Apparent Molar Volumes And Viscosity B Coefficients Of Chlorothalonil Pesticide In Binary Mixture DMF And DMSO At Different Temperatures.

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Abstract: Apparent molar volumes (ϕ_v) and viscosity B-coefficients for Chlorothalonil in binary mixture DMF and DMSO was measured from density (d) and viscosity (η) at 298.15 to 313.15 K using a bicapillary pycnometer and Ubbelohde viscometer respectively. The density data were analyzed in terms of limiting apparent molar volume (ϕ_v^o) and experimental slopes (S_v) obtained from Masson equation has been used to interpret the ion-solvent interaction and ion-ion interaction respectively. The viscosity data was analyzed in term of A and B coefficient obtained from Jone-Dole equation and the obtained parameters were interpreted in terms of solute–solute and solute–solvent interactions.

Index Terms: Apparent molar, volume, B-coefficient, density, viscosity, Chlorothalonil pesticide.

1 INTRODUCTION

The economy of India is largely dependent on the quality and quantity of agricultural product. Better harvest required pesticides to protect plants from pests and plant diseases. Pesticides are one of the widely used products developed by man in the last century. Chlorothalonil (2, 4, 5, 6-tetrachloroisophthalonitrile), a non-systemic foliar fungicide, is widely applied for the control of a variety of fungal diseases on vegetable, field, and ornamental crops [1]. Chlorothalonil is classified as a probable carcinogen, and the 4-hydroxy of Chlorothalonil transformation product is more soluble, more stable, and, for some species, more toxic than its parent compound [2]. The study of physiochemical properties of Chlorothalonil play vital role in design of new pesticides. The absorption of pest on target site is depends on their solute-solvent interactions. The fate and distribution of agrochemical in soil and water environments were based on sorption-desorption phenomenon, since they determined amount of pesticide reached to target site and the amount that was leached, volatilized, and degraded [3,4]. The rate of pesticide reached to target site depends on physiochemical factors. Physiochemical factor include salt complexation, dissolution rate, solute-solvent interactions, solvation, viscosity and toxicity [5]. However, there is no information available on sorption-desorption of Chlorothalonil pesticides. In this paper, we are reported salvation behavior of Chlorothalonil pesticide in binary mixture of DMF and DMSO at different temperature.

2 EXPERIMENTAL SECTION

The chemicals DMSO and DMF employed were of analytical grade and were purchased from E. Merck, Germany (99.5%), were used as such without further purification. Pesticides Chlorothalonil were purchased from local mark. The densities of the sample solutions were measured by using a bicapillary pycnometer (made of borosil glass) having a bulb capacity of~ 15 ml. The pycnometer was calibrated by determined densities of distilled organic liquids like acetone, alcohol, benzene, carbon tetrachloride, aniline, and nitrobenzene were evaluated with respect to density of water as a standard. The dynamic viscosities were measured using an Ubbelohde suspended-level viscometer, calibrated with water and organic solvents.

3 RESULTS AND DISCUSSION

The values of the densities (d) and apparent molar volumes (ϕ_v) of Chlorothalonil in binary mixture DMF and DMSO at 298.15, 303.15, 308.15 and 310.15K temperature are shown in Table 1 to Table 7.

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TABLE 1 *Concentration (C), Density (d), Viscosity (η), apparent molar Volume (ϕ_v) of Chlorothalonil in DMF*

C (mol/dm^3)	d g.cm^3	η cp	ϕ_v cm^3.mol^{-1}	d g.cm^3	η cp	ϕ_v cm^3.mol^{-1}
Chlorothalonil in DMF						
		298.15 K			**303.15 K**	
0.0150	0.94510	0.8240	205.41	0.94254	0.7827	209.50
0.0231	0.94563	0.8330	207.78	0.94306	0.7906	211.10
0.0329	0.94627	0.8432	209.19	0.94365	0.8013	213.30
0.0445	0.94697	0.8552	211.42	0.94432	0.8128	215.33
0.0577	0.94774	0.8668	213.37	0.94505	0.8232	217.26
0.0727	0.94856	0.8795	215.52	0.94583	0.8378	219.31
0.0894	0.94943	0.8958	217.58	0.94667	0.8539	221.13
0.1079	0.95036	0.9141	219.42	0.94755	0.8733	222.96
0.1281	0.95131	0.9332	221.38	0.94848	0.8925	224.62
0.1500	0.95229	0.9535	223.28	0.94939	0.9101	226.63
		308.15 K			**313.15 K**	
0.0150	0.93625	0.7352	214.46	0.93216	0.7052	218.97
0.0231	0.93674	0.7442	216.21	0.93262	0.7162	220.87
0.0329	0.93731	0.7556	217.98	0.93314	0.7285	223.17
0.0445	0.93795	0.7665	219.89	0.93373	0.7420	225.19
0.0577	0.93866	0.7798	221.49	0.93436	0.7571	227.29
0.0727	0.93939	0.7933	223.71	0.93505	0.7751	229.11
0.0894	0.94021	0.8102	225.24	0.93574	0.7966	231.38
0.1079	0.94102	0.8313	227.32	0.93652	0.8189	232.88
0.1281	0.94183	0.8492	229.55	0.93726	0.8419	234.99
0.1500	0.94268	0.8704	231.49	0.93804	0.8681	236.79

TABLE 2 *Concentration (C), Density (d), Viscosity (η), Apparent molar Volume (ϕ_v) of Chlorothalonil in 10% DMSO*

C (mol/dm^3)	**d g.cm^3**	**η cp**	**ϕ_v cm^3.mol^{-1}**	**d g.cm^3**	**η cp**	**ϕ_v cm^3.mol^{-1}**
Chlorothalonil in 10% DMSO						
		298.15 K			**303.15 K**	
0.0150	0.96144	0.8977	208.14	0.95882	0.8571	211.49
0.0231	0.96192	0.9063	210.55	0.95929	0.8681	213.37
0.0329	0.96249	0.9185	212.26	0.95983	0.8822	215.37
0.0445	0.96315	0.9316	213.66	0.96043	0.8962	217.52
0.0577	0.96384	0.9469	215.68	0.96109	0.9133	219.34
0.0727	0.96453	0.9625	218.42	0.96178	0.9320	221.45
0.0894	0.96531	0.9802	220.27	0.96254	0.9494	223.08
0.1079	0.96615	0.9968	221.84	0.96332	0.9728	224.86
0.1281	0.96702	1.0173	223.45	0.96412	0.9972	226.66
0.1500	0.96787	1.0393	225.36	0.96491	1.0235	228.61
		308.15 K			**313.15 K**	
0.0150	0.95232	0.8012	216.42	0.94821	0.7854	222.27
0.0231	0.95276	0.8125	218.46	0.94861	0.7965	224.43
0.0329	0.95327	0.8245	220.35	0.94908	0.8097	226.10
0.0445	0.95384	0.8379	222.30	0.94959	0.8238	228.23
0.0577	0.95445	0.8552	224.28	0.95015	0.8415	230.00
0.0727	0.95510	0.8725	226.28	0.95074	0.8627	231.89
0.0894	0.95581	0.8917	227.88	0.95135	0.8832	233.81
0.1079	0.95653	0.9145	229.70	0.95201	0.9084	235.37
0.1281	0.95727	0.9397	231.48	0.95265	0.9358	237.24
0.1500	0.95803	0.9668	233.17	0.95329	0.9634	239.09

TABLE 3 *Concentration (C), Density (d), Viscosity (η), Apparent molar Volume (ϕ_v) of Chlorothalonil in 30 % DMSO*

C (mol/dm^3)	**d g.cm^3**	**η cp**	**ϕ_v cm^3.mol^{-1}**	**d g.cm^3**	**η cp**	**ϕ_v cm^3.mol^{-1}**
Chlorothalonil in 30 % DMSO						
		298.15 K			**303.15 K**	
0.0150	0.99496	1.0593	209.81	0.99124	1.0191	215.30
0.0231	0.99539	1.0738	211.26	0.99162	1.0332	217.29
0.0329	0.99587	1.0895	213.34	0.99206	1.0499	219.04
0.0445	0.99641	1.1077	215.25	0.99255	1.0695	220.81
0.0577	0.99697	1.1288	217.45	0.99307	1.0893	222.62
0.0727	0.99758	1.1528	219.33	0.99361	1.1127	224.58
0.0894	0.99823	1.1793	221.02	0.99419	1.1392	226.24
0.1079	0.99889	1.2034	222.82	0.99476	1.1686	228.13
0.1281	0.99953	1.2358	224.84	0.99531	1.2018	230.16
0.1500	1.00019	1.2704	226.65	0.99588	1.2358	231.92

		308.15 K			313.15 K	
0.0150	0.98469	0.9351	221.46	0.98027	0.8270	226.53
0.0231	0.98504	0.9476	223.13	0.98058	0.8406	228.54
0.0329	0.98543	0.9625	225.11	0.98094	0.8571	230.15
0.0445	0.98587	0.9789	226.83	0.98132	0.8745	232.20
0.0577	0.98632	0.9985	228.84	0.98173	0.8957	233.93
0.0727	0.98681	1.0242	230.53	0.98216	0.9157	235.63
0.0894	0.98731	1.0482	232.28	0.98258	0.9392	237.54
0.1079	0.98779	1.0762	234.25	0.98301	0.9719	239.27
0.1281	0.98829	1.1087	235.96	0.98342	0.9984	241.08
0.1500	0.98873	1.1403	237.99	0.98380	1.0354	242.93

TABLE 4 *Concentration ©, Density (d), Viscosity (η), Apparent molar Volume (ϕ_v) of Chlorothalonil in 50 % DMSO*

C (mol/dm^3)	d g.cm^3	η cp	ϕ_v cm^3.mol^{-1}	d g.cm^3	η cp	ϕ_v cm^3.mol^{-1}
			Chlorothalonil in 50 % DMSO			
		298.15 K			303.15 K	
0.0150	1.02731	1.2550	211.62	1.02266	1.1551	215.18
0.0231	1.02766	1.2723	213.44	1.02299	1.1713	216.95
0.0329	1.02806	1.2929	215.18	1.02337	1.1902	218.53
0.0445	1.02851	1.3171	216.76	1.02381	1.2103	219.72
0.0577	1.02898	1.3429	218.50	1.02427	1.2331	221.18
0.0727	1.02949	1.3738	220.03	1.02474	1.2622	222.91
0.0894	1.02998	1.4038	221.98	1.02523	1.2945	224.52
0.1079	1.03051	1.4429	223.54	1.02571	1.3324	226.28
0.1281	1.03102	1.4824	225.25	1.02618	1.3679	228.04
0.1500	1.03152	1.5241	226.94	1.02667	1.4088	229.53
		308.15 K			313.15 K	
0.0150	1.01624	1.0735	226.36	1.01238	1.0332	228.53
0.0231	1.01649	1.0873	228.10	1.01262	1.0494	230.25
0.0329	1.01677	1.1047	229.76	1.01289	1.0691	231.83
0.0445	1.01708	1.1266	231.25	1.01317	1.0925	233.69
0.0577	1.01742	1.1497	232.45	1.01347	1.1193	235.21
0.0727	1.01774	1.1794	234.17	1.01376	1.1447	236.96
0.0894	1.01807	1.2087	235.70	1.01403	1.1751	238.81
0.1079	1.01835	1.2458	237.61	1.01431	1.2129	240.35
0.1281	1.01865	1.2799	239.12	1.01462	1.2482	241.50
0.1500	1.01891	1.3189	240.73	1.01482	1.2959	243.29

TABLE 5 *Concentration (C), Density (d), Viscosity (η), Apparent molar Volume (ϕ_v) of Chlorothalonil in 70 % DMSO*

C (mol/dm^3)	d g.cm^3	η cp	ϕ_v cm^3.mol^{-1}	d g.cm^3	η cp	ϕ_v cm^3.mol^{-1}
			Chlorothalonil in 70 % DMSO			
		298.15 K			303.15 K	
0.0150	1.05431	1.6062	215.03	1.05019	1.4623	219.67
0.0231	1.05459	1.6307	216.58	1.05043	1.4865	221.55
0.0329	1.05490	1.6582	218.30	1.05071	1.5158	222.91
0.0445	1.05525	1.6896	219.71	1.05101	1.5499	224.41
0.0577	1.05560	1.7231	221.43	1.05130	1.5831	226.25
0.0727	1.05596	1.7635	223.11	1.05161	1.6249	227.77
0.0894	1.05633	1.8133	224.65	1.05192	1.6644	229.25
0.1079	1.05665	1.8629	226.58	1.05220	1.7189	230.90
0.1281	1.05703	1.9242	227.83	1.05247	1.7755	232.43
0.1500	1.05736	1.9766	229.32	1.05273	1.8406	233.83
		308.15 K			313.15 K	
0.0150	1.04395	1.3171	227.99	1.04080	1.2543	232.51
0.0231	1.04414	1.3395	229.49	1.04096	1.2771	233.92
0.0329	1.04434	1.3656	231.21	1.04114	1.3028	235.11
0.0445	1.04456	1.3945	232.63	1.04132	1.3342	236.56
0.0577	1.04478	1.4283	234.05	1.04148	1.3674	238.25
0.0727	1.04501	1.4737	235.31	1.04164	1.4091	239.71
0.0894	1.04519	1.5138	237.03	1.04179	1.4576	241.06
0.1079	1.04536	1.5678	238.56	1.04191	1.5032	242.48
0.1281	1.04548	1.6244	240.23	1.04199	1.5529	243.94
0.1500	1.04555	1.6773	241.91	1.04204	1.6071	245.32

TABLE 6 *Concentration (C), Density (d), Viscosity (η), Apparent molar Volume (ϕ_v) of Chlorothalonil in 90 % DMSO*

C (mol/dm^3)	d g.cm^3	η cp	ϕ_v cm^3.mol^{-1}	d g.cm^3	η cp	ϕ_v cm^3.mol^{-1}
Chlorothalonil in 90 % DMSO						
		298.15 K			**303.15 K**	
0.0150	1.08149	1.9101	218.84	1.07786	1.7240	220.19
0.0231	1.08169	1.9386	220.32	1.07825	1.7551	221.83
0.0329	1.08191	1.9723	221.78	1.07827	1.7920	223.09
0.0445	1.08214	2.0127	223.31	1.07849	1.8322	224.68
0.0577	1.08237	2.0561	224.81	1.07871	1.8786	226.21
0.0727	1.08261	2.1047	226.12	1.07893	1.9256	227.65
0.0894	1.08278	2.1590	228.08	1.07909	1.9845	229.57
0.1079	1.08297	2.2302	229.51	1.07926	2.0468	231.05
0.1281	1.08316	2.2985	230.73	1.07938	2.1184	232.67
0.1500	1.08327	2.3684	232.28	1.07944	2.1858	234.37
		308.15 K			**313.15 K**	
0.0150	1.07185	1.5558	230.73	1.06877	1.4759	232.64
0.0231	1.07197	1.5863	231.98	1.06889	1.5038	233.45
0.0329	1.07210	1.6236	233.11	1.06902	1.5405	234.34
0.0445	1.07223	1.6629	234.30	1.06915	1.5758	235.39
0.0577	1.07235	1.7103	235.53	1.06928	1.6189	236.37
0.0727	1.07246	1.7533	236.72	1.06942	1.6723	237.14
0.0894	1.07256	1.8081	237.82	1.06953	1.7319	238.18
0.1079	1.07262	1.8692	239.07	1.06963	1.7926	239.14
0.1281	1.07265	1.9392	240.28	1.06973	1.8579	239.95
0.1500	1.07267	2.0133	241.31	1.06979	1.9353	240.87

TABLE 7 *Concentration (C), Density (d), Viscosity (η), Apparent molar Volume (ϕ_v) of Chlorothalonil in DMSO*

C (mol/dm^3)	d g.cm^3	η cp	ϕ_v cm^3.mol^{-1}	d g.cm^3	η cp	ϕ_v cm^3.mol^{-1}
Chlorothalonil in DMSO						
		298.15 K			**303.15 K**	
0.0150	1.09548	2.0693	221.50	1.09156	1.8703	224.13
0.0231	1.09563	2.1024	223.03	1.09170	1.9024	225.41
0.0329	1.09579	2.1415	224.48	1.09185	1.9396	226.68
0.0445	1.09595	2.1897	225.98	1.09199	1.9847	228.23
0.0577	1.09608	2.2443	227.77	1.09212	2.0369	229.70
0.0727	1.09620	2.3017	229.37	1.09224	2.0936	231.07
0.0894	1.09631	2.3621	230.76	1.09233	2.1593	232.51
0.1079	1.09638	2.4364	232.23	1.09238	2.2281	233.99
0.1281	1.09640	2.5202	233.76	1.09241	2.3030	235.31
0.1500	1.09642	2.6056	234.96	1.09244	2.3823	236.35
		308.15 K			**313.15 K**	
0.0150	1.08578	1.6833	226.54	1.08298	1.5795	226.52
0.0231	1.08591	1.7142	227.81	1.08312	1.6132	227.60
0.0329	1.08605	1.7513	229.00	1.08327	1.6541	228.75
0.0445	1.08619	1.7958	230.26	1.08343	1.6970	229.82
0.0577	1.08633	1.8437	231.40	1.08357	1.7533	231.20
0.0727	1.08644	1.8986	232.80	1.08372	1.8103	232.26
0.0894	1.08655	1.9579	233.95	1.08385	1.8737	233.42
0.1079	1.08663	2.0253	235.15	1.08396	1.9495	234.56
0.1281	1.08669	2.1044	236.27	1.08407	2.0216	235.51
0.1500	1.08674	2.1827	237.23	1.08413	2.1042	236.62

It can be observed from this figure that density (d) of solution increases with the concentration of solute (m) in the solution for all the systems studied in the present work. The same type of behavior is observed at other temperatures. It is also observed from the above figure that the density of the solution decreases with increase in the temperature of the solution for all the systems. The ϕ_v values of Chlorothalonil pesticide for all the system are large and positive which indicate strong solute-solvent interaction [6]. Apparent molar volumes (ϕ_v) increase with increasing temperature and molality of Chlorothalonil Pesticide in the binary mixture DMF and DMSO. Such trends indicate that the interactions between solute and solvent as well as those between solute-solute or solute-cosolute change with temperature and solvent compositions. Fig.1. shows plots of apparent molar volume ϕ_v against square root of concentration, C for Chlorothalonil in DMF + DMSO solution at 298.15 K.

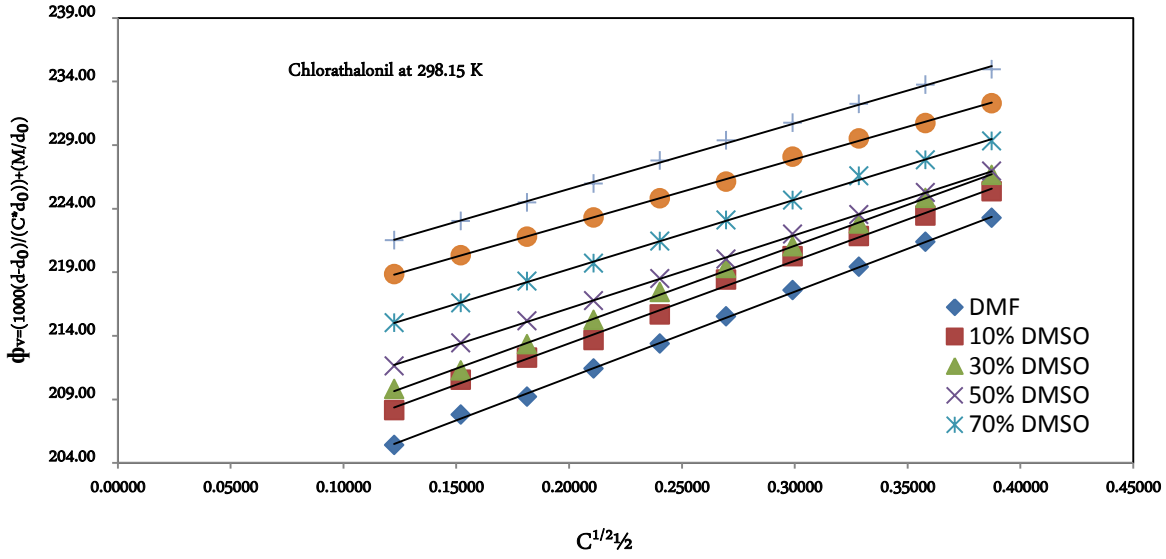

***Fig.1**. plots of apparent molar volume ϕ_v against square root of concentration, C for Chlorothalonil in DMF + DMSO solution at 298.15 K.*

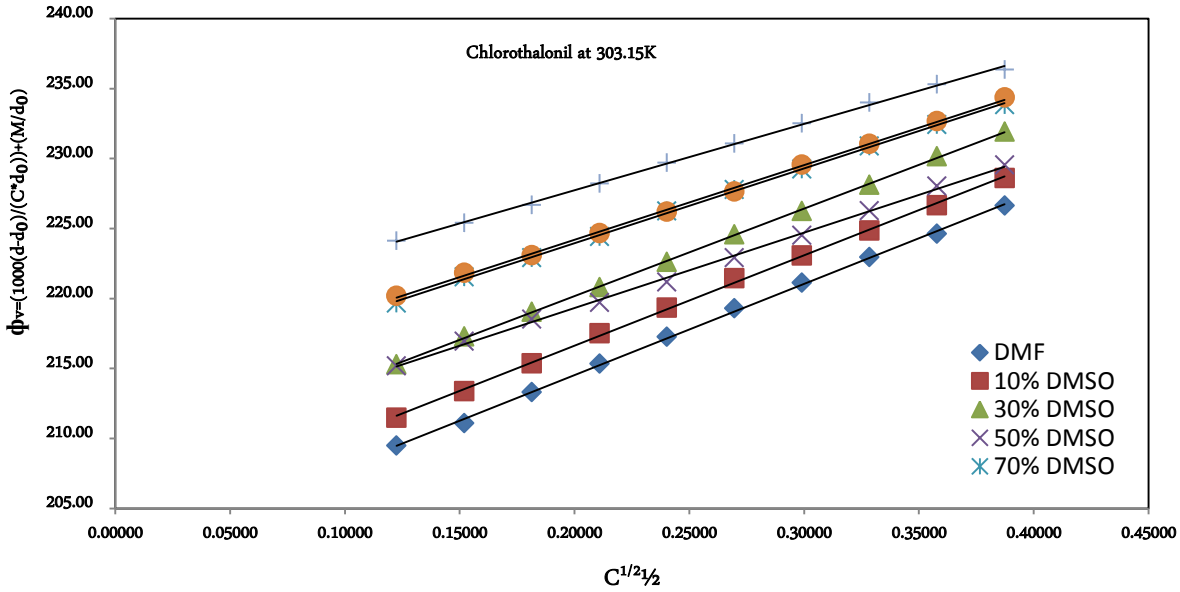

***Fig. 2.** plots of apparent molar volume ϕ_v against square root of concentration, C for Chlorothalonil in DMF + DMSO solution at 303.15 K.*

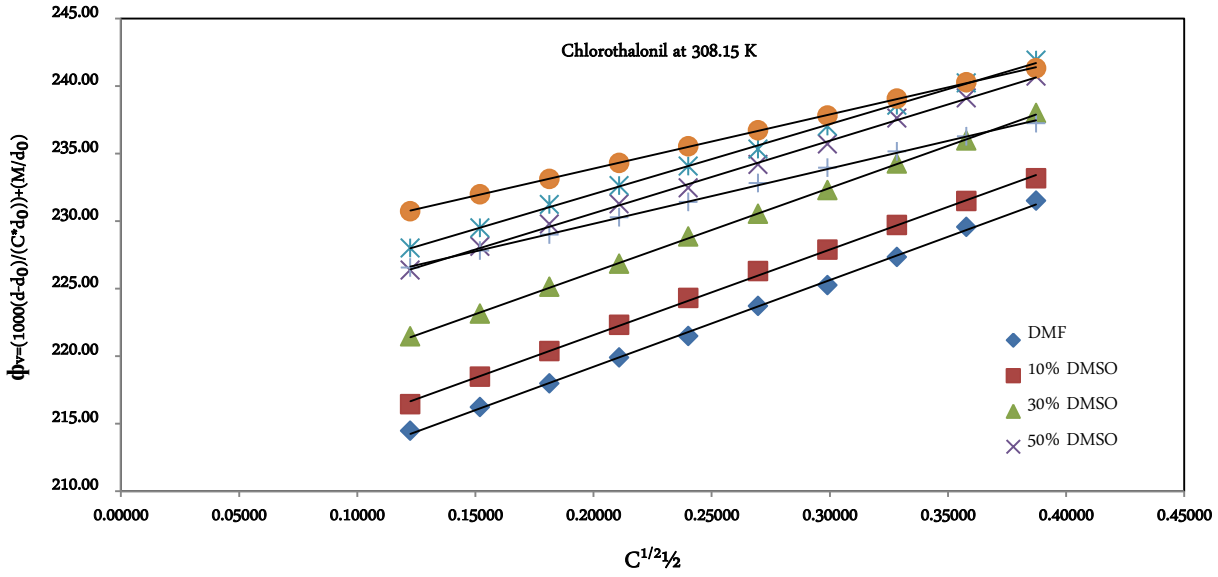

Fig. 3. *plots of apparent molar volume ϕ_v against square root of concentration, C for Chlorothalonil in DMF + DMSO solution at 308.15 K.*

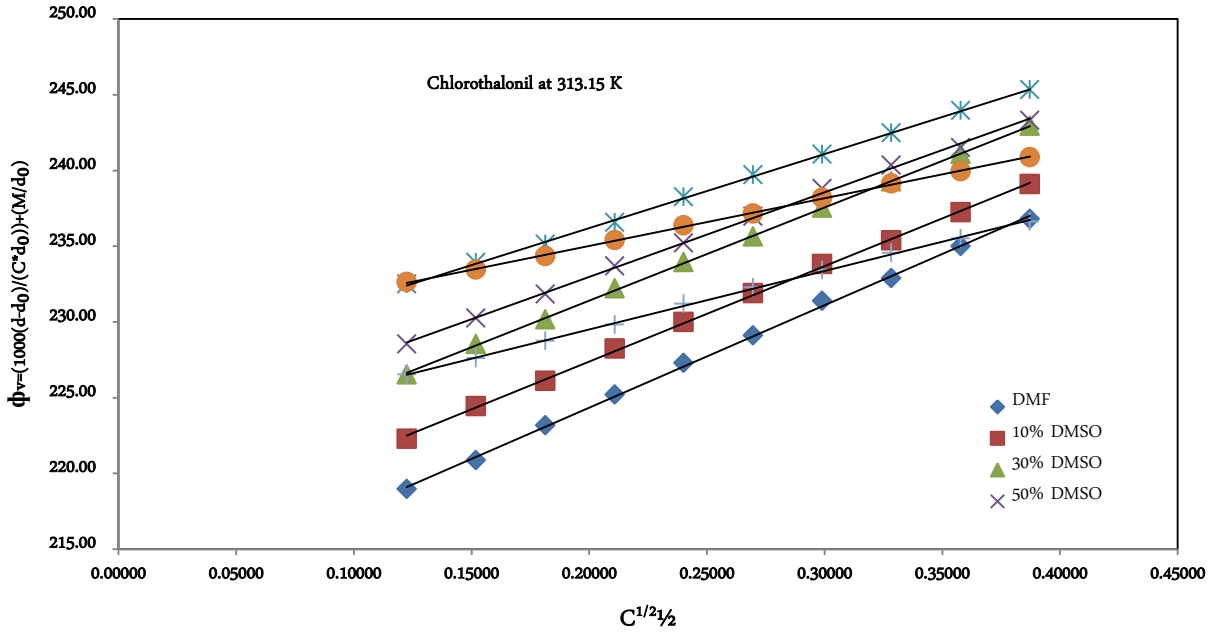

Fig. 4. *plots of apparent molar volume ϕ_v against square root of concentration, C for Chlorothalonil in DMF + DMSO solution at 313.15 K.*

The plot apparent molar volumes (ϕ_v) of verses √C were found to be linear with positive slopes in different compositions of binary mixture DMF and DMSO. Similar such plots were observed for Chlorothalonil in DMF + DMSO solutions at 303.15, 308.15, and 313.15 K. The limiting apparent molar volumes (ϕ_v^0) and S_v value were calculated from the linear plots of apparent molar volume ϕ_v against square root of concentration, C for Chlorothalonil.

TABLE 8 *ϕ_v^0 ($cm^3.mol^{-1}$), S_V ($cm^3.mol^{-2/3}.L^{1/2}$) , A ($dm^{3/2}.mol^{-1/2}$) and B ($dm^3.Mol^{-1}$) of Chlorothalonil in percentage of DMSO in binary mixture DMF and DMSO at different temperatures.*

Temp. (K)	DMF	10% DMSO	30% DMSO	50% DMSO	70% DMSO	90% DMSO	DMSO
				ϕ_v^0 ($cm^3.mol^{-1}$)			
298.15	197.2	200.3	201.7	204.6	208.3	212.5	215.2
303.15	201.4	203.7	207.6	208.5	213.2	213.5	218.2
308.15	206.3	208.9	213.7	219.8	221.6	225.8	221.6
313.15	210.8	214.7	219.1	221.8	226.4	228.7	221.8

				S_V ($cm^3.mol^{-2/3}.L^{1/2}$)			
298.15	67.51	65.03	64.50	57.59	54.65	51.11	51.67
303.15	65.22	64.53	62.51	53.88	53.48	53.43	47.38
308.15	64.19	63.29	62.28	53.73	51.85	40.13	40.91
313.15	67.61	63.04	61.52	55.87	48.88	31.46	38.55
				A ($dm^{3/2}.mol^{-1/2}$)			
298.15	0.081	0.077	0.075	0.072	0.089	0.099	0.096
303.15	0.076	0.062	0.070	0.065	0.098	0.095	0.089
308.15	0.067	0.067	0.062	0.063	0.087	0.093	0.081
313.15	0.073	0.051	0.057	0.083	0.070	0.091	0.077
				B (dm^3. Mol^{-1})			
298.15	1.022	1.056	1.362	1.496	1.593	1.644	1.795
303.15	1.095	1.350	1.476	1.542	1.761	1.879	1.944
308.15	1.264	1.425	1.554	1.635	1.942	2.062	2.121
313.15	1.616	1.628	1.790	1.757	2.047	2.216	2.431

Table 8 shows that (ϕ_v^0) values are generally positive and increases with an increase in both the temperature and percentage of DMSO in binary mixture DMF + DMSO. This indicates the presence of strong solute–solvent interactions [7], and these interactions are further strengthened at higher temperatures and higher composition of DMSO in binary mixtures [8] These facts may be attributed to increase in solvation of the ions at elevated temperatures [9, 10]. The parameter S_v is a volumetric coefficient that characterizes pair-wise interaction between the solvated species or ion-ion interaction in solution phase [11, 12]. Its sign is determined by the interactions between the solute species. In the present study, S_v values were found to positive for all the studied solutions. But interestingly S_v values decreases as increases with an increase in both the temperature and percentage of DMSO in binary mixture DMF + DMSO. This indicating decreased solute-solute interactions in the binary mixtures. Anyway, the S_v values are always smaller than the (ϕ_v^0) values for Chlorothalonil pesticide for all compositions of binary mixtures and this fact indicates that the ion-solvent interactions play a dominant role over the ion-ion interactions in characterizing the volumetric properties of studied systems. The experimental viscosities of Chlorothalonil pesticide in binary mixture DMF and DMSO as a function of its molality and temperature are displayed in Table 1 to Table 7 The η values increases with concentration and decreases with rise in temperature. fig.5. to fig.8. shows the variation of (ηr-1)/$C^{½}$ against square root of concentration C for Chlorothalonil in DMF + DMSO solution at different temperature.

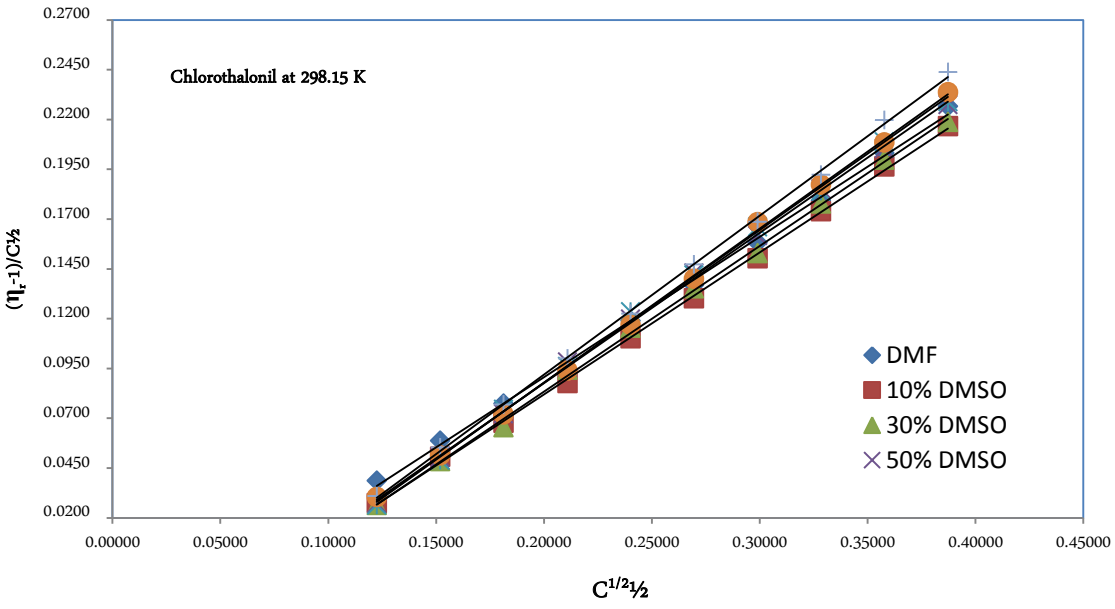

Fig. 5. Plots of variation of (η_r-1)/$C^{½}$ against square root of concentration C for Chlorothalonil in DMF + DMSO solution at 298.15 K.

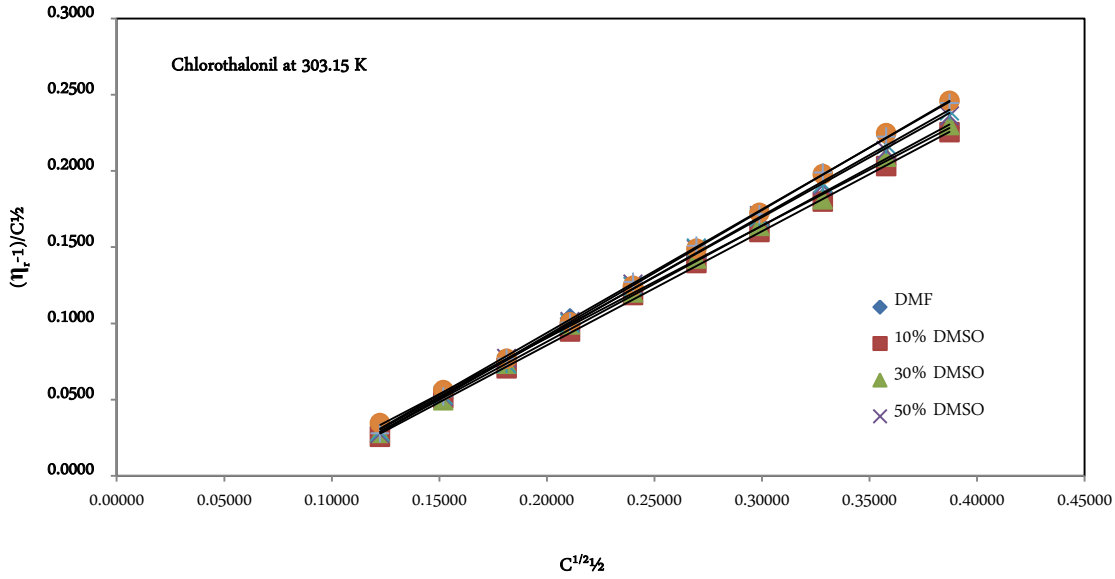

Fig.6. Plots of variation of $(\eta_r-1)/C^{½}$ against square root of concentration C for Chlorothalonil in DMF + DMSO solution at 303.15 K.

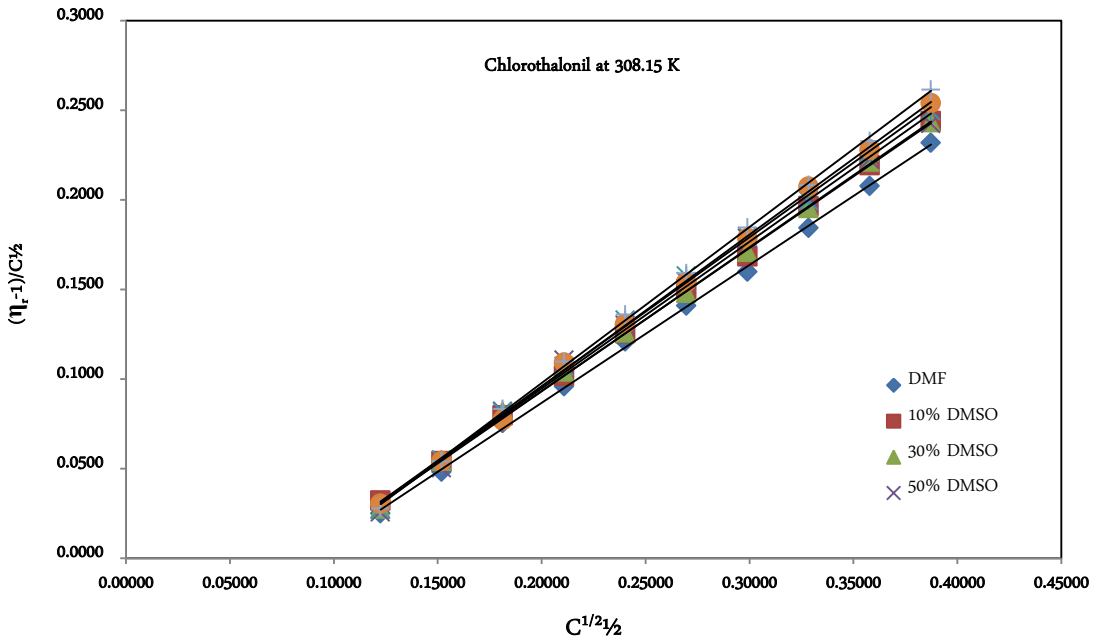

Fig.7. Plots of variation of $(\eta_r-1)/C^{½}$ against square root of concentration C for Chlorothalonil in DMF + DMSO solution at 308.15 K.

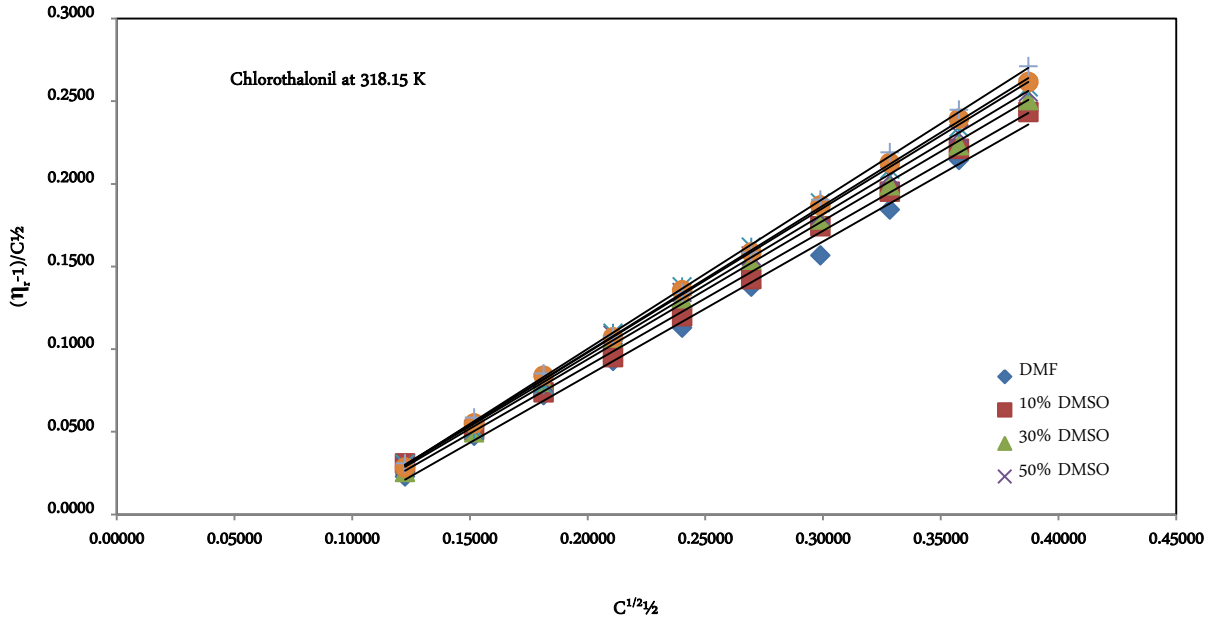

Fig.8. Plots of variation of $(\eta_r-1)/C^{½}$ against square root of concentration C for Chlorothalonil in DMF + DMSO solution at 313.15 K.

The value of 'A' coefficient increases with increase in percentage of DMSO in binary mixture DMF + DMSO solutions for Chlorothalonil. But interestingly 'A' coefficient values decreases with rise in temperature form 298.15 K to 313.15 K. The viscosity B- coefficients for positive and thus suggest the presence of strong solute-solvent interactions in present work. The B value for Chlorothalonil pesticide shows solute-solvent interactions was increases when both the percentage of DMSO in binary mixture DMF+DMSO [13, 14] and also increases with the rise in temperature, thereby showing the ion-solvent interactions further improve with the increase in temperature [15]. The A-coefficients is found to be much smaller in magnitude as compared to B coefficients indicating the presence of weak solute-solute interactions [16].

4 RESULTS VALIDATION

The apparent molar volume can be considered to be the sum of the geometric volume of the solute molecules and changes that occur in to the solution due to its interaction with solvent. The data are filled to Masson equation and calculate limiting partial molar volume and experimental slope by least square method [17].

$$\phi_v = \phi_v^o + S_v\sqrt{C} \quad \textbf{(1)}$$

Where ϕ_v^o is the limiting apparent molar volume and S_v a semi-empirical parameter which depends on the nature of solvent, solute and temperature. Apparent molar volume has been calculated and estimated the slope (S_v) is obtained by plotting the graph ϕ_v vs $\sqrt{C}$. This paper investigates the theoretical aspects of the nature of molecular interactions to see the validity of Masson's equation in binary liquid mixtures [18]. The relative viscosities have been analyzed by Jones-Dole equation [18]

$$(\eta_r - 1)/\sqrt{C} = A + B\sqrt{C} \quad \textbf{(2)}$$

Where $\eta_r = (\eta/\eta_o)$ and η, η_o are viscosities of the solution and solvent respectively, c is molar concentration , A is the Falkenhagen coefficient which is the measure of solute – solute interactions and B is the Jones-Dole coefficient which is the measure of solute - solvent interaction. . The viscosity data have been analyzed and interpreted in terms of the extended Jones-Dole equation for the relative viscosity. The derived values of the viscosity A- and B-coefficients were compared with the values calculated from the Falkenhagen-Dole theory and ionic B-coefficient data, respectively

5 CONCLUSIONS

The density and viscosity of Chlorothalonil pesticide in binary mixture DMF and DMSO at 298.15, 303.15, 308.15 and 310.15K temperature are,

1. All the values of ϕ_v^o at all temperatures are positive and higher; suggest the strong solute-solvent interactions for Chlorothalonil pesticide in binary mixture DMF + DMSO. All the S_v values are positive and suggesting strong solute-solute interactions.
2. The positive values of Jones-Dole coefficient 'B' indicate strong interactions between solute and solvent at high temperature.
3. The Masson's equations and Jones-Dole equations were found to be obeyed for Chlorothalonil pesticide in binary mixture DMF + DMSO.

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