	1.41728	1216	0.08904	0.094	0.00041
0.9487	0.7486	1.40994	1210	0.08865	0.042	0.00016
1.0000	0.7400	1.40292	1204	0.08837	0.000	0.00000
			Cyclohexane (1) + *o*-Xylene (2)			
0.0000	0.8754	1.50262	1350	0.07607	0.000	0.00000
0.0471	0.8708	1.49895	1343	0.07685	0.036	0.00016
0.0981	0.8655	1.49488	1336	0.07778	0.118	0.00042
0.1961	0.8552	1.48705	1323	0.07957	0.272	0.00091
0.2986	0.8445	1.47886	1310	0.08138	0.395	0.00136
0.3979	0.8340	1.47092	1298	0.08311	0.504	0.00178
0.4964	0.8238	1.46293	1288	0.08466	0.554	0.00203
0.5975	0.8135	1.45493	1278	0.08611	0.550	0.00214
0.6978	0.8032	1.44691	1269	0.08742	0.525	0.00212
0.7960	0.7934	1.43924	1263	0.08834	0.428	0.00175
0.8995	0.7834	1.43126	1257	0.08911	0.245	0.00115
0.9512	0.7786	1.42739	1255	0.08925	0.111	0.00061
1.0000	0.7739	1.42360	1255	0.08929	0.000	0.00000
			Cyclohexane (1) + *m*-Xylene (2)			
0.0000	0.8598	1.49466	1321	0.08235	0.000	0.00000
0.0346	0.8569	1.49219	1317	0.08276	0.037	0.00018
0.0960	0.8514	1.48781	1310	0.08360	0.150	0.00059
0.1974	0.8422	1.48052	1300	0.08495	0.329	0.00123
0.2879	0.8341	1.47391	1291	0.08606	0.449	0.00171

Table 2. Continued

x_1	ρ / g·cm^{-3}	n_D	u / m·s^{-1}	$K_{S,m}$ / m^3·TPa^{-1}·mol^{-1}	V^E / cm^3·mol^{-1}	$K^E_{S,m}$ / m^3·TPa^{-1}·mol^{-1}
			Cyclohexane (1) + *m*-Xylene (2)			
0.3982	0.8241	1.46589	1281	0.08734	0.580	0.00223
0.5005	0.8150	1.45851	1273	0.08833	0.645	0.00251
0.6019	0.8062	1.45128	1267	0.08912	0.645	0.00260
0.6976	0.7979	1.44447	1261	0.08970	0.614	0.00251
0.7985	0.7894	1.43723	1257	0.09001	0.514	0.00212
0.9021	0.7811	1.42992	1254	0.08999	0.314	0.00138
0.9509	0.7774	1.42673	1254	0.08974	0.177	0.00079
1.0000	0.7739	1.42360	1255	0.08929	0.000	0.00000
			Cyclohexane (1) + *p*-Xylene (2)			
0.0000	0.8566	1.49312	1310	0.08436	0.000	0.00000
0.0459	0.8529	1.49003	1306	0.08481	0.050	0.00023
0.0952	0.8486	1.48660	1301	0.08541	0.145	0.00058
0.1948	0.8401	1.47959	1292	0.08654	0.289	0.00122
0.2874	0.8323	1.47324	1284	0.08745	0.384	0.00168
0.3929	0.8230	1.46560	1275	0.08853	0.522	0.00223
0.4964	0.8141	1.45843	1269	0.08930	0.593	0.00250
0.5938	0.8057	1.45142	1263	0.08997	0.632	0.00268
0.6949	0.7972	1.44417	1258	0.09040	0.609	0.00262
0.7906	0.7895	1.43762	1254	0.09050	0.507	0.00224
0.8927	0.7815	1.43057	1253	0.09026	0.334	0.00150
0.9493	0.7775	1.42692	1253	0.08982	0.161	0.00078
1.0000	0.7739	1.42360	1255	0.08929	0.000	0.00000
			Cyclohexane (1) + Mesitylene (2)			
0.0000	0.8611	1.49693	1336	0.09075	0.000	0.00000
0.0459	0.8573	1.49390	1331	0.09099	0.103	0.00031
0.0956	0.8531	1.49061	1326	0.09126	0.217	0.00065
0.1930	0.8448	1.48396	1315	0.09175	0.411	0.00128
0.2937	0.8359	1.47698	1304	0.09224	0.602	0.00191
0.3878	0.8275	1.46995	1294	0.09266	0.737	0.00248
0.4953	0.8179	1.46201	1283	0.09294	0.822	0.00291
0.5980	0.8086	1.45441	1274	0.09300	0.851	0.00312
0.6944	0.7997	1.44675	1265	0.09294	0.838	0.00320
0.7960	0.7903	1.43896	1258	0.09257	0.753	0.00299
0.8942	0.7815	1.43119	1252	0.09187	0.559	0.00243
0.9515	0.7769	1.42697	1250	0.09109	0.335	0.00173
1.0000	0.7739	1.42360	1255	0.08929	0.000	0.00000
			Methylcyclohexane (1) + *o*-Xylene (2)			
0.0000	0.8754	1.50262	1350	0.07607	0.000	0.00000
0.0558	0.8687	1.49758	1340	0.07806	0.025	−0.00011
0.0973	0.8635	1.49375	1333	0.07961	0.083	−0.00012
0.1875	0.8529	1.48587	1318	0.08289	0.119	−0.00023
0.2979	0.8397	1.47605	1300	0.08714	0.221	−0.00014
0.4084	0.8270	1.46659	1283	0.09138	0.274	−0.00005
0.4965	0.8171	1.45929	1271	0.09478	0.299	0.00003
0.5946	0.8063	1.45128	1259	0.09848	0.313	0.00005
0.6948	0.7955	1.44332	1246	0.10247	0.308	0.00026
0.7944	0.7852	1.43568	1235	0.10625	0.255	0.00029
0.8912	0.7756	1.42852	1225	0.10981	0.150	0.00022
0.9497	0.7699	1.42429	1219	0.11190	0.076	0.00010
1.0000	0.7650	1.42062	1215	0.11370	0.013	0.00000
			Methylcyclohexane (1) + *m*-Xylene (2)			
0.0000	0.8598	1.49466	1321	0.08235	0.000	0.00000
0.0514	0.8544	1.49046	1313	0.08402	0.048	0.00006
0.0975	0.8496	1.48670	1307	0.08549	0.092	0.00009
0.1590	0.8432	1.48174	1298	0.08752	0.151	0.00019
0.2977	0.8291	1.47072	1281	0.09208	0.257	0.00040
0.3990	0.8191	1.46292	1269	0.09538	0.305	0.00052
0.4954	0.8097	1.45565	1258	0.09853	0.347	0.00065
0.5965	0.8002	1.44827	1248	0.10175	0.344	0.00070
0.6974	0.7910	1.44107	1238	0.10492	0.310	0.00070
0.7948	0.7823	1.43430	1230	0.10788	0.256	0.00060
0.8933	0.7738	1.42759	1222	0.11079	0.163	0.00042
0.9495	0.7691	1.42388	1218	0.11236	0.089	0.00024
1.0000	0.7650	1.42062	1215	0.11370	0.000	0.00000
			Methylcyclohexane (1) + *p*-Xylene (2)			
0.0000	0.8566	1.49312	1310	0.08436	0.000	0.00000
0.0513	0.8514	1.48906	1303	0.08593	0.049	0.00007
0.0979	0.8467	1.48531	1297	0.08738	0.094	0.00015
0.1917	0.8372	1.47789	1285	0.09038	0.200	0.00040
0.3009	0.8265	1.46944	1272	0.09383	0.282	0.00064
0.3971	0.8173	1.46214	1262	0.09681	0.333	0.00080
0.4963	0.8080	1.45480	1252	0.09990	0.367	0.00097
0.5987	0.7988	1.44757	1243	0.10289	0.349	0.00096
0.6966	0.7899	1.44052	1234	0.10582	0.359	0.00102
0.7958	0.7816	1.43389	1227	0.10849	0.261	0.00078
0.8922	0.7734	1.42739	1221	0.11115	0.197	0.00061

Table 2. Continued

x_1	ρ / g·cm^{-3}	n_D	u / m·s^{-1}	$K_{S,m}$ / m^3·TPa^{-1}·mol^{-1}	V^E / cm^3·mol^{-1}	$K_{S,m}^E$ / m^3·TPa^{-1}·mol^{-1}
			Cyclohexane (1) + *m*-Xylene (2)			
0.9501	0.7689	1.42377	1217	0.11252	0.090	0.00028
1.0000	0.7650	1.42062	1215	0.11370	0.000	0.00000
			Methylcyclohexane (1) + Mesitylene (2)			
0.0000	0.8611	1.49693	1336	0.09075	0.000	0.00000
0.0463	0.8567	1.49346	1330	0.09177	0.046	–0.00005
0.0962	0.8519	1.48973	1323	0.09290	0.103	–0.00006
0.1970	0.8422	1.48211	1310	0.09523	0.199	–0.00005
0.2868	0.8335	1.47524	1298	0.09736	0.274	0.00003
0.3963	0.8228	1.46685	1283	0.09996	0.355	0.00012
0.4972	0.8130	1.45909	1271	0.10235	0.391	0.00020
0.5956	0.8034	1.45153	1259	0.10470	0.410	0.00029
0.6974	0.7936	1.44373	1247	0.10706	0.377	0.00032
0.7932	0.7843	1.43635	1236	0.10929	0.335	0.00035
0.8942	0.7748	1.42859	1226	0.11137	0.209	0.00011
0.9497	0.7696	1.42444	1220	0.11271	0.122	0.00018
1.0000	0.7651	1.42062	1215	0.11368	0.000	0.00000
			Cyclooctane (1) + *o*-Xylene (2)			
0.0000	0.8754	1.50262	1350	0.07607	0.000	0.00000
0.0513	0.8718	1.49887	1347	0.07717	0.151	0.00069
0.1015	0.8684	1.49595	1348	0.07795	0.292	0.00109
0.2000	0.8625	1.49039	1349	0.07933	0.477	0.00169
0.3067	0.8569	1.48468	1351	0.08057	0.585	0.00208
0.4026	0.8522	1.47987	1354	0.08154	0.649	0.00229
0.5037	0.8476	1.47508	1358	0.08242	0.679	0.00238
0.6262	0.8426	1.46963	1364	0.08326	0.648	0.00225
0.7007	0.8399	1.46653	1368	0.08362	0.585	0.00203
0.8028	0.8365	1.46260	1375	0.08397	0.461	0.00157
0.8953	0.8339	1.45933	1381	0.08409	0.281	0.00096
0.9498	0.8325	1.45752	1386	0.08406	0.156	0.00051
1.0000	0.8315	1.45598	1391	0.08395	0.000	0.00000
			Cyclooctane (1) + *m*-Xylene (2)			
0.0000	0.8598	1.49466	1321	0.08235	0.000	0.00000
0.0545	0.8574	1.49186	1322	0.08285	0.103	0.00042
0.0993	0.8555	1.48961	1324	0.08324	0.182	0.00073
0.2059	0.8511	1.48450	1328	0.08407	0.361	0.00139
0.3074	0.8474	1.47990	1333	0.08462	0.471	0.00178
0.3933	0.8444	1.47623	1338	0.08498	0.553	0.00201
0.5031	0.8410	1.47176	1346	0.08526	0.602	0.00211
0.6002	0.8382	1.46806	1353	0.08537	0.622	0.00206
0.6993	0.8359	1.46461	1361	0.08529	0.562	0.00183
0.8198	0.8335	1.46072	1372	0.08499	0.434	0.00133
0.8909	0.8324	1.45869	1379	0.08467	0.310	0.00090
0.9503	0.8318	1.45714	1385	0.08428	0.157	0.00042
1.0000	0.8315	1.45598	1391	0.08395	0.000	0.00000
			Cyclooctane (1) + *p*-Xylene (2)			
0.0000	0.8566	1.49312	1310	0.08436	0.000	0.00000
0.0534	0.8543	1.49055	1312	0.08477	0.122	0.00044
0.1004	0.8526	1.48830	1314	0.08507	0.186	0.00075
0.2025	0.8488	1.48358	1319	0.08567	0.349	0.00139
0.3030	0.8454	1.47920	1325	0.08607	0.470	0.00184
0.4020	0.8424	1.47506	1332	0.08628	0.545	0.00208
0.4986	0.8396	1.47129	1339	0.08636	0.607	0.00221
0.5990	0.8371	1.46764	1348	0.08628	0.614	0.00216
0.6981	0.8350	1.46424	1357	0.08598	0.570	0.00191
0.7968	0.8333	1.46119	1367	0.08554	0.469	0.00151
0.8926	0.8320	1.45850	1377	0.08495	0.318	0.00095
0.9504	0.8315	1.45707	1384	0.08446	0.182	0.00050
1.0000	0.8315	1.45598	1391	0.08395	0.000	0.00000
			Cyclooctane (1) + Mesitylene (2)			
0.0000	0.8611	1.49693	1336	0.09075	0.000	0.00000
0.0496	0.8589	1.49453	1338	0.09078	0.124	0.00036
0.1026	0.8568	1.49198	1339	0.09075	0.218	0.00070
0.2035	0.8527	1.48725	1341	0.09067	0.410	0.00130
0.3070	0.8488	1.48253	1345	0.09037	0.555	0.00170
0.4062	0.8452	1.47807	1349	0.08998	0.668	0.00199
0.5042	0.8419	1.47384	1354	0.08943	0.735	0.00211
0.5980	0.8390	1.46995	1359	0.08874	0.754	0.00206
0.6960	0.8362	1.46606	1366	0.08791	0.733	0.00189
0.8308	0.8333	1.46115	1376	0.08642	0.543	0.00132
0.8926	0.8323	1.45905	1381	0.08563	0.400	0.00095
0.9484	0.8317	1.45738	1386	0.08478	0.221	0.00049
1.0000	0.8315	1.45598	1391	0.08395	0.000	0.00000

Table 3. Densities (ρ), Refractive Indices (n_D), Speeds of Sound (u), Isentropic Compressibility ($K_{S,m}$), Excess Molar Volumes (V^E), and Excess Molar Isentropic Compressibility ($K^E_{S,m}$) of the Binary Mixtures at 298.15 K

x_1	ρ / g·cm^{-3}	n_D	u / m·s^{-1}	$K_{S,m}$ / m^3·TPa^{-1}·mol^{-1}	V^E / cm^3·mol^{-1}	$K^E_{S,m}$ / m^3·TPa^{-1}·mol^{-1}
			Cyclopentane (1) + *o*-Xylene (2)			
0.0000	0.8629	1.49466	1290	0.08576	0.000	0.00000
0.0720	0.8550	1.48922	1277	0.08681	−0.015	−0.00029
0.0931	0.8527	1.48739	1274	0.08706	−0.022	−0.00044
0.1919	0.8415	1.47936	1257	0.08865	−0.041	−0.00070
0.2934	0.8293	1.47048	1241	0.09032	−0.049	−0.00094
0.3772	0.8188	1.46299	1227	0.09173	−0.061	−0.00109
0.4855	0.8046	1.45278	1209	0.09372	−0.060	−0.00113
0.5894	0.7901	1.44238	1192	0.09570	−0.047	−0.00109
0.6850	0.7762	1.43216	1177	0.09757	−0.037	−0.00102
0.8099	0.7569	1.41833	1158	0.10016	−0.022	−0.00076
0.8912	0.7436	1.40862	1146	0.10201	−0.011	−0.00043
0.9479	0.7341	1.40200	1138	0.10326	−0.006	−0.00025
1.0000	0.7250	1.39456	1130	0.10448	0.000	0.00000
			Cyclopentane (1) + *m*-Xylene (2)			
0.0000	0.8469	1.48653	1259	0.09336	0.000	0.00000
0.0431	0.8429	1.48387	1253	0.09373	−0.008	−0.00010
0.0812	0.8392	1.48096	1248	0.09410	−0.007	−0.00016
0.1859	0.8286	1.47303	1234	0.09520	0.004	−0.00023
0.2864	0.8180	1.46521	1220	0.09629	0.014	−0.00025
0.3348	0.8126	1.46128	1213	0.09683	0.034	−0.00025
0.4741	0.7964	1.44893	1194	0.09846	0.061	−0.00017
0.5747	0.7841	1.43989	1181	0.09967	0.076	−0.00008
0.6933	0.7688	1.42834	1166	0.10106	0.086	−0.00001
0.7932	0.7552	1.41810	1153	0.10225	0.082	0.00007
0.8961	0.7405	1.40670	1141	0.10347	0.058	0.00014
0.9472	0.7330	1.40122	1135	0.10398	0.024	0.00009
1.0000	0.7250	1.39456	1130	0.10448	0.000	0.00000
			Cyclopentane (1) + *p*-Xylene (2)			
0.0000	0.8435	1.48444	1248	0.09574	0.000	0.00000
0.0443	0.8397	1.48224	1243	0.09595	−0.045	−0.00018
0.0981	0.8348	1.47862	1236	0.09633	−0.061	−0.00027
0.2012	0.8247	1.47117	1224	0.09710	−0.067	−0.00040
0.2998	0.8145	1.46343	1211	0.09797	−0.054	−0.00039
0.3542	0.8085	1.45890	1204	0.09850	−0.026	−0.00034
0.4799	0.7943	1.44816	1189	0.09971	0.008	−0.00023
0.6021	0.7794	1.43702	1173	0.10102	0.050	0.00001
0.7030	0.7664	1.42761	1161	0.10211	0.089	0.00022
0.8072	0.7523	1.41693	1149	0.10322	0.113	0.00043
0.9090	0.7379	1.40570	1138	0.10406	0.100	0.00038
0.9601	0.7306	1.39936	1133	0.10442	0.069	0.00029
1.0000	0.7250	1.39456	1130	0.10448	0.000	0.00000
			Cyclopentane (1) + Mesitylene (2)			
0.0000	0.8488	1.48923	1277	0.10237	0.000	0.00000
0.0414	0.8451	1.48675	1271	0.10242	0.018	−0.00003
0.0948	0.8402	1.48324	1263	0.10252	0.050	−0.00005
0.1986	0.8302	1.47585	1248	0.10276	0.103	−0.00002
0.2985	0.8199	1.46786	1232	0.10309	0.162	0.00010
0.4078	0.8077	1.45906	1216	0.10346	0.221	0.00023
0.4703	0.8003	1.45335	1206	0.10373	0.256	0.00037
0.6043	0.7835	1.44110	1186	0.10424	0.302	0.00059
0.7006	0.7704	1.43120	1171	0.10460	0.313	0.00076
0.8048	0.7554	1.42003	1155	0.10490	0.286	0.00083
0.9074	0.7397	1.40648	1140	0.10499	0.184	0.00070
0.9595	0.7314	1.40014	1134	0.10484	0.108	0.00045
1.0000	0.7250	1.39456	1130	0.10448	0.000	0.00000
			Cyclohexane (1) + *o*-Xylene (2)			
0.0000	0.8629	1.49466	1289	0.08576	0.000	0.00000
0.0528	0.8574	1.49053	1282	0.08697	0.079	0.00022
0.0977	0.8527	1.48716	1275	0.08797	0.134	0.00039
0.1958	0.8423	1.47934	1261	0.09027	0.287	0.00085
0.2169	0.8400	1.47754	1258	0.09079	0.326	0.00098
0.4011	0.8204	1.46285	1234	0.09498	0.519	0.00172
0.4999	0.8099	1.45473	1222	0.09714	0.582	0.00204
0.5976	0.7996	1.44694	1211	0.09914	0.600	0.00221
0.6971	0.7894	1.43921	1201	0.10096	0.552	0.00216
0.7994	0.7790	1.43094	1193	0.10260	0.455	0.00189
0.8995	0.7691	1.42311	1186	0.10385	0.275	0.00127
0.9484	0.7645	1.41926	1183	0.10425	0.147	0.00076
1.0000	0.7596	1.41516	1182	0.10446	0.000	0.00000
			Cyclohexane (1) + *m*-Xylene (2)			
0.0000	0.8469	1.48653	1259	0.09336	0.000	0.00000
0.0355	0.8437	1.48408	1255	0.09397	0.062	0.00022
0.0950	0.8383	1.47988	1248	0.09504	0.174	0.00063
0.1903	0.8296	1.47305	1238	0.09671	0.334	0.00124

Table 3. Continued

x_1	ρ / g·cm^{-3}	n_D	u / m·s^{-1}	$K_{S,m}$ / m^3·TPa^{-1}·mol^{-1}	V^E / cm^3·mol^{-1}	$K^E_{S,m}$ / m^3·TPa^{-1}·mol^{-1}
			Cyclohexane (1) + *m*-Xylene (2)			
0.2937	0.8202	1.46566	1227	0.09845	0.484	0.00184
0.3969	0.8108	1.45826	1217	0.10007	0.584	0.00230
0.4919	0.8023	1.45153	1209	0.10136	0.640	0.00254
0.5952	0.7931	1.44402	1200	0.10267	0.655	0.00270
0.6963	0.7843	1.43677	1193	0.10369	0.611	0.00260
0.7968	0.7755	1.42954	1187	0.10451	0.528	0.00231
0.8984	0.7673	1.42246	1183	0.10481	0.317	0.00148
0.9496	0.76345	1.41885	1182	0.10472	0.159	0.00083
1.0000	0.75959	1.41516	1182	0.10446	0.000	0.00000
			Cyclohexane (1) + *p*-Xylene (2)			
0.0000	0.8435	1.48444	1248	0.09574	0.000	0.00000
0.0494	0.8394	1.48145	1243	0.09645	0.068	0.00027
0.1056	0.8345	1.47781	1238	0.09734	0.161	0.00067
0.2078	0.8258	1.47072	1228	0.09882	0.287	0.00127
0.3149	0.8165	1.46341	1218	0.10038	0.417	0.00189
0.4156	0.8075	1.45628	1209	0.10179	0.543	0.00242
0.5115	0.7992	1.44953	1202	0.10286	0.597	0.00266
0.6083	0.7909	1.44272	1195	0.10387	0.609	0.00283
0.7079	0.7825	1.43584	1189	0.10458	0.569	0.00266
0.8167	0.7737	1.42845	1184	0.10502	0.426	0.00216
0.9109	0.7662	1.42167	1182	0.10505	0.260	0.00137
0.9601	0.7625	1.41809	1181	0.10481	0.130	0.00070
1.0000	0.7596	1.41516	1182	0.10446	0.000	0.00000
			Cyclohexane (1) + Mesitylene (2)			
0.0000	0.8488	1.48923	1277	0.10237	0.000	0.00000
0.0488	0.8448	1.48628	1271	0.10274	0.094	0.00028
0.1020	0.8402	1.48264	1265	0.10320	0.211	0.00062
0.2008	0.8317	1.47604	1253	0.10402	0.396	0.00123
0.3053	0.8226	1.46880	1241	0.10478	0.544	0.00177
0.4160	0.8124	1.46071	1229	0.10554	0.700	0.00231
0.5105	0.8035	1.45340	1219	0.10616	0.811	0.00272
0.6084	0.7943	1.44576	1209	0.10658	0.855	0.00294
0.7068	0.7852	1.43825	1200	0.10671	0.805	0.00286
0.8092	0.7759	1.43012	1191	0.10652	0.657	0.00246
0.9110	0.7669	1.42220	1185	0.10578	0.384	0.00151
0.9612	0.7627	1.41833	1183	0.10516	0.183	0.00079
1.0000	0.7596	1.41516	1182	0.10446	0.000	0.00000
			Methylcyclohexane (1) + *o*-Xylene (2)			
0.0000	0.8629	1.49466	1289	0.08576	0.000	0.00000
0.0490	0.8568	1.49036	1281	0.08786	0.039	−0.00014
0.0983	0.8508	1.48589	1272	0.09002	0.084	−0.00023
0.1972	0.8389	1.47705	1255	0.09438	0.152	−0.00039
0.2832	0.8287	1.46962	1241	0.09827	0.210	−0.00042
0.4030	0.8148	1.45951	1222	0.10380	0.267	−0.00036
0.5001	0.8038	1.45140	1208	0.10833	0.295	−0.00026
0.5980	0.7930	1.44349	1195	0.11294	0.305	−0.00012
0.6977	0.7823	1.43558	1182	0.11762	0.285	0.00001
0.7947	0.7722	1.42810	1171	0.12215	0.236	0.00011
0.9013	0.7615	1.42003	1160	0.12705	0.132	0.00014
0.9474	0.7569	1.41650	1154	0.12913	0.081	0.00011
1.0000	0.7519	1.41274	1150	0.13142	0.000	0.00000
			Methylcyclohexane (1) + *m*-Xylene (2)			
0.0000	0.8469	1.48653	1259	0.09336	0.000	0.00000
0.0457	0.8421	1.48290	1252	0.09510	0.040	0.00000
0.0933	0.8371	1.47908	1246	0.09693	0.090	0.00002
0.1938	0.8267	1.47103	1232	0.10085	0.178	0.00012
0.2886	0.8170	1.46361	1219	0.10461	0.253	0.00027
0.3966	0.8063	1.45534	1206	0.10885	0.308	0.00040
0.5077	0.7955	1.44702	1194	0.11323	0.347	0.00055
0.5950	0.7873	1.44063	1184	0.11660	0.344	0.00060
0.6933	0.7783	1.43362	1175	0.12038	0.326	0.00064
0.7987	0.7688	1.42615	1165	0.12436	0.264	0.00060
0.8973	0.7603	1.41945	1157	0.12795	0.168	0.00044
0.9504	0.7561	1.41609	1153	0.12967	0.056	0.00014
1.0000	0.7519	1.41274	1150	0.13142	0.000	0.00000
			Methylcyclohexane (1) + *p*-Xylene (2)			
0.0000	0.8435	1.48444	1248	0.09574	0.000	0.00000
0.0506	0.8384	1.48121	1242	0.09761	0.047	0.00006
0.1051	0.8329	1.47710	1234	0.09966	0.103	0.00016
0.2040	0.8231	1.46914	1221	0.10342	0.177	0.00040
0.3096	0.8126	1.46083	1209	0.10741	0.281	0.00062
0.4064	0.8034	1.45361	1198	0.11103	0.330	0.00079
0.5061	0.7940	1.44635	1188	0.11478	0.367	0.00098
0.6050	0.7851	1.43928	1179	0.11835	0.361	0.00102

Table 3. Continued

x_1	ρ / g·cm^{-3}	n_D	u / m·s^{-1}	$K_{S,m}$ / m^3·TPa^{-1}·mol^{-1}	V^E / cm^3·mol^{-1}	$K_{S,m}^E$ / m^3·TPa^{-1}·mol^{-1}
			Cyclohexane (1) + *m*-Xylene (2)			
0.7057	0.7762	1.43227	1170	0.12190	0.332	0.00098
0.8112	0.7672	1.42509	1162	0.12548	0.243	0.00080
0.9095	0.7590	1.41853	1155	0.12873	0.154	0.00054
0.9599	0.7550	1.41538	1152	0.13023	0.071	0.00024
1.0000	0.7519	1.41274	1150	0.13142	0.000	0.00000
			Methylcyclohexane (1) + Mesitylene (2)			
0.0000	0.8488	1.489230	1277	0.10237	0.000	0.00000
0.0524	0.8438	1.485471	1269	0.10377	0.045	−0.00012
0.1075	0.8385	1.481439	1262	0.10530	0.096	−0.00019
0.2051	0.8291	1.474180	1248	0.10805	0.181	−0.00027
0.3140	0.8185	1.466000	1233	0.11119	0.249	−0.00030
0.4067	0.8095	1.458921	1221	0.11391	0.295	−0.00028
0.5093	0.7995	1.451033	1207	0.11693	0.321	−0.00023
0.6083	0.7898	1.443354	1195	0.11988	0.326	−0.00015
0.7071	0.7801	1.435583	1183	0.12287	0.308	−0.00004
0.8106	0.7701	1.427524	1171	0.12597	0.243	0.00005
0.9093	0.7604	1.419829	1159	0.12891	0.164	0.00012
0.9596	0.7557	1.415882	1154	0.13032	0.081	0.00007
1.0000	0.7519	1.412735	1150	0.13142	0.000	0.00000
			Cyclooctane (1) + *o*-Xylene (2)			
0.0000	0.8629	1.49466	1289	0.08576	0.000	0.00000
0.0508	0.8597	1.49181	1289	0.08671	0.104	0.00048
0.0905	0.8573	1.48933	1289	0.08739	0.173	0.00078
0.1697	0.8527	1.48503	1289	0.08868	0.297	0.00133
0.2967	0.8459	1.47816	1291	0.09052	0.454	0.00197
0.3824	0.8416	1.47392	1293	0.09160	0.521	0.00226
0.4839	0.8369	1.46911	1296	0.09272	0.563	0.00242
0.5878	0.8324	1.46435	1300	0.09367	0.580	0.00240
0.6869	0.8286	1.46018	1305	0.09439	0.522	0.00218
0.7892	0.8251	1.45617	1310	0.09490	0.416	0.00173
0.8891	0.8220	1.45244	1317	0.09516	0.255	0.00105
0.9368	0.8207	1.45072	1321	0.09519	0.152	0.00064
1.0000	0.8192	1.44877	1326	0.09515	0.000	0.00000
			Cyclooctane (1) + *m*-Xylene (2)			
0.0000	0.8469	1.48653	1259	0.09336	0.000	0.00000
0.0506	0.8447	1.48423	1260	0.09394	0.101	0.00048
0.0888	0.8431	1.48242	1262	0.09430	0.167	0.00078
0.1861	0.8393	1.47779	1265	0.09513	0.314	0.00143
0.2924	0.8354	1.47308	1270	0.09585	0.448	0.00197
0.3795	0.8324	1.46944	1275	0.09626	0.524	0.00222
0.4870	0.8291	1.46522	1282	0.09660	0.580	0.00237
0.5832	0.8264	1.46159	1289	0.09672	0.590	0.00231
0.6823	0.8240	1.45808	1296	0.09664	0.551	0.00206
0.7874	0.8219	1.45469	1305	0.09639	0.448	0.00162
0.8879	0.8203	1.45169	1315	0.09591	0.279	0.00096
0.9389	0.8197	1.45047	1320	0.09559	0.162	0.00055
1.0000	0.8192	1.44877	1326	0.09515	0.000	0.00000
0.0000	0.8469	1.48653	1259	0.09336	0.000	0.00000
			Cyclooctane (1) + *p*-Xylene (2)			
0.0000	0.8435	1.48444	1248	0.09574	0.000	0.00000
0.0485	0.8416	1.48247	1250	0.09618	0.086	0.00046
0.0874	0.8402	1.48077	1252	0.09648	0.152	0.00079
0.1848	0.8367	1.47651	1256	0.09711	0.300	0.00147
0.2948	0.8332	1.47200	1262	0.09759	0.422	0.00201
0.3853	0.8304	1.46825	1268	0.09791	0.507	0.00238
0.4829	0.8277	1.46454	1274	0.09802	0.558	0.00254
0.5809	0.8253	1.46094	1282	0.09796	0.571	0.00253
0.6837	0.8231	1.45755	1291	0.09765	0.537	0.00228
0.7877	0.8213	1.45432	1301	0.09715	0.441	0.00184
0.8888	0.8200	1.45148	1312	0.09635	0.283	0.00109
0.9413	0.8195	1.45010	1318	0.09593	0.164	0.00070
1.0000	0.8192	1.44877	1325	0.09520	0.000	0.00000
			Cyclooctane (1) + Mesitylene (2)			
0.0000	0.8488	1.48923	1277	0.10237	0.000	0.00000
0.0517	0.8466	1.48694	1277	0.10243	0.110	0.00044
0.0872	0.8452	1.48532	1278	0.10243	0.181	0.00069
0.1842	0.8413	1.48082	1280	0.10234	0.358	0.00130
0.2935	0.8372	1.47590	1283	0.10208	0.519	0.00181
0.3891	0.8338	1.47166	1287	0.10169	0.624	0.00211
0.4882	0.8304	1.46743	1291	0.10112	0.699	0.00226
0.5857	0.8275	1.46340	1296	0.10038	0.706	0.00221
0.6847	0.8246	1.45952	1302	0.09945	0.683	0.00199
0.7910	0.8221	1.45559	1309	0.09826	0.566	0.00156
0.8911	0.8203	1.45214	1317	0.09690	0.364	0.00092
0.9390	0.8197	1.45053	1321	0.09617	0.225	0.00053
1.0000	0.8192	1.44877	1325	0.09520	0.000	0.00000

Table 4. Fitting Parameters and Root-Mean-Square Deviations (σ) for Binary Mixtures at 298.15 K

	B_0	B_1	B_2	B_3	σ
Cyclopentane (1) + *o*-Xylene (2)					
V^E/cm^3·mol^{-1}	−0.002	0.458	0.523	0.770	0.005
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	−0.00174	−0.00167			0.00004
Cyclopentane (1) + *m*-Xylene (2)					
V^E/cm^3·mol^{-1}	0.412	0.303	0.477	0.410	0.002
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00119	0.00203			0.00006
Cyclopentane (1) + *p*-Xylene (2)					
V^E/cm^3·mol^{-1}	0.079	0.902	0.474	−0.163	0.008
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00020	0.00241			0.00004
Cyclopentane (1) + Mesitylene (2)					
V^E/cm^3·mol^{-1}	1.615	0.481	−0.230	−0.482	0.010
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00283	0.00285			0.00007
Cyclohexane (1) + *o*-Xylene (2)					
V^E/cm^3·mol^{-1}	2.229	0.634	−0.308	0.341	0.010
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00826	0.00445			0.00004
Cyclohexane (1) + *m*-Xylene (2)					
V^E/cm^3·mol^{-1}	2.561	0.705	0.125	0.705	0.006
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.01023	0.00469			0.00007
Cyclohexane (1) + *p*-Xylene (2)					
V^E/cm^3·mol^{-1}	2.393	1.123	0.168		0.009
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.01049	0.00498			0.00007
Cyclohexane (1) + Mesitylene (2)					
V^E/cm^3·mol^{-1}	3.255	0.997	1.426	1.927	0.012
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.01129	0.00921	0.00816		0.00021
Methylcyclohexane (1) + *o*-Xylene (2)					
V^E/cm^3·mol^{-1}	1.226	0.530	−0.059		0.010
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00015	0.00240			0.00004
Methylcyclohexane (1) + *m*-Xylene (2)					
V^E/cm^3·mol^{-1}	1.360	0.365	0.020		0.005
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00261	0.00188			0.00002
Methylcyclohexane (1) + *p*-Xylene (2)					
V^E/cm^3·mol^{-1}	1.452	0.257	0.119	0.385	0.011
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00380	0.00221			0.00004
Methylcyclohexane (1) + Mesitylene (2)					
V^E/cm^3·mol^{-1}	1.570	0.526	0.215	0.281	0.005
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00083	0.00175			0.00004
Cyclooctane (1) + *o*-Xylene (2)					
V^E/cm^3·mol^{-1}	2.697	0.058	0.634	−0.208	0.006
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00942	−0.00057	0.00266		0.00004
Cyclooctane (1) + *m*-Xylene (2)					
V^E/cm^3·mol^{-1}	2.422	0.633	0.311		0.006
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00855	0.00046			0.00002
Cyclooctane (1) + *p*-Xylene (2)					
V^E/cm^3·mol^{-1}	2.393	0.578	0.523	0.267	0.009
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00890	0.00070			0.00003
Cyclooctane (1) + Mesitylene (2)					
V^E/cm^3·mol^{-1}	2.931	1.028	0.611	0.094	0.005
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00849	0.00120			0.00002

Table 5. Fitting Parameters and Root-Mean-Square Deviations (σ) for Binary Mixtures at 313.15 K

	B_0	B_1	B_2	B_3	σ
Cyclopentane (1) + *o*-Xylene (2)					
V^E/cm^3·mol^{-1}	−0.225	0.092	0.070		0.002
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	−0.00456	−0.00011	−0.00037		0.00002
Cyclopentane (1) + *m*-Xylene (2)					
V^E/cm^3·mol^{-1}	0.261	0.395	−0.011		0.003
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	−0.00063	0.00132	0.00047	0.00121	0.00001
Cyclopentane (1) + *p*-Xylene (2)					
V^E/cm^3·mol^{-1}	0.055	0.653	0.264	0.860	0.004
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	−0.00075	0.00314	0.00229	0.00290	0.00002
Cyclopentane (1) + Mesitylene (2)					
V^E/cm^3·mol^{-1}	1.061	0.953	0.495		0.006
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00154	0.00334	0.00329	0.00335	0.00002
Cyclohexane (1) + *o*-Xylene (2)					
V^E/cm^3·mol^{-1}	2.327	0.822	−0.006		0.005
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00807	0.00540	0.00181		0.00003
Cyclohexane (1) + *m*-Xylene (2)					
V^E/cm^3·mol^{-1}	2.579	0.822	0.280		0.008
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.01031	0.00498	0.00234		0.00004
Cyclohexane (1) + *p*-Xylene (2)					
V^E/cm^3·mol^{-1}	2.362	0.929	−0.050		0.007
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.01060	0.00553	0.00135		0.00004
Cyclohexane (1) + Mesitylene (2)					
V^E/cm^3·mol^{-1}	3.179	1.554	0.420		0.008
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.01064	0.00697	0.00286		0.00003
Methylcyclohexane (1) + *o*-Xylene (2)					
V^E/cm^3·mol^{-1}	1.186	0.391	0.060		0.002
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	−0.00107	0.00261	0.00071		0.00001
Methylcyclohexane (1) + *m*-Xylene (2)					
V^E/cm^3·mol^{-1}	1.378	0.389	−0.002		0.009
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00212	0.00234	0.00034		0.00003
Methylcyclohexane (1) + *p*-Xylene (2)					
V^E/cm^3·mol^{-1}	1.446	0.410	−0.111		0.007
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00379	0.00246	0.00014		0.00002
Methylcyclohexane (1) + Mesitylene (2)					
V^E/cm^3·mol^{-1}	1.276	0.450	0.236		0.007
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	−0.00095	0.00118	0.00081	0.00141	0.00001
Cyclooctane (1) + *o*-Xylene (2)					
V^E/cm^3·mol^{-1}	2.292	0.325	0.082		0.004
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00971	0.00080	0.00065		0.00001
Cyclooctane (1) + *m*-Xylene (2)					
V^E/cm^3·mol^{-1}	2.337	0.489	0.157		0.002
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00947	0.00008	0.00031		0.00001
Cyclooctane (1) + *p*-Xylene (2)					
V^E/cm^3·mol^{-1}	2.230	0.579	0.271		0.003
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.01016	0.00105	0.00068		0.00002
Cyclooctane (1) + Mesitylene (2)					
V^E/cm^3·mol^{-1}	2.790	0.881	0.383		0.004
$K^E_{S,m}$/m^3·TPa^{-1}·mol^{-1}	0.00902	0.00057	0.00007		0.00001

the pure component *i*. The values of $\alpha^*_{p,i}$ and $C^*_{p,i}$ are obtained from the literature,[10] and these values are shown in Table 1 at $T = 298.15$ K.

The excess and deviation properties at the studied temperatures were fitted to a Redlich−Kister[16] type equation

$$\Delta Q_{12} = x_1 x_2 \sum_{p=0}^{m} B_p (x_1 - x_2)^p \qquad (6)$$

where ΔQ_{12} is the excess property; x_1 and x_2 are the mole fraction of component 1 and 2, respectively; B_p is the fitting parameter; and m is the degree of the polynomic expansion, which was optimized using the F-test.[17] The fitting parameters are given in Tables 4 and 5 together with the root-mean-square deviations, σ, given by

$$\sigma = \{ \sum_{i}^{n_{dat}} (z_{exptl} - z_{calcd})^2 / n_{dat} \}^{1/2} \qquad (7)$$

where z_{exptl}, z_{calcd}, and n_{dat} are the values of the experimental and calculated property and the number of experimental data, respectively.

Figures 1 and 2 show the fitted curves of the excess molar volume of the studied binary systems containing cycloalkanes (1) with aromatic compounds (2) at $T = (298.15$ and $313.15)$ K, respectively. Figure 4 shows the fitted curves of the excess molar isentropic compressibility of the studied binary systems at $T = 313.15$ K.

Figures 1 and 2 show the excess molar volume for cyclopentane (1), cyclohexane (1), and cyclooctane (1) with *o*-xylene (2), *p*-xylene (2), *m*-xylene (2), and mesitylene (2) at $T = (298.15$ and $313.15)$ K, respectively. All binary systems containing cyclohexane, methylcyclohexane, and cyclooctane

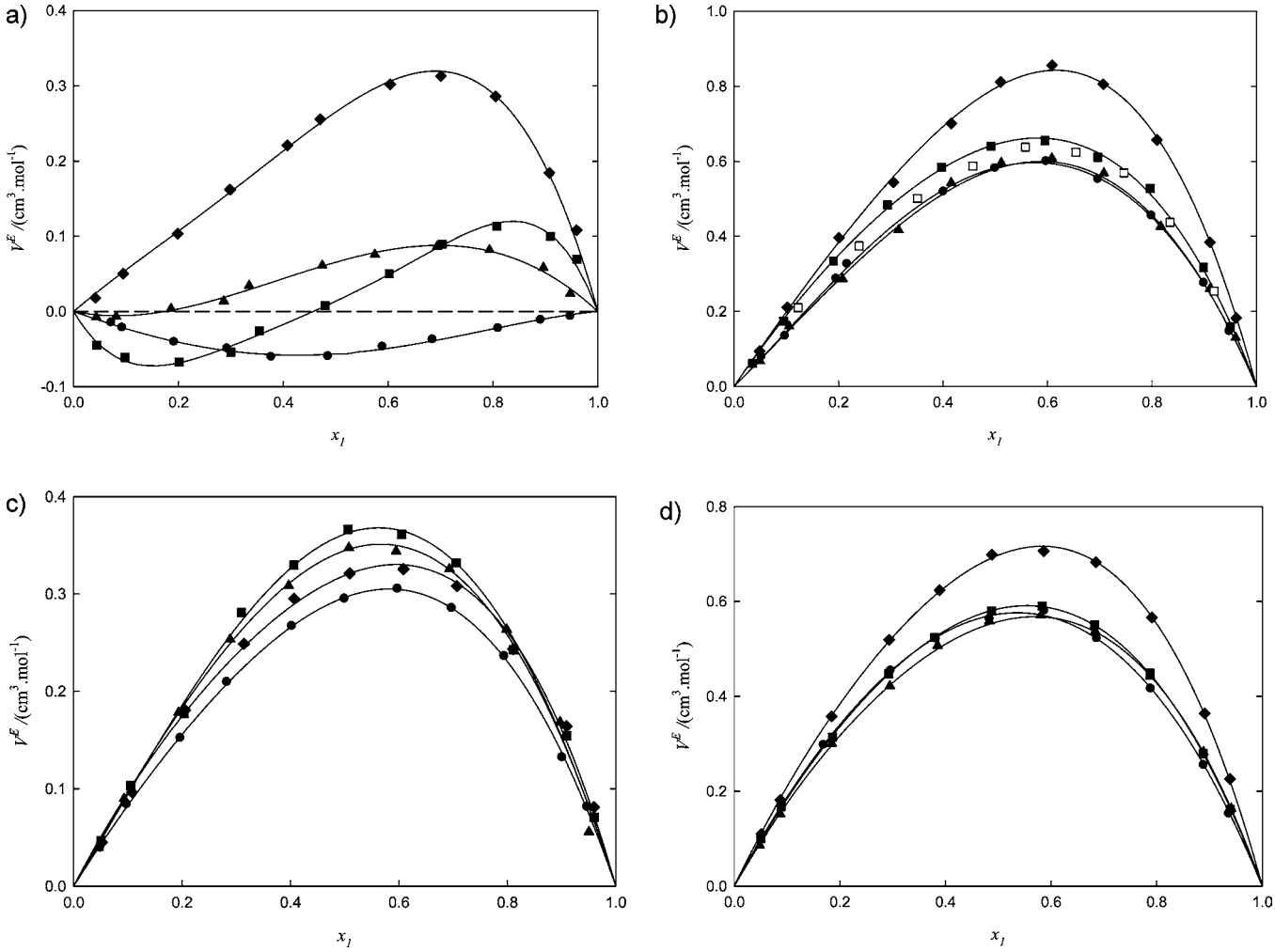

Figure 2. Excess molar volumes, V^E, from the Redlich−Kister equation plotted against mole fraction for the binary mixtures at $T = 313.15$ K: cycloalkane (1) + aromatic (2); for (a) cyclopentane, (b) cyclohexane, (c) methylcyclohexane, and (d) cyclooctane. Closed symbols correspond to experimental data: ●, *o*-xylene; ▲, *m*-xylene; ■, *p*-xylene; and ◆, mesitylene. Open symbols correspond to literature data.[3]

present a similar behavior for this physical property, presenting a maximum between $x_1 = 0.5$ and $x_1 = 0.6$. For the systems with cyclopentane, it is possible to observe a sigmoid behavior for the systems with *m*-xylene (Figure 2a), *o*-xylene (Figure 1a), and *p*-xylene (Figure 1a and 2a), a maximum between $x_1 = 0.6$ and $x_1 = 0.7$ for the system cyclopentane (1) + mesytilene (2), and a minimum of about $x_1 = 0.5$ for the binary system with *o*-xylene (Figue 2a). For comparison purposes, the experimental data from Yang et al.,[3] Baragi et al.,[5] and Diaz et al.[6] are also presented in Figure 1b and 2b and Figure 1c. The variation of equimolar excess molar volume with the number of carbon atoms for the studied binary mixtures is shown in Figure 3.

In general, the higher molecular packing is obtained in the binary mixtures of the cyclopentane with xylenes, a slight increase of the excess molar volume being observed in the order *o*-xylene < *m*-xylene < *p*-xylene, due to, probably, a slight increase of the forces of London's dispersion and to a more complex molecular adjustment. Nevertheless, the worst molecular packing of the mixtures with cyclopentane was obtained with mesytilene. Probably, this is due to the presence of the third group methyl in the benzene ring which generates a higher molecular symmetry and a higher decrease of the molecular packing.

The cycloalkanes, cyclohexane and cyclooctane, show a similar molecular packing with the aromatic compounds,

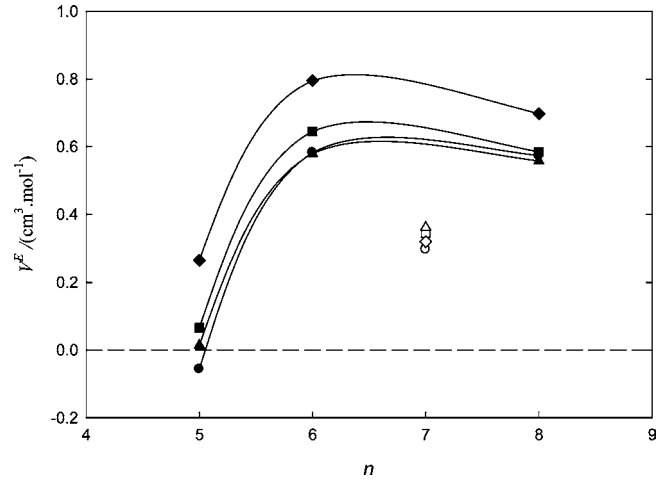

Figure 3. Variation of equimolar excess volumes, V^E, for the binary mixtures cycloalkane (1) + aromatic (2) from the number of carbon atoms, *n*, in cycloalkane compounds: ●, *o*-xylene; ▲, *m*-xylene; ■, *p*-xylene; and ◆, mesitylene. The open symbol is methylcyclohexane (1) + aromatic compound (2) at $T = 313.15$ K.

observing in both cases a slight increase of the excess molar volume for the mixtures cycloalkane (1) + mesitylene (2). We speculate that the increase from six to eight atoms of carbon in the molecule of the cycloalkane does not play a significant role in a higher or lesser molecular packing.

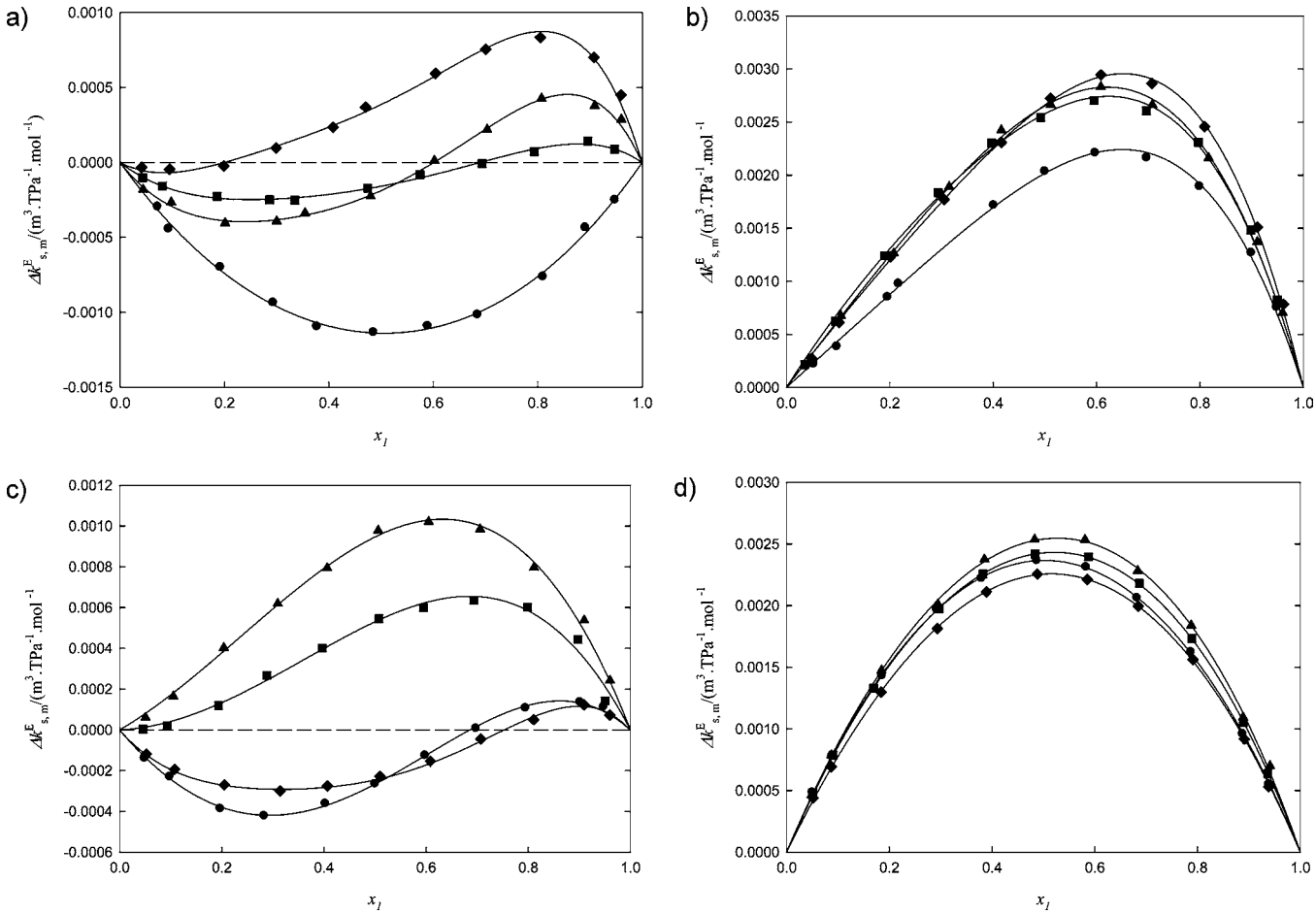

Figure 4. Excess molar isentropic compressibility, $\Delta k^E_{s,m}$, from the Redlich−Kister equation plotted against mole fraction for the binary mixtures: cycloalkane (1) + aromatic (2) at $T = 313.15$ K; for (a) cyclopentane, (b) cyclohexane, (c) methylcyclohexane, and (d) cyclooctane. Closed symbols correspond to experimental data: ●, *o*-xylene; ▲, *m*-xylene; ■, *p*-xylene; and ◆, mesitylene.

When the studied binary systems contain methylcyclohexane, it is possible to observe that these mixtures present a higher packing and therefore a lower excess molar volume than the mixtures with cyclohexane and cyclooctane. Possibly, it is due to the presence of the methyl group in the ring of the cycloalkane, which can motive a slight increase of the attractive intermolecular forces between the cycloalkane and the aromatic compounds. It is also important to comment that, for equimolar values of the binary systems mesytilene + methylcyclohexane, the excess molar volume is lower than with the xylenes, possibly, due to a higher intermolecular attraction.

The excess molar isentropic compressibility is plotted in Figure 4 over the entire composition range at $T = 313.15$ K. All studied systems present behavior very close to ideality.

Conclusions

Densities, speeds of sound, and refractive indices of 16 binary systems containing cycloalkanes with aromatics (cyclopentane (1), or cyclohexane (1), or methylcyclohexane (1) or cyclooctane (1) + *o*-xylene (2), + *m*-xylene (2), + *p*-xylene (2), + mesitylene (2)) at $T =$ (298.15 and 313.15) K under atmospheric pressure over the whole composition range are presented in this article.

The excess properties (excess molar volumes and excess molar isentropic compressibilities) have been determined from experimental data for all binary systems, and these data have been fitted to the Redlich−Kister equation to test the quality of the experimental values. Very good results were obtained.

All the studied systems present values of excess molar isentropic compressibility very close to zero for both studied temperatures.

From the experimental data obtained in this article, it is possibly observed that the temperature has scarce influence in the studied excesses. Similar results were obtained in previous papers.[18,19]

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