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Acoustical Parameter Studies of Binay Organic Solvent Mixtures by Ultrasonic Measurements at 303.15K Temperature

P E S Bhaskar and K Lokeswara Rao
Dept. of Physics
Ramachandra College of Engineering
Eluru, Andhra Pradesh, India.

N Satish
Dept. of Physics
RGUKT
Srikakulam, India

Z Spandana
Dept. of Physics
Krishna University
Machilipatnam

G Lalitha Devi
Dept. of Physics
Sir CRR College (A)
Eluru, India

S V Ranganayakulu
Dean R & D, Guru Nanak Institutions
Technical Campus
Hyderabad, India

Abstract— **In this paper, the ultrasonic velocity, density and viscosity of *"Cinnamaldehyde with Methanol andAcetone"* are measured at 303.15K. Acoustical parameterssuch as adiabatic compressibility*(β_s)*, inter-molecular free length *(L_f)*, molar volume*(V)*, Rao's constant*(R)*, Wada's constant*(W)*, acoustic impedance*(Z)*, Vander wall's constant*(b)* and Lennard jones potential*(n)* determined from these. The study on thermodynamic parameters paves the path for understanding the molecular interaction in binary mixture system. The ultrasonic measurements,thermodynamical parameters & acoustic parameters give the information for understanding the behavior of the binary liquid systems.**

Keywords- Ultrasonic measurements, thermodynamical parameters, acoustical parameters

I. INTRODUCTION

Evaluation of sound velocitiesin binary liquid mixtures at different concentrations based on theoretical molecular models has been the interest of many works. A comparison of the data with experimentally determined values has been found to yield information regarding the nature of the molecular interactions.

The thermodynamic functionsof binary liquid mixtures [1], [2] provide inside into the structure breaking and making effect of the component liquids. Although several studies have been made of the thermodynamic parameters in binary liquid mixtures in with Cinnamaldehyde as a common component, the adiabatic compressibility of *Cinnamaldehyde with Methanol, Acetone* have been studied. Computations of the adiabatic compressibility of the mixture can lead a better understanding of the type of interactions.

Several workers have been carried out thermodynamic parameters of binary mixtures to study the molecular interactions [3], [4] of binary systems.

Ultrasonic studies are being extensively used in recent years for understanding in molecular interactions in pure liquids and liquid mixtures. Among the most characterizing intensive Physicochemical properties of the solvent system, *density(ρ)* and *viscosity(η)* also represent, some of the common thermodynamic parameters that are in general useful in order to study and interpret the medium effects that takes place in solution. From the knowledge of Ultrasonic velocity *(u)*, density *(ρ)* and viscosity *(η)* of a liquid, various Acoustic parameters such as Adiabatic Compressibility *(β_s)*, Intermolecular Free Length *(L_f)*, Relaxation time *(τ)* can be easily evaluated [5], [6]. Addition of another liquid changes the values of parameters, because the resulting liquid behave as a mixture, a solution (or) a new substance depending upon the nature of the component. Ultrasonic velocity *(u)* and Adiabatic Compressibility *(β_s)* which can be obtained with a great degree of accuracy.

II. SAMPLE PREPARATION AND EXPERIMENTAL TECHNIQUES

The chemicals used in the present study are AR grade, and were obtained from Sd fine chemicals Ltd., Bombay, India and Qualigens chemicals, India. The liquids are thoroughly

distilled to remove dissolved impurities suing standard chemical procedures. The purity of the samples was checked by the density measurements. By taking two liquids in separate burettes, job's method of continuous variations has been used to prepare the mixtures of required proportions. The mixture of Cinnamaldehyde, methanol and acetone are preserved in well stoppered bottles. After mixing the liquids thoroughly the bottles are left undisturbed to allow attaining thermal equilibrium.

An Ultrasonic interferometer is a simple and direct device to determine the ultrasonic velocity of liquids with a high degree of accuracy. A variable path single crystal interferometer has been employed for the study of ultrasonic velocity(u). The density of pure liquid and liquid mixtures are measured by employing a specific gravity bottle. The volume of bottle is standardized using double distilled water at 303.15K, 308.15K, 318.15K temperatures.

A. The chemicals used for the present study are:

1. Cinnamaldehyde

   Chemical formula: $C_6H_5CH{=}CHCHO$

   Molecular weight: 132.16

   Refractive index: 1.6221 at 20°C

   Density: 1.048 gm/cc at 20°C

2. Methanol

   Chemical formula: CH_3OH

   Molecular weight: 33.03

   Refractive index: 1.3290 at 20°C

   Density: 0.7920 gm/cc at 20°C

3. Acetone

   Chemical formula: CH_3COCH_3

   Molecular weight: 59.07

   Refractive index: 1.359 at 20°C

   Density: 0.7880 gm/cc at 20°C

B. A number of acoustic parametersbased on ultrasonic velocity have been calculated using the theorical relations

1. Adiabatic compressibility $\beta_s = \frac{1}{u^2\rho}$
2. Inter molecular free length $L_f = \frac{2\times10^{-8}}{\sqrt{\rho u}}$
3. Molar volume $V = \frac{M_{eff}}{\rho}$
4. Rao's constant $R = V \times u^{\frac{1}{3}}$
5. Wada's constant $W = \frac{V}{\beta_s^{\frac{-1}{7}}}$
6. Acoustic impedance $Z = u \times \rho$
7. Vander Wall's constant $b = \left(\frac{M}{\rho}\right)\left[1 - \left(\frac{RT}{Mu^2}\right)\left\{1 + \frac{Mu^2}{3RT}\right\}^{\frac{1}{2}} - 1\right]$
8. Lennard Jones potential $n = \left[\frac{6V}{V_a} - 13\right]$

III. RESULTS AND DISCUSSION

The experimental data of ultrasonic velocity (u), density (ρ) and calculated values of compressibility (β_s), molar sound velocity (R), molar compressibility (w), acoustic impedance (Z), intermolecular free length (L_f), Vander wall's constant (b) and Lenard Jones potential exponent (n) of binary mixtures of Methanol, Acetone with Cinnamaldehyde are reported in Table I and II.

Ultrasonic velocity (u) of all these systems [7], [8] shows a linearity variation (Fig 1a and 2a) with mole fraction of Cinnamaldehyde. This linearity has been described to the existence of molecular association of Cinnamaldehyde with Methanol and Acetone.

Density (ρ) of the binary mixtures [9], [10] of Cinnamaldehyde with Methanol and Acetone shows linearity behaviour as shown in (Fig. 1(b) and 2(b)). Variation of Vander walls constant (b) of binary mixtures [11], [12] shows a linearity as shown in Fig.1(c) and 2(c).

Acoustical parameters such as Vander wall's constant (Fig 1(c) and 2(c)) and Rao's constant (Fig.1(d) and 2(d)) shows linearity behaviour [13], [14], which indicates no complex formation in the mixture.

Variation of acoustical impedance (Z) indicates linearity [15] and increasing trend [16] as shown in Fig.1(e) and 2(e) and Adiabatic compressibility (β_s) values are in decreasing trend as shown in Fig.1(f) and 2(f). Acoustical impedance (Z) and adiabatic compressibility (β_s) relationship [17], [18] are valid in the present investigation studies.

TABLE I. **ACOUSTICAL PARAMETERS OF BINARY LIQUID MIXTURES OF METHANOL AND CINNAMALDEHYDE SYSTEM AT 303.15K TEMPERATURE**

Mole fraction of Cinnamaldehyde	Ultrasonic Velocity (u) m/s	Density (ρ) x 10^{-3} Kg/m^3	Vander wall's Constant (b) x 10^6 m^3/mol	Rao's Constant (R) x 10^{-3} [m^3/mol]/ [N/m2]$^{1/7}$	Wada's Constant (W) [m^3/mol]/ [N/m2]$^{1/7}$	Inter molecular free length (L_f) ^{0}A	Acoustic impedance (Z) x 10^{-3} [Kg/m^3] [m/s]	Lennard Jones Potential (n)	Adiabatic compressibility (β_s) x 10^{-12} m^2/N
0.0	1101.15	0.7809	34.19	1966.60	1092.16	0.6423	859.88	6.24	105.61
0.1	1123.75	0.8073	43.41	2513.83	1401.34	0.6190	907.15	7.16	98.10
0.2	1151.43	0.8370	51.84	3026.15	1693.71	0.5933	963.74	8.40	90.12
0.3	1172.83	0.8730	59.21	3477.61	1956.66	0.5701	1024.76	9.47	83.20
0.4	1202.53	0.8798	68.29	4044.53	2275.15	0.5541	1057.92	11.15	78.61
0.5	1220.43	0.9035	75.73	4507.32	2543.36	0.5388	1102.65	12.29	74.31
0.6	1246.75	0.9210	83.35	4996.31	2824.15	0.5224	1148.26	14.18	69.85
0.7	1279.20	0.9385	90.69	5482.84	3103.70	0.5043	1200.52	16.92	65.12
0.8	1310.50	0.9660	96.75	5896.31	3347.70	0.4852	1265.94	20.16	60.28
0.9	1351.68	0.9800	103.88	6396.63	3633.88	0.4671	1324.64	25.66	55.85
1.0	1352.40	0.9943	110.79	6889.56	3916.45	0.4502	1384.39	33.24	51.88

Mole fraction of Cinnamaldehyde	Ultrasonic Velocity (u) m/s	Density (ρ) x 10^{-3} Kg/m^3	Vanderwall's Constant (b) x 10^6 m^3/mol	Rao's Constant (R) x 10^{-3} [m^3/mol]/ [N/m2]$^{1/7}$	Wada's Constant (W) [m^3/mol]/ [N/m2]$^{1/7}$	Inter molecular free length (L_f) ^{0}A	Acoustic impedance (Z) x 10^{-3} [Kg/m^3] [m/s]	Lennard Jones Potential (n)	Adiabatic compressibility (β_s) x 10^{-12} m^2/N
0.0	1160.44	0.7846	61.60	3610.56	2001.49	0.6080	910.51	8.84	94.64
0.1	1197.10	0.8023	68.03	4023.11	2233.97	0.5829	960.37	10.83	89.98
0.2	1215.85	0.8403	72.30	4297.89	2400.60	0.5608	1021.62	11.99	80.51
0.3	1233.75	0.8465	79.06	4722.65	2638.81	0.5506	1044.37	13.21	77.61
0.4	1256.25	0.8700	84.02	5049.31	2829.95	0.5334	1092.94	14.93	72.83
0.5	1273.75	0.8848	89.60	5409.36	3037.03	0.5217	1126.95	16.43	69.66
0.6	1297.50	0.9108	93.82	5699.18	3210.19	0.5047	1181.70	18.74	65.22
0.7	1318.75	0.9305	98.47	6013.74	3395.14	0.4913	1227.10	21.13	61.80
0.8	1340.10	0.9705	100.77	6187.44	3511.59	0.4734	1300.57	23.94	57.38
0.9	1362.50	0.9813	105.96	6542.04	3715.75	0.4631	1336.95	27.42	54.90
1.0	1392.40	0.9943	110.79	6889.56	3916.45	0.4502	1384.39	33.24	51.88

TABLE II. **ACOUSTICAL PARAMETERS OF BINARY LIQUID MIXTURES OF ACETONE AND CINNAMALDEHYDE SYSTEM AT 303.15K TEMPERATURE**

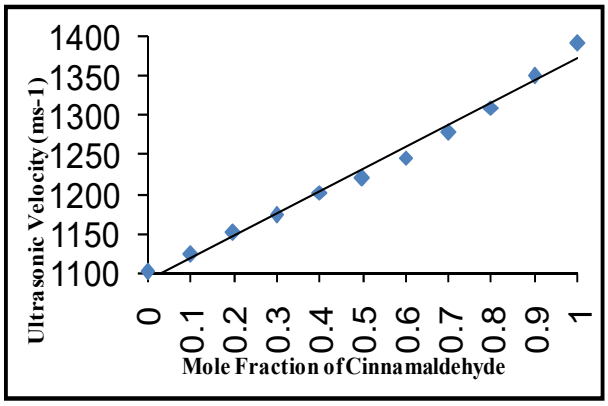

Fig: 1(a) Mole fraction of Cinnamaldehyde Vs UltrasonicVelocity (u) of liquid mixtures of Cinnamaldehyde and Methanol at room temperature of about 303.15K

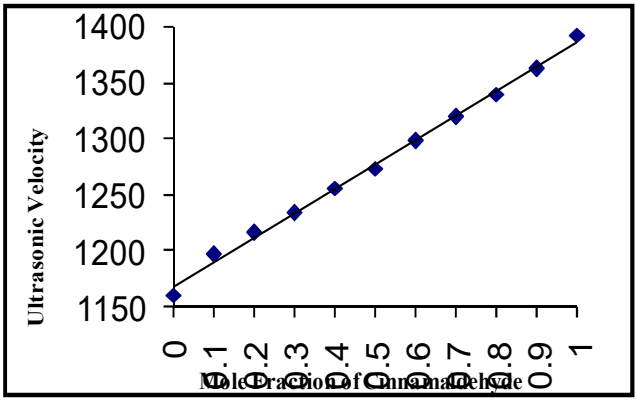

Fig: 2(a) Mole fraction of Cinnamaldehyde Vs Ultrasonic Velocity (u) of liquid mixtures of Cinnamaldehyde and Acetone at room temperature of about 303.15K

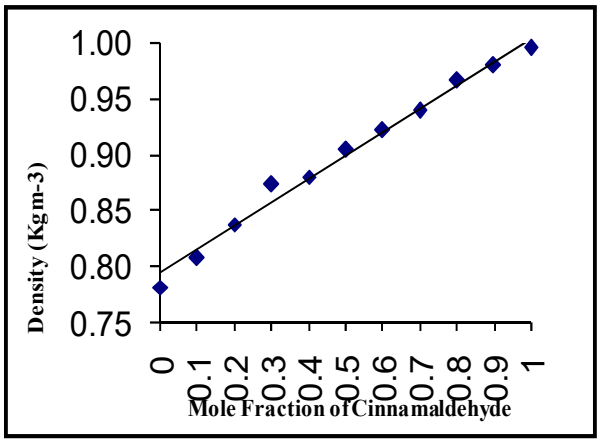

Fig: 1(b) Mole fraction of Cinnamaldehyde Vs Density (ρ) of liquid mixtures of Cinnamaldehyde and Methanol at room temperature of about 303.15K

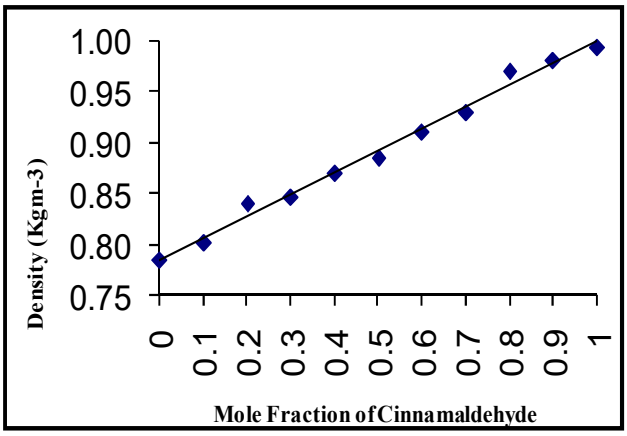

Fig: 2(b) Mole fraction of Cinnamaldehyde Vs Density (ρ) of liquid mixtures of Cinnamaldehyde and Acetone at room temperature of about 303.15K

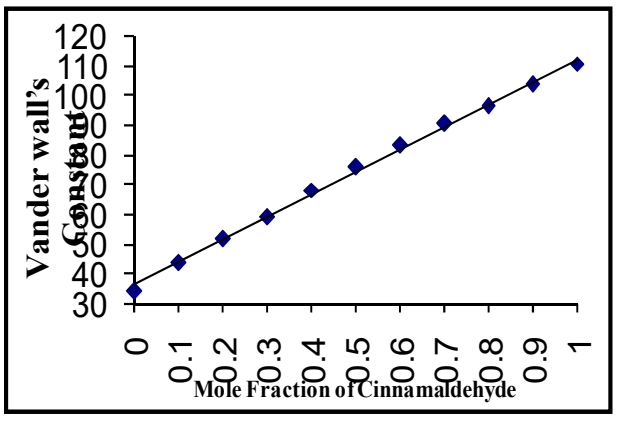

Fig: 1(c) Mole fraction of Cinnamaldehyde Vs and Vander wall's Constant of Binary mixture of Cinnamaldehyde and Methanol at room temperatureof about 303.15K

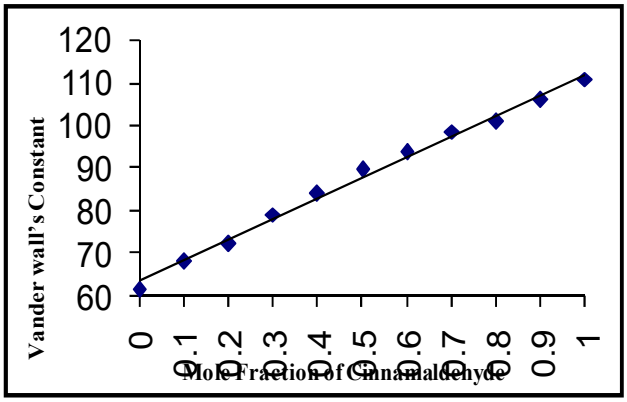

Fig: 2(c) Mole fraction of Cinnamaldehyde Vs and Vander wall's Constant of Binary mixture of Cinnamaldehyde and Acetone at room temperature of about 303.15K

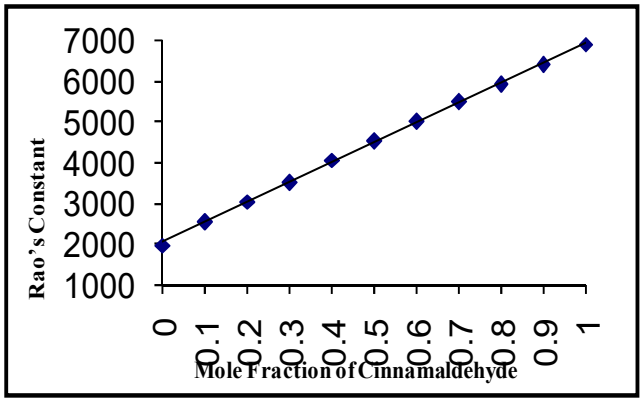

Fig: 1(d) Mole fraction of Cinnamaldehyde Vs and Rao's Constant (R) of Binary mixture of Cinnamaldehyde and Methanol at room temperature of about 303.15K.

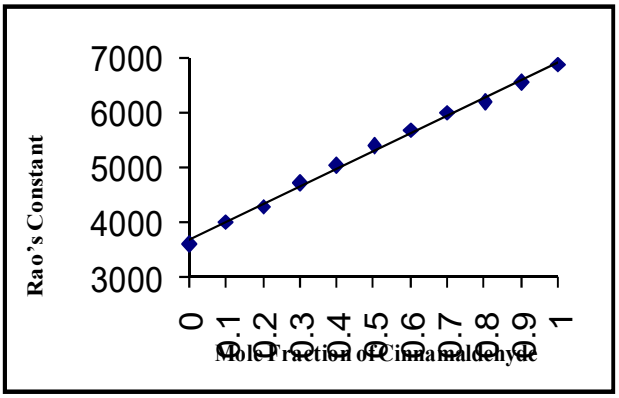

Fig: 2(d) Mole fraction of Cinnamaldehyde Vs and Rao's Constant (R) of Binary mixture of Cinnamaldehyde and Acetone at room temperature of about 303.15

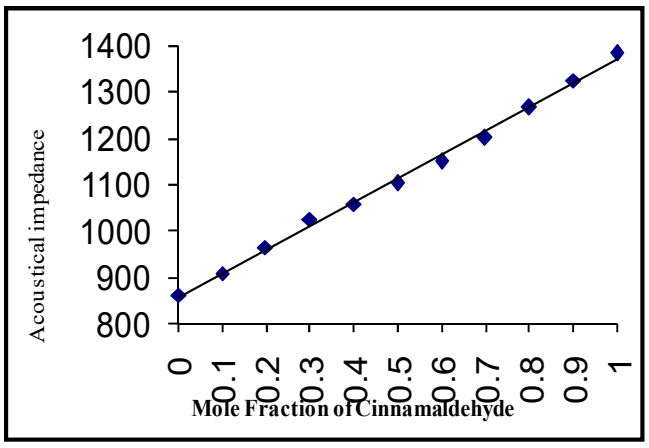

Fig: 1(e) Mole fraction of Cinnamaldehyde Vs and Acoustical impedance (z) of Binary mixture of Cinnamaldehyde and Methanol at room temperature of about 303.15K

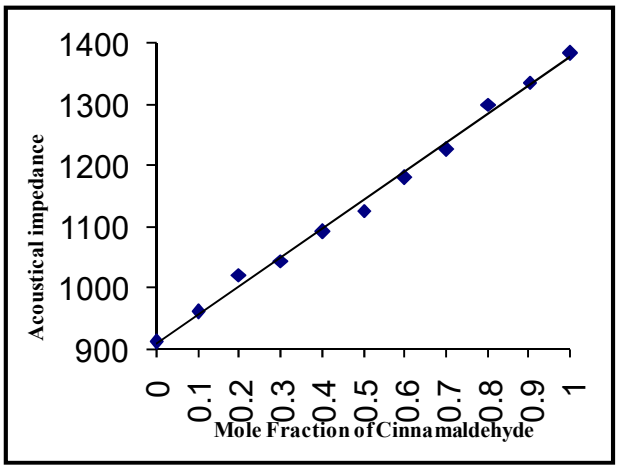

Fig: 2(e) Mole fraction of Cinnamaldehyde Vs and Acoustical impedance (z) of Binary mixture of Cinnamaldehyde and Acetone at room temperature of about 303.15K

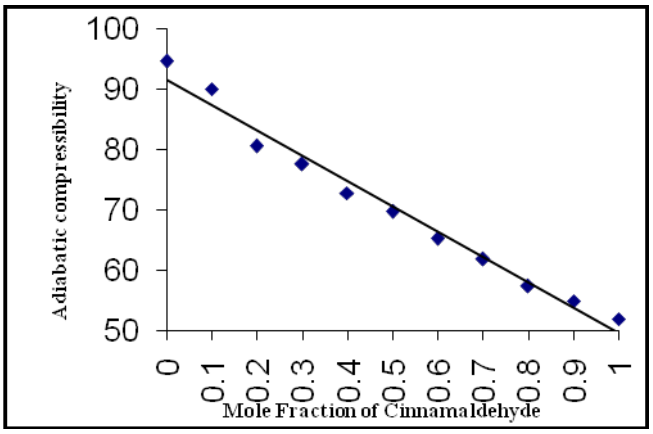

Fig: 1(f) Mole fraction of Cinnamaldehyde Vs and Adiabatic compressibility (β_s) of Binary mixture of Cinnamaldehyde and Methanol at room temperature of about 303.15K

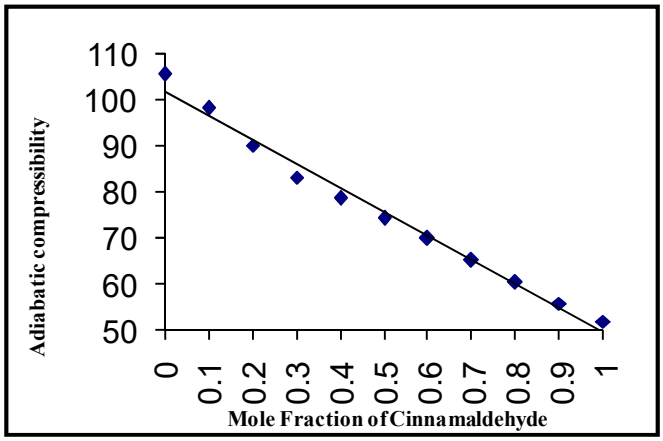

Fig: 2(f) Mole fraction of Cinnamaldehyde Vs and Adiabatic compressibility (β_s) of Binary mixture of Cinnamaldehyde and Acetone at room temperature of about 303.15K

IV. CONCLUSION

The ultrasonic parameters such as compressibility ***(β_s),*** molar sound velocity ***(R),*** molar compressibility ***(w),*** free length ***(L_ρ),*** Vander Wall's constant ***(b)*** and Lennard Jones potential ***(n)*** are calculated for the binary liquid mixtures of cinnamaldehyde with methanol, acetone. It is found that, there is molecular association in all the systems.

V. FURTHER RESEARCH

Excess parameters such as excess ultrasonic velocity ***(u^E),*** excess compressibility ***(β_S^E)*** will also be evaluated as part of further research. In addition to the above studies, Linear free Energy Relationship ***(LFER)*** will also be applied and extent of validity of ultrasonic parameters will be tested.

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