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Dielectric constant measurement for 30 liquids and three binary liquid mixtures

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ABSTRACT

The dielectric constant measurement for 30 liquids and three binary liquid mixtures at room temperatures using microcontroller based system. The liquids include polar, non-polar, alkenes, etc.

KEYWORDS

Dielectric constant;
Three binary liquid mixtures;
Microcontroller based system.

INTRODUCTION

The dielectric constant of a liquid, ε is defined by the ratio of the capacitance between two plates filled with the liquid, C_s to that in vacuum, C_a

$\varepsilon = C_s / C_a$

Therefore the measurement of the dielectric constant is reduced to that of the capacitance.

Dielectric studies have a long and distinguished history, the dielectric data is used to determine the electric dipole moments, which is not only significant as a reflection of electronic structure of the molecule, but is also of prime importance in understanding of molecular interactions and it at least partly controls the transitions between the solid, liquid and gaseous states.

EXPERIMENTAL

Samples

In the present paper analytical reagent grade samples were used after necessary purification and distillation mostly as per procedure cited by Weissberger[1]. The chemicals used were benzene, chlorobenzene, cyclohexanone and nitrobenzene. Benzene was allowed to stand on anhydrous calcium chloride for two days and then filtered. Then the liquid was refluxed with phosphorus pentoxide for six hours and distilled. Spectroscopically pure sodium was drawn in wires in the distillate and redistilled. The liquid was collected at its boiling point 80° C. The densities and the dielectric constants of the pure liquids at 303 K agreed within 0.002 and ± 0.2 with the corresponding literature values.

Apparatus

The guarded one–terminal dielectric cell, cell constant calibration measurement of capacitance and temperature measurement unit has been described. The dielectric cell consists of two circular discs (25 mm diameter) of brass metal, whose faces are well machined and later polished with fine emery. The two conducting plates are positioned parallel to each other at close prox-

imity by two brass leads of about 3 mm diameter which are connected to a thick circular hylam sheet of diameter 50 mm. The length of leads is kept as small as possible (2.5 cm). These leads form interconnections between BNC (SRF – 10 recepticle of 50 ohms impedance) and the two conducting circular plates of the capacitor. It offers a capacitance of 25 pf approximately. The design of dielectric cell for use with solutions is made such that the structure of the cell is rigid so that the variation of its capacitance due to strain is negligible and also it is less fragile. The dielectric constants were determined by microcontroller-based system[2]. The accuracy of the instrument is ± 0.2 %.

RESULTS AND DISCUSSION

The system is used to measure the dielectric constant of 30 liquids (polar, non-polar, alkenes, etc.) and three binary liquid mixtures at 30°C and at different concentrations (mole/l). The results of measurements for these systems are presented in TABLES 1 & 2 respectively. The system is used to measure the dielectric constant of binary liquid mixtures (1) Acetonitrile + heptane (2) Nitrobenzene + cyclohexane (3) Dimethyl sulphoxide + Carbon Tetrachloride at 30°C and at different concentrations (mole/l). The results of measurements for these systems are presented in TABLE 3. And also the results are presented graphically as shown in Figure 1. It is observed that at a given temperature the dielectric constant varies as a function of concentration for all the three binary liquid mixtures.

TABLE 1 : Dielectric constants of pure liquids at 30°C

Sample	Present work	Literature	Reference
Toulene	2.46	2.40	9
Carbon Tetrachloride	2.21	2.20	9
Chlorobenzene	5.96	5.91 5.90	10 9
Chlorobenzine, Liquid	6.2	5.5-6.3	9
Aniline	6.3	7.3-5.5	9
Cyclohexane	2.09	2.0	9
Hexane	1.9	2.0	9
Heptane	1.89	1.9-2.0	9
Cyclopentane	2.02	2.0	9
Anisole	4.98	4.3	9
Benzyl Alcohol	13.02	13.0	9
Butylamine	5.39	5.40	9
Cyclohexylamine	5.29	5-5.3	9
Ethyl Acetate	5.89	6.0	9
Ethylbenzene	2.39	2.39	1
Acetonitrile	35.01	35-37.5	9
Cyclohexanone	17.96	18.2	9
Acetone	20.30	20.35	9
Methanol	32.56	32.6	9
Nitrobenzene	34.89	34.81 34.80	12 11

TABLE 2 : Dielectric constants of pure liquids at 30°C

Sample	Present work	Literature	Reference
P-Dichlorobenzene	2.39	2.41	7
Diethyl carbonate	2.80	2.82	7
Acetic Acid	6.18	6.20	5
Benzyl Chloride	6.98	7.00	5
o-xylene	2.56	2.54	6
m- xylene	2.33	2.34	6
n-hexane	1.88	1.89	2
DMSO	47.05	47.0	3
Chloroform	4.02	3.7-4.8	9
p-Xylene	2.28	2.27	3

TABLE 3 : Dielectric constants of the binary liquid mixtures at 30°C

Mole fraction	Dielectric constant (ε)		
	Acetonitrile + heptane	Nitrobenzene + cyclohexane	Dimethyl sulphoxide + Carbon Tetrachloride
0.0	1.9	2.29	2.21
0.2	2.89	5.99	6.45
0.4	9.19	7.82	15.26
0.6	15.9	8.72	22.58
0.8	24.64	15.71	32.54
1.0	35.09	34.89	47.05

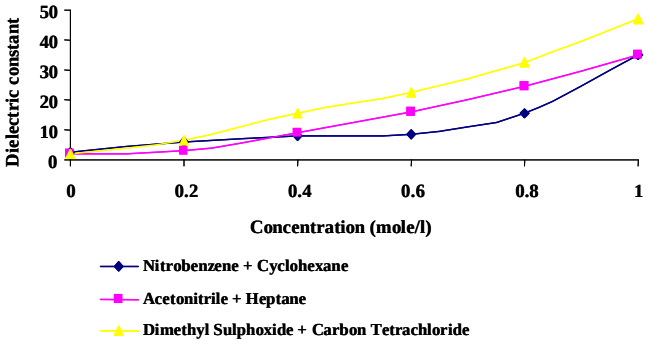

Figure 1 : Dielectric constant for three binary liquid mixtures versus concentration at 30°C.

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