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Optomechanical Properties of 10% PVA (Polyvinylalcohol) in Presence of $CoCl_2$ and 44% Ethanol Water Compositions

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Abstract The optical and mechanical properties of 10% by weight for PVA (Polyvinyl alcohol) in presence of different $CoCl_2$ concentrations in absence and presence of 44 % by weight ethanol – water solvents were estimated at 298.15 K. The evaluated optical parameters like molar refraction (R_M),specific refractivity(ε) and molecular polarizability (α) were compared and discussed with that of mechanical tension parameters like elastic modulus and Shear modulus.

Keywords Optical Properties, Mechanical Properties, Polyvinyl Alcohol, Cobalt Chloride, Ethanol Water Solvent

1. Introduction

Polymer solutions like PVA solutions are important in applied electrochemistry due to their applications in electrodes,especially when doped with transition metals [1,2] Transition metals plus polymer solutions improve the conducting properties and play important role in forming thin films [3]. Conductivity and refractive index measurements explain the ion - ion, ion – solvent Interactions and the association of ions in different media [4,5]. Estimation of the optical and mechanical properties of polymers in absence and presence of metals are very important to give relations between the optomechanical characterizations [6]. The aim of this work is to evaluate the optical and mechanical properties of PVA in presence of $CoCl_2$ and solutions in presence and absence of both PVA (polyvinyl alcohol) and 44% by weight ethanol – water mixtures together or separately.

2. Experimental

Cobalt chloride from Merck Co. and polyvinyl alcohol (PVA), M.W 17,000, water soluble polymer from Arondate laborations were provided. The ethanol was BDH supplement and water used was secondly distilled one. 5 ml of bidistilled water were put in test tubes, then different concentrations of solid $CoCl_2$ were added and dissolved. Also another solutions were prepared by adding different concentrations of $CoCl_2$ to 44% by weight ethanol-water solvents in absence and presence of 10% (by weight) PVA. The solutions were left for more than one day in water thermostat of the type (Polyscience 8105, USA) at 298.15 K. The densities were measured by taking 1ml of the prepared solutions and put in specific gravity bottle (1 ml capacity) and weight them by the use of Mettler Toledo USA four digital balance with accuracy of plus, minus 0.001 gram. The densities have been used for evaluating the solvated radii [7]. The refractive indices of the different solutions used here in this work were measured using a refractometer of the type ATAGO-3T (No 5250) at 298.15 K.

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3. Results and Discussions

From densities of $CoCl_2$ aqueous solutions in absence and presenceof 10% by weight PVA, the molar volumes were evaluated by dividing the molecular weight of $CoCl_2$ by densities, and the evaluated volumes (V) are represented in Table 1.

From the experimental refractive indices (n), the molar refraction (R_M) were calcu44% by weight lated

By applying [8] eq.1.

$$R_M = \frac{n^2 - 1}{n^2 + 2} V \quad (1)$$

Where V is the measured molar volumes.The evaluated R_M values are listed also in Table 1. The specific refractivities of the isotropic dielectric (ε) were calculated by using de Vries equation [9,10] as seen in eq.2.

$$\frac{n^2 - 1}{n^2 + 2} = \varepsilon\, d \quad (2)$$

Where d are the densities of the solutions. The mean values of the molecular dipole polarizability(α) i.e the dipole

moment induced by electric field were calculated from Lorenz-Lorenz formula [11] following equation (3)

$$\frac{n^2-1}{n^2+2}=\frac{4\pi N\alpha}{3} \quad (3)$$

The number of molecular chains (N),the molduli of elasticity E and Shear modulus G were calculated by using equations (4), (5) and (6) after Fouda and Gomaa and Mognashi [10-12].

$$N = N_A d/M \quad (4)$$

$$E = NkT = 3G \quad (5)$$

$$G = 3NKT \quad (6)$$

Where k is Boltzman's constant , T the absolute temperature , N_A is the Avogadro's number and M is the molecular weight of $CoCl_2$

Table 1. Densities (d),molar volume (V),refractive index (n), molar refraction (R_M), specific refractivity (ε) number of chain molecules (N).polarizability (α).elastic modulus (E) and Shear modulus (G) for $CoCl_2$ in aqueous solutions at 298.15K

.Conc.of $CoCl_2$ (Molarity)	Density d (g/cm^3)	Volume V ($cm^3 mol^{-1}$)	Refractive index n	R_M ($cm^3.mol^{-1}$)	ε	N. 10^{21}	α .10^{-3} (cm^3)	E .10^8 Pa	G .10^8 Pa
0.084	0.994	130.623	1.3360	27.0780	0.2086	2.515	2.1890	3.101	1.034
0.1	0.995	130.491	1.3365	27.0890	0.2086	2.517	2.1895	3. 035	1.035
0.15	0.997	130.229	1.3375	27.1136	0.2088	2.522	2.192	3.111	1.037
0.21	1.000	129.839	1.3390	27.1364	0.2090	2.530	2.194	3.121	1.040
0.25	1.002	129.580	1.3400	27.1599	0.2091	2.535	2.196	3.127	1.042
0.34	1.008	128.809	1.3425	27.1786	0.2093	2.550	2.199	3.155	1.048
0.42	1.012	128.299	1.3450	27.2500	0.2114	2.560	2.202	3.168	1.052
0.52	1.018	127.543	1.3475	27.265	0.2100	2.580	2.204	3.182	1.060

Table 2. Densities (d),molar volume (V),refractive index (n), molar refraction (R_M), specific refractivity (ε) number of chain molecules (N).polarizability (α).elastic modulus (E) and Shear modulus (G) for $CoCl_2$ in 44 % by weight ethanol water solutions at 298.15K

.Conc.of $CoCl_2$ (Molarity)	Density d (g/cm^3)	Volume V ($cm^3 mol^{-1}$)	Refractive index n	R_M ($cm^3.mol^{-1}$)	ε	N . 10^{21}	α .10^{-3} (cm^3)	E .10^8 Pa	G .10^8 Pa
0.084	1.006	129.224	1.3600	28.5197	0.2194	2.545	2.302	3.139	1.046
0.1	1.012	128.299	1.3605	28.3412	0.2184	2.560	2.291	3158	1.052
0.15	1.014	128.046	1.3615	28.3622	0.2184	2.565	2.293	3.164	.1054
0.21	1.015	127.926	1.3630	28.4507	0.2191	2.567	2.299	3.166	1.055
0.25	1.018	127.543	1.3640	28.4293	0.2189	2.576	2.297	3.178	1.059
0.34	1.024	126.796	1.3660	28.3896	0.2185	2.590	2.296	3.195	1.056
0.42	1.028	126.303	1.3680	28.4308	0.2189	2.600	2.297	3.207	1.069
0.52	1.034	125.561	1.3705	28.4352	0.2191	2.610	2.298	3.227	1.075

Table 3. Densities (d),molar volume (V),refractive index (n), molar refraction (R_M), specific refractivity (ε) number of chain molecules (N).polarizability (α).elastic modulus (E) and Shear modulus (G) for 10% PVA + $CoCl_2$ in aqueous solutions at 298.15K

.Conc.of $CoCl_2$ (Molarity)	Density d (g/cm^3)	Volume V ($cm^3 mol^{-1}$)	Refractive index n	R_M ($cm^3.mol^{-1}$)	ε	N . 10^{21}	α .10^{-3} (cm^3)	E .10^8 Pa	G .10^8 Pa
0.084	1.002	129.586	1.3500	27783	0.2139	2.535	2.255	3.127	1.042
0.1	1.004	129.322	1.3505	28.179	0.2170	2.540	2.252	3. 133	1.044
0.15	1.006	129.065	1.3520	27.916	0.2150	2.545	2.256	3.139	1.046
0.21	1.010	128.553	1.3540	27.626	0.2138	2.555	2.258	3.152	1.050
0.25	1.012	128.299	1.3550	27.956	0.2150	2.560	2.260	3.158	1.052
0.34	1.017	127.669	1.3575	27.959	0.2153	2.573	2.263	3.174	1.058
0.42	1.023	126.920	1.3600	28.011	0.2157	2.588	2.265	3.192	1.064
0.52	1.028	126.303	1.3630	28.228	0.2170	2.600	2.270	3.207	1.069

Table 4. Densities (d),molar volume (V),refractive index (n), molar refraction (RM), specific refractivity (ε) number of chain molecules (N).polarizability (α).elastic modulus (E) and Shear modulus (G) for 10% PVA + $CoCl_2$ in 44 % mixed ethanol water solvents at 298.15K

.Conc.of $CoCl_2$ (Molarity)	Density d (g/cm^3)	Volume V ($cm^3 mol^{-1}$)	Refractive index n	R_M ($cm^3.mol^{-1}$)	ε	N . 10^{21}	α .10^{-3} (cm^3)	E .10^8 Pa	G .10^8 Pa
0.084	1.012	128.299	1.3690	28.9442	0.2229	2.560	2.339	3.158	1.052
0.1	1.014	128.046	1.3695	28.9256	0.2228	2.565	2.339	3. 164	1.054
0.15	1.017	127.669	1.3715	28.9809	0.2232	2.573	2.342	3.174	1.058
0.21	1.022	126.809	1.3735	28.9251	0.2232	2.585	2.343	3.189	1.063
0.25	1.025	126.672	1.3750	28.9952	0.2233	2.590	2.344	3.195	1.065
0.34	1.032	125.813	1.3780	28.9998	0.2234	2.610	2.345	3.220	1.073
0.42	1.037	125.206	1.3810	29.0728	0.2239	2.623	2.349	3.236	1.078
0.52	1.044	124.367	1.3845	29.1143	0.2242	2.641	2.353	3.258	1.086

All the measured and evaluated data for $CoCl_2$ aqueous solutions (Table 1), $CoCl_2$ in mixed ethanol-water solvents (Table2) and 10% polyvinylalcohol + $CoCl_2$ in absence of 44 % ethanol-water mixed solvents (Table 3) and in presence of 44 % mixed ethanol-water solvents (Table 4), are evaluated at 298.15 K. In comparing the four given tables we can conclude that both the optical and mechanical properties of $CoCl_2$ are increased by using mixed 44% ethanol-water solvents and 10 % PVA. $CoCl_2$ + 10% PVA + 44% ethanol-water solutions show the biggest optical and mechanical properties from all the used media.The organic solvents increase the salvation parameters [13-15] affecting the optical and mechanical properties.

Therefore the optical and mechanical properties of PVA solutions can easily be improved by the addition $CoCl_2$ and 44 % ethanol-water solutions.

4. Conclusions

The optomechanical properties of PVA increase in presence of $CoCl_2$+44% ethanol by weight due to the increase in molar refraction (R_M), specific refractivity (ε), molecular polarizability (α), elastic modulus (E) and Shear modulus (G).

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