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Study The Effect of Prepared Sulfonated Phenol-Formaldehyde Resin (SPF) on the Electrical Characterization of Polyvinyl Acetate (PVA) - Polyol as Bulk Samples

KEYWORDS: PVA, Polyol, SPF, Composite, FTIR spectroscopy, I-V characteristics Electric field strength, Current density and Electrical conductivity.

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ABSTRACT *Samples of poly vinyl acetate (PVA)-Polyol were blended by percentage of weight 3:1 and were mixed with different percentages by weight of prepared sulfonated-phenol formaldehyde resin (SPF) on clean glass substrate as a bulk films, with different thicknesses (0.1-0.18)x10-2 m. Diagnosis of SPF was determined by FTIR spectrophotometer. The current-voltage (I-V) characteristics and the potential across the bulk samples were measured at room temperature at applied electric field 13 volts dc. The electric field strength and, the current density were calculated and were investigated at time of measurements. The electrical conductivity was calculated, this was increased from (1.743x10-6, 6.756x10-3) S m-1 to (3.7, 185.8) S m-1. The minimum and maximum values are at (15, 40) wt% SPF and (15, 30) %wt SPF.*

Introduction:

Polymers materials in pure state are electrical insulators. However they are filled with specific additives, such as metallic powders or metallic fibres, carbon black, ionic conductive polymer And intrinsically conductive polymer powder[I. I. Soliman et al (2002)].

Polyvinyl acetate (PVA) is one of the most important commercial polymers, and has many advantages, such as safe operation, low coat and room temperature cure. Therefore, it is suitable for population in birch process. It has other applications such as adhesives, membrane, paper and many other applications[Y. Zhang, et al (2011)]. PVA is a synthetic resin polymer and due its non-polar nature, is insoluble in water, oil, fats or gasoline. On the other hand, it is soluble in alcohols, ketones and esters[WiseGEEK (2013)].

A polyol is an alcohol containing multiple hydroxyl functional groups. The term polyol means here polymer chemistry, which are compounds available for organic reactions. A molecule with two hydroxyl groups is a diol, one with three is triol and one with four is tetrol and so on[Wikipedia (2013)].

Composite are engineering materials made from two or more constituents with significantly different physical or chemical properties which remain separate and distinct on macroscopic level with in the finished structure. One material (the matrix or binder) surrounds and binds together a cluster of fibers or fragments of much stronger material (the reinforcement). For the matrix many modern composites use thermosetting or thermoplastic polymers[S. Baghat (2013)].

Electric conductivity is one of the most delicate physical properties of polymer composites due to the weakness of the current and size generally small of sample characterized. To a clime a good accuracy measurements of current and voltage across the film, the surface must be large compared with its thickness and high value of applied electric field, thus the geometric shape of the sample almost feasibility of such process; specific preparation of the sample with initial phase during which particular electrodes have to be used. Electrically conducting composites based on conducting particles in non-conducting polymer matrix are now being in many practical applications. These filled polymers have a number of advantages in term of absorbing the specific radiation, improving thermal stability, enhancing electrical conductivities and reducing the cost and easy processability to achieve conductivity[V. S. Sangawar, et al (2006)]. These materials are typically disorder structures consisting of randomly arranged conducting fillers dispersed in polymer medium. Some of the earliest conducting composites were formulated using carbon black or graphite as a filler[J. Vilcakova, et al (2000)].

The type of the electric conductivity measurement reported in the literature usually involves simple measurements of current as a function of time, temperature, ambient atmosphere and potential. Attempts are then made to relate the conductivity to physical processes thought to be occurring in the polymer. It is found that electrical conductivity varies exponentially with temperature, is a function of time and may vary with electric field[M. Serin, et al (2003)]. Polymeric materials either organic or inorganic are well known insulating materials suitable for many industrial applications such as coating adhesion, coverage, fiber etc. in spite of conflicts and difficulties associated with study of the conduction mechanisms in polymeric materials, some fair results still describe gently the charge carriers migration and its variation with temperature and voltage. Sometimes, it is difficult to prove or disprove the expected conduction mechanism by direct analytical measurements because of low currents implied. Hence, different measurement techniques such as surface conductivity, dc conductivity, thermally stimulated dc current have been employed for studying the relationship between their electrical properties and chemical structure for several purposes such as the high temperature applications because of its thermal and oxidative resistance and high glass transition temperature[L. I. Soliman, et al (2002)]. The potential of PVA/polyol blend and SPF mixtures as reinforced fillers rather reflects a significant improvement by reinforcing filler. These significant properties are expected to impart major enhancements in the electric properties of polymer composites. The measured electrical properties gave a motivated considerable interest in the development of polymer composite materials make now this field even more competitive[L. Bokobza (2012)].

Electrically conductive polymers are of great interest as a new class of materials in the field of technology during last two decades, the effect of polymer blending on the electrical conductivity of polymer composite films was investigated such as polyester resin/ carbon fibre composite and have studied intensively to improve environmental stability and mechanical properties [J. Vilcakova, et al (2000)]. Interaction between SPF and PVA/polyol implies a strong interfacial bonding, while functional properties of the composite greatly depend on the conductive structure of SPF[Y. Zeng, et al (2010)]. Sulfonated phenol-formaldehyde resin is prepared by the method which was described in experiment and was used in preparing PVA/Polyol and SPF polymer composite as conductive polymer films. Fundamental research's and po-

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tential applications in field of conducting polymer composites, since the electrical conductivity of conjugated polymers can be increased by many orders of magnitude from 10^{-10}-10^{-5} to 10^{3}-10^{5} S.cm^{-1}[Y-Z. Long, et al (2010)].

EXPERIMENT:

Preparation of Sulfonated Phenol-Formaldehyde Resin:

42.5 moles of phenol was put in clean tri-neck round Flask 500 ml. in capacity, which was emplaced in Isomental heater sort LabHeat BAECO, Germany. The side neck (B19) (mm. inner diameter) of the round flask was closed by stop-fit thermometer and the other side (B19) (mm. inner diameter) was closed by a condenser which is connected to water pump emplaced in ice path, while a stirrer sort Heidolph, Germany is inserted in the middle neck (B24) (mm. inner diameter), the system was run and the phenol was heated to appropriate temperature to dissolve any solid bodies. The system was stopped and 4 moles of sulfuric acid 97% in concentration Thomas Baker India, was added slowly from one side neck by using pipettes. The round flask was closed again as above and the system was operated, while the stirrer was adjusted to appropriate speed and the temperature is raised, which is maintained between 100-120 °C for two hours. The system was stopped and the temperature was cooled slowly, then the round was emplaced in ice path, 12 moles of Formaldehyde Thomas Baker, India. Was added by using pipettes, a fizzing and bubbling have occurred, the temperature is raised and stirring by hand was done using glass rod and the temperature was cooled to 35 °C then below 22 °C. a stirring was continued until a viscose solid mass is obtained. The product was left over night. The PH was examined by using indicator paper which is colored red low PH. NaOH solution was prepared in a separate flask and drops were added until over saturation is reached high PH, a few drops were add of H_2SO_4 for equilibrium until PH=7 was reached. The solution was removed in flask and the precipitate resin was put in a glass plate to be dried at room temperature and the product was collected in plastic container. Figure (1), shows the setup of instruments used in preparation of SPF.

Fig.(1). The setup of instruments used in preparation of SPF.

2-FTIR Test:

Sample of sulfonated phenol-formaldehyde resin, was examined with KBR disc by Fourier transform Infrared Instrument (FTIR) as shown in Figure (2). The peaks at 1128.39 cm^{-1}and 1175cm^{-1}correspounding to C-C-O asymmetric stretch and C-H in plane formulation respectively while the 1000 cm^{-1} and 748.8 cm^{-1} peaks belonged to the C-H out of plane vibration. The peak at 1034.14 is carbonyl group C-O. The peak at 1506.37 cm^{-1} corresponded to the C=C aromatic ring vibration. The above mentioned peaks diminished with increasing reaction time while the absorbance band of hydroxyl groups have increased Table (1) show the functional groups and their wave numbers obtained in this investigation and comparison with other functional group from previous study[I. Poljansek, et al (2005)].

Table (1) The obtained functional groups compared with literature and previous functional groups from Reference. [I. Poljansek et al.(2005)].

Literature data cm^{-1}Ref.	Functional group obtained	Wave number cm^{-1}	Functional group. Ref.	Observed cm^{-1}
1240	C-C-O	1128.39	C-C-O phenol	1224
1180	C-H in plane	1175	C-H aromatic phenol	1170
835	C-H out of plane phenol	1000 and 748.8	C-H out of plane, para	826
760			C-H out of plane, ortho	756.6
1153	C-O	1034.14	C-O stretch	1154
	C-H unsaturated	3024.43	C-H unsaturated stretchd phenol	3026
1610 and 1517	C=C	1506.37	C=C	1610 and 1552
3400	OH	3530.3	OH	3389

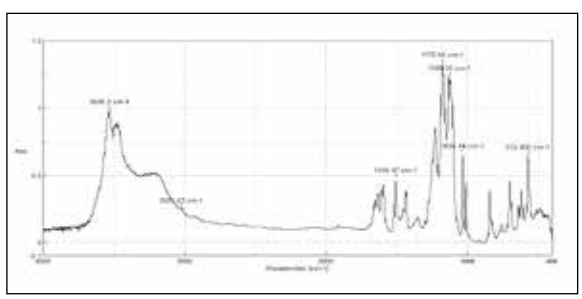

Fig.(2). The FTIR spectroscopy of SPF.

3-Preparation of samples:

Glass substrates were cleaned by rinse with distilled water then by acetone, again with distilled water and dried in oven under vacuum for one hour. PVA-Polyol blend were prepared by weight 3:1 using sensitive electric balance sort Sartorius, Germany and was blended on the clean glass substrates by hand using spatula, percentages by weight of sulfonated phenol-formaldehyde resin (SPF) was crushed using Pyrex mortar, was added and mixed by hand using spatula until the required mixtures were obtained and to ensure uniform thicknesses Two copper wires were connected at both ends of bulk films which left to dry overnight. The thicknesses, width, length and diameter of the samples were measured using Capilar Certificate Vernier made in China, as in Table-2. The samples then undergo electrical measurements.

4-Electrical Measurements:

Measurements of current-voltage characteristics of the prepared samples were carried out using the schematic diagram as shown in Figure (3). It is consists of DC power supply sort, LEYBOLD-HERAEUS. Amplifier, sort PHYWE, Germany which is connected to a pointer ammeter for low current measurements, sort PHYWE, Germany, digital voltmeter trade mark was used to measure the voltage across the bulk samples and the potential. The electrical contact of the wires was made as electrode configuration to reduce any effect of leakage current. The samples were put in side front slide glass wood box to prevent the effect of the environment. The current-voltage was measured at applied electric field 13 volt DC. Table -3. Shows the I-V characteristics of the samples. The dependencies of current density passing through the bulk samples on applied field strength were calculated as shown in Table-4-. The formula were used for calculating the electrical conductivity from Table-3- [Y. Zeng, et al (2010)]:

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$$\rho = \frac{RA}{t} \qquad (1):$$
$$\sigma = \frac{1}{\rho} = \frac{t}{RA}$$

Where: t: is the thickness of bulk sample.
R: is the resistance of the sample.
A: is the effective cross sectional area of the calculated electrodes of the sample $\pi D^2/4$. as in Table-2-.

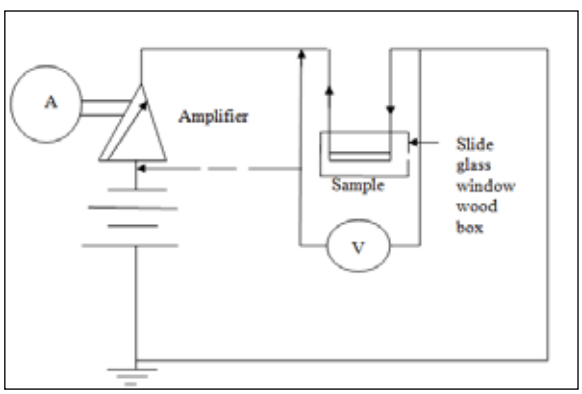

Fig.(3). Schematic diagram of the electrical measurements circuit.

Table (2). Samples preparation of PVA-Polyol and SPF.

PVA-Polyol kgm.	percents of SPF	thickness m.	Width m.	Length m.	diameter (D)m.	Effective cross sectional area m^2
$0.533x10^{-3}$	5wt%	$0.13x10^{-2}$	$1.79x10^{-2}$	$3.44x10^{-2}$	$0.183x10^{-2}$	$0.0262x10^{-4}$
$0.533x10^{-3}$	10wt%	$0.10x10^{-2}$	$1.83x10^{-2}$	$3.35x10^{-2}$	$0.184x10^{-2}$	$0.0265x10^{-4}$
$0.533x10^{-3}$	15wt%	$0.17x10^{-2}$	$1.29x10^{-2}$	$3.2x10^{-2}$	$0.129x10^{-2}$	$0.0130x10^{-4}$
$0.533x10^{-3}$	20wt%	$0.10x10^{-2}$	$1.69x10^{-2}$	$3.81x10^{-2}$	$0.167x10^{-2}$	$0.0218x10^{-4}$
$0.533x10^{-3}$	30wt%	$0.17x10^{-2}$	$1.8x10^{-2}$	$3.39x10^{-2}$	$0.185x10^{-2}$	$0.0268x10^{-4}$
$0.533x10^{-3}$	40wt%	$0.18x10^{-2}$	$1.24x10^{-2}$	$3.2x10^{-2}$	$0.124x10^{-2}$	$0.0120x10^{-4}$

Table-3-. I-V characteristics of the prepared samples.

5wt% SPF		10wt% SPF		15wt% SPF		20wt% SPF		30wt% SPF		40wt% SPF	
Vmv	InA	Vmv	InA	Vmv	InA	Vmv	InA	Vmv	InA	Vmv	InA
42	1.8	5.76	0.09	150	0.2	7.1	0.8	1.1	0.8	0.2	0.9
41.8	2	0.7	0.45	69	0.6	5	0.7	0.6	8	0.1	0.7
43	5.5	1.1	0.8	57.1	0.8	5.9	0.89	0.1	9	0.1	2.9
44	7	1.0	0.5	102	3	6.69	1.35	0.3	10	51.1	6
44.9	21	1.2	0.8	68.5	6	6.1	1.35	3.5	40	34.8	8
44.9	18	4.5	6.5	82	2	6.2	1.35	0.1	90	60	91
44.9	21	0.841	50	66.1	10	5.9	7	1.2	30	50	50
46	80	8	8000	60.2	10	4.4	6	0.7	80	48.4	185
46.6	240	1.3	6000	68	21	6.4	33	3.8	40	48.5	190
45	190	9.5	6000	81	90	6.4	23	10.2	290	48.4	220
45	290	9.5	15000	71	280	6.4	27	10.2	400	48.5	250
45	5000	9.8	40000	73	290	6.1	32	5.6	500	48.6	300
46	9000			67.7	240	6	38	1.2	400	48.6	900
45.6	5000			60	600	6.5	60	4.3	1100	48.7	800
45	4000			61.6	2000	6.7	100	3.6	900	48.4	2800
44	6900			55.5	1800	6.5	220	0.2	2400	48.4	2900

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44	7000			60.8	2500	6.5	340	0.3	2900	48.4	3000
44	23000			146	8000	6.5	400	0.4	2200	48.3	12000
44.1	15000			22.4	28000	6.2	800	0.4	2900	48.2	13000
44	60000			29.4	29000	6.5	1000	3.2	8900	48.1	30000
44	50000			30.4	26000	6.9	2400	0.2	4700	48	100000
44	60000			18.9	30000	5.9	1400	0.2	4900	47.9	100000
				31.4	80000	5.9	30000	1.1	6900		
				31.2	90000	5.8	2800	0.4	10900		
						6.3	2000	1.1	5900		
						7.1	3000	0.2	4300		
						6.8	8000	2.7	11500		
						7.1	4000	1.9	12700		
						7.5	13000	1.7	8900		
						6.0	24000	0.2	11900		
						6.2	30000	0.3	5300		
						7.6	12000	0.1	23300		
						7.8	50000	0.1	29300		

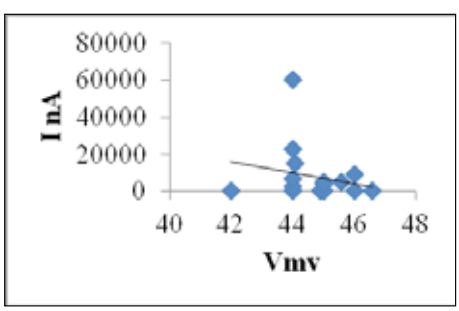

Fig.(4). I-V characteristics of PVA and Polyol blend with 5wt% SPF.

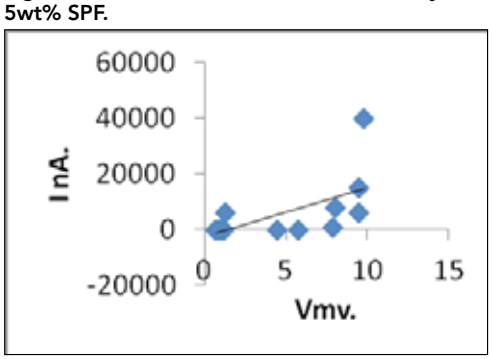

Fig.(5). I-V characteristics of PVA and Polyol blend with 10wt% SPF.

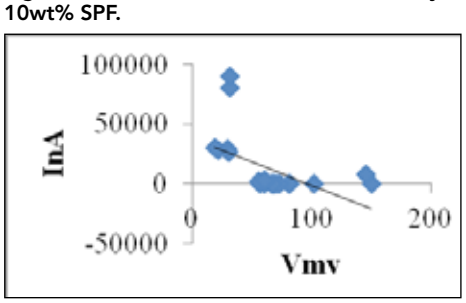

Fig.(6). I-V characteristics of PVA and Polyol blend with 15wt% SPF.

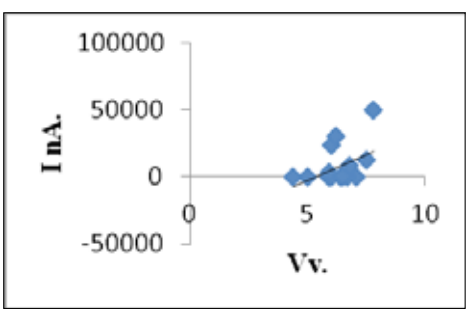

Fig.(7). I-V characteristics of PVA and Polyol blend with 20wt% SPF.

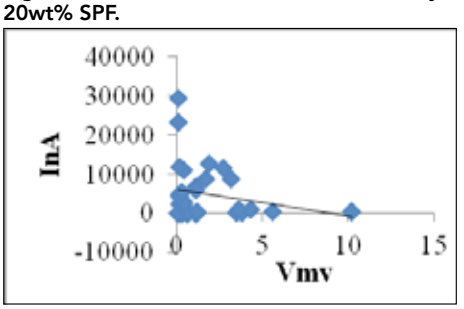

Fig.(8). I-V characteristics of PVA and Polyol blend with 30wt% SPF.

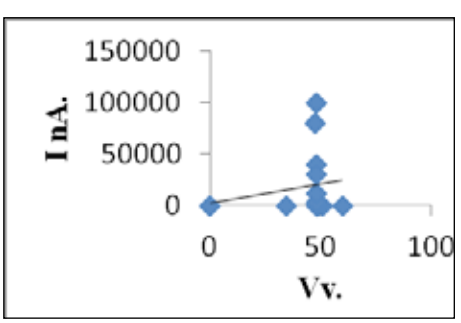

Fig.(9). I-V characteristics of PVA and Polyol blend with 40wt%. SPF.

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Table-4-. Current density passing through the samples at applied field strength.

5wt% SPF				10wt% SPF				15wt% SPF			
InA	V v	I A m^{-2}	$U_o V$ m^{-1}	InA	Vv	I A m^{-2}	$U_o V$ m^{-1}	I nA	Vv	I A m^{-2}	$U_o V$ m^{-1}
1.8	9.59	$7.692x10^{-5}$	$2.787x10^{2}$	0.09	10.58	$0.489x10^{-5}$	$3.158x10^{2}$	0.2	11.39	$0.913x10^{-5}$	$3.559x10^{2}$
2	9.60	$8.547x10^{-13}$	$2.79x10^{2}$	0.45	10.36	$2.445x10^{-5}$	$3.092x10^{2}$	0.6	10.08	$2.739x10^{-5}$	$3.15x10^{2}$
5.5	6.79	$23.504x10^{-5}$	$1.973x10^{2}$	0.8	10.34	$4.347x10^{-9}$	$3.086x10^{2}$	0.8	10.31	$3.653x10^{-5}$	$3.221x10^{2}$
7	6.79	$29.914x10^{-5}$	$1.973x10^{2}$	0.5	10.33	$2.717x10^{5}$	$3.083x10^{2}$	3	9.2	$13.697x10^{-5}$	$2.875x10^{2}$
21	3.69	$89.743x10^{-5}$	$1.07x10^{2}$	0.8	10.4	$4.34x\ 10^{-5}$	$3.11x10^{2}$	6	6.63	$27.3x\ 10^{-5}$	$2.07x10^{2}$
18	3.72	$76.923x10^{-5}$	$1.08x10^{2}$	0.6	10.4	$3.26x\ 10^{-5}$	$3.11x10^{2}$	2	6.63	$9.13x\ 10^{-5}$	$2.07x10^{2}$
80	1.08	$341.88x10^{-5}$	$0.31x10^{2}$	6.5	9.33	$35.3x\ 10^{-5}$	$2.78x10^{2}$	10	6.68	$45.6x\ 10^{-5}$	$2.08x10^{2}$
240	0.34	$1025.6x10^{-5}$	$0.10x10^{2}$	50	1.34	$271x\ 10^{-5}$	$0.4x\ 10^{2}$	10	3.84	$45.6x\ 10^{-5}$	$1.21x10^{2}$
190	0.49	$811.96x10^{-5}$	$0.13x10^{2}$	8000	0.52	$43478x10^{-5}$	$0.157x10^{2}$	21	3.74	$95.8x\ 10^{-5}$	$1.17x10^{2}$
290	0.49	$1239.3x10^{-5}$	$0.13x10^{2}$	6000	0.19	$32608x10^{-5}$	$0.059x10^{2}$	90	3.79	$410x\ 10^{-5}$	$1.18x10^{2}$
5000	0.04	$21367x10^{-5}$	$0.01x10^{2}$	6000	0.05	$32608x10^{-5}$	$0.015x10^{2}$	280	0.27	$1278x\ 10^{-5}$	$0.08x10^{2}$
9000	0.06	$38461x10^{-5}$	$0.017x10^{2}$	25000	0.04	$135869x10^{-5}$	$0.013x10^{2}$	240	0.737	$1095.8x10^{-5}$	$0.230x10^{2}$
5000	0.06	$21367x10^{-5}$	$0.018x10^{2}$	15000	.008	$81521x10^{-5}$	$0.002x10^{2}$	600	0.043	$2739.7x10^{-5}$	$0.0136x10^{2}$
4000	0.06	$17094x10^{-5}$	$0.02x10^{2}$	19000	0.05	$103260x10^{-5}$	$0.017x10^{2}$	2000	0.012	$9132.4x10^{-5}$	$0.0039x10^{2}$
6900	0.02	$29487x10^{-5}$	$0.008x10^{2}$	15000	0.08	$81521x10^{-5}$	$0.027x10^{2}$	1800	0.08	$8219.1x10^{-5}$	$0.025x10^{2}$
7000	0.03	$29914x10^{-5}$	$0.009x10^{2}$	40000	.009	$217391x10^{-5}$	$0.002x10^{2}$	2500	0.251	$11415x10^{-5}$	$0.0784x10^{2}$
23000	0.03	$98290x10^{-5}$	$0.010x10^{2}$					8000	0.28	$36529x10^{-5}$	$0.0875x10^{2}$
15000	0.04	$64102x10^{-5}$	$0.012x10^{2}$					28000	0.252	$127853x10^{-5}$	$0.0787x10^{2}$
60000	0.02	$256410x10^{-5}$	$0.008x10^{2}$					29000	-0.16	$132420x10^{-5}$	$-.052\ x10^{2}$
50000	0.02	$213675x10^{-5}$	$0.008x10^{2}$					26000	-0.14	$118721.4x10^{-5}$	$-.045\ x10^{2}$
60000	0.12	$256410x10^{-5}$	$0.051x10^{2}$					30000	-0.83	$136986x10^{-5}$	$-.260\ x10^{2}$
								80000	-0.12	$365296x10^{-5}$	$-0.04\ x10^{2}$
								90000	0.126	$410958x10^{-5}$	$0.0393x10^{2}$
20wt% SPF				30wt% SPF				40wt% SPF			
InA	V v	I A m^{-2}	$U_o V$ m^{-1}	InA	V v	I A m^{-2}	$U_o V$ m^{-1}	InA	V v	I A m^{-2}	$U_o V$ m^{-1}
0.8	9.9	$4.733\ x10^{-5}$	$2.59\ x10^{2}$	0.8	10.8	$2.54\ x\ 10^{-5}$	$3.18\ x10^{2}$	0.9	.009	$4.035\ x10^{-5}$	$0.002x10^{2}$
0.7	1.66	$4.142\ x10^{-5}$	$0.43\ x10^{2}$	8	7.53	$25.4\ x10^{-5}$	$2.22\ x10^{2}$	0.7	2.3	$3.13\ x10^{-5}$	$0.58\ x10^{2}$
0.89	10.0	$5.266\ x10^{-5}$	$2.64\ x10^{2}$	9	7.58	$28.6\ x10^{-5}$	$2.41\ x10^{2}$	2.9	2.5	$13x10^{-5}$	$0.64\ x10^{2}$
1.35	7.81	$7.988\ x10^{-5}$	$2.04\ x10^{2}$	10	7.54	$31.8\ x10^{-5}$	$2.22\ x10^{2}$	6	3.62	$26.9\ x10^{-5}$	$0.92\ x10^{2}$
1.35	8.8	$7.988\ x10^{-5}$	$2.30\ x10^{2}$	40	1.41	$127\ x10^{-5}$	$0.41\ x10^{2}$	8	3.61	$35.8\ x10^{-5}$	$0.92\ x10^{2}$
1.35	881	$7.988\ x10^{-5}$	$2.31\ x10^{2}$	90	1.20	$286\ x10^{-5}$	$0.35x10^{2}$	91	1.5	$408\ x10^{-5}$	$0.38\ x10^{2}$
7	8.92	$41.42\ x10^{-5}$	$2.34\ x10^{2}$	30	1.29	$95.5\ x10^{-5}$	$0.38\ x10^{2}$	50	1.95	$224\ x10^{-5}$	$0.5\ x10^{2}$
4	6.19	$23.66\ x10^{-5}$	$1.62\ x10^{2}$	80	1.28	$254\ x10^{-5}$	$0.37\ x10^{2}$	185	0.51	$829\ x10^{-5}$	$0.13\ x10^{2}$
6	6.18	$35.50\ x10^{-5}$	$1.62\ x10^{2}$	40	1.29	$127\ x10^{-5}$	$0.38\ x10^{2}$	190	0.43	$852\ x10^{-5}$	$0.11\ x10^{2}$
8	6.18	$47.33\ x10^{-5}$	$1.62\ x10^{2}$	290	0.46	$923\ x10^{-5}$	0.13	220	0.5	$986\ x10^{-5}$	$0.13\ x10^{2}$
33	3.41	$195.3\ x10^{-5}$	$0.89\ x10^{2}$	400	0.46	$1273\ x10^{-5}$	$0.13\ x10^{2}$	250	0.5	$1121\ x10^{-5}$	$0.13\ x10^{2}$
23	3.41	$136.1\ x10^{-5}$	$0.89\ x10^{2}$	500	0.13	$1592\ x10^{-5}$	$0.04\ x10^{2}$	300	0.49	$1345\ x10^{-5}$	$0.12\ x10^{2}$

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27	3.42	159.7 $x10^{-5}$	0.89 $x10^{2}$	400	0.14	1273 $x10^{-5}$	0.04 $x10^{2}$	900	0.12	4035 $x10^{-5}$	0.03 $x10^{2}$
32	3.42	189.3 $x10^{-5}$	0.89 $x10^{2}$	1100	0.14	3503$x10^{-5}$	0.04 $x10^{2}$	800	0.11	3587 $x10^{-5}$	0.028$x10^{2}$
38	3.42	224.8 $x10^{-5}$	0.89 $x10^{2}$	900	0.13	2866	0.04 $x10^{2}$	900	0.11	4036 $x10^{-5}$	0.02 $x10^{2}$
60	3.33	355 x 10^{-5}	0.87 $x10^{2}$	2400	0.0098	7643.3$x10^{-5}$	0.003$x10^{2}$	2800	0.035	12556 $x10^{-5}$	0.008$x10^{2}$
100	1.30	591.7 $x10^{-5}$	0.34 $x10^{2}$	2900	0.0092	9235.6$x10^{-5}$	0.002$x10^{2}$	2900	0.017	13004 $x10^{-5}$	0.004$x10^{2}$
220	0.47	1301.7$x10^{-5}$	0.124$x10^{2}$	2200	0.0092	7006.3$x10^{-5}$	027 $x10^{2}$	3000	0.013	13452 $x10^{-5}$	0.003$x10^{2}$
340	0.404	2011.834$x10^{-5}$	0.106$x10^{2}$	2900	0.0099	9235.66$x10^{-5}$	0.0029$x10^{2}$	12000	0.0197	53811.65$x10^{-5}$	0.005$x10^{2}$
400	0.42	2366.8$x10^{-5}$	0.110$x10^{2}$	8900	0.009	28343.94$x10^{-5}$	0.0026$x10^{2}$	13000	0.02	58295.96$x10^{-5}$	0.005$x10^{2}$
800	0.09	4733.7$x10^{-5}$	0.024$x10^{2}$	4700	.0146	14988.15$x10^{-5}$	0.0043$x10^{2}$	13000	0.07	58295 $x10^{-5}$	0.017$x10^{2}$
1000	0.02	5917 x 10^{-5}	0.07$x10^{2}$	4900	0.0146	15605.09$x10^{-5}$	0.0043$x10^{2}$	30000	0.041	134529$x10^{-5}$	0.01 $x10^{2}$
2400	0.252	14201 $x10^{-5}$	0.066$x10^{2}$	6900	0.0146	21974$x10^{-5}$	0.004$x10^{2}$	100000	0.054	448430$x10^{-5}$	0.013$x10^{2}$
1400	-.042	8284 x 10^{-5}	-.011 $x10^{2}$	10900	0.046	34713.37$x10^{-5}$	0.0043$x10^{2}$	100000	0.048	448430x10-5	0.012$x10^{2}$
3000	-.011	17751 $x10^{-5}$	-.028 $x10^{2}$	5900	0.046	18789.80$x10^{-5}$	0.004$x10^{2}$				
2800	-.052	16568 $x10^{-5}$	-.036 $x10^{2}$	4100	0.03	13057$x10^{-5}$	0.008$x10^{2}$				
2000	-.026	11834 $x10^{-5}$	-.006 $x10^{2}$	4300	0.03	13694$x10^{-5}$	0.008$x10^{2}$				
3000	-.047	17751 $x10^{-5}$	-.012 $x10^{2}$	11500	0.03	36624$x10^{-5}$	0.008$x10^{2}$				
8000	-.198	47337 $x10^{-5}$	-.051 $x10^{2}$	4900	0.059	15605 $x10^{-5}$	0.017$x10^{2}$				
4000	-.014	23668 $x10^{-5}$	-.003 $x10^{2}$	12700	0.04	40445 $x10^{-5}$	0.011$x10^{2}$				
13000	-.042	76923 $x10^{-5}$	-.011 $x10^{2}$	8900	0.04	28343 $x10^{-5}$	0.011$x10^{2}$				
24000	-.027	142011$x10^{-5}$	-.007 $x10^{2}$	11900	0.04	37898 $x10^{-5}$	0.011$x10^{2}$				
30000	-.030	177514$x10^{-5}$	-.007 $x10^{2}$	4500	0.04	14331 $x10^{-5}$	0.011$x10^{2}$				
12000	-.016	71005 $x10^{-5}$	-.004 $x10^{2}$	5300	0.04	16878 $x10^{-5}$	0.011$x10^{2}$				
50000	-.037	295857$x10^{-5}$	-.009 $x10^{2}$	23300	-0.04	74203 $x10^{-5}$	-.013 $x10^{2}$				
40000	-.018	236686$x10^{-5}$	-.004 $x10^{2}$	29300	-0.04	93312 $x10^{-5}$	-.013 $x10^{2}$				
80000	-.038	473372$x10^{-5}$	-.009 $x10^{2}$	25300	-0.04	80573 $x10^{-5}$	-.013 $x10^{2}$				
				30300	-0.04	96496 $x10^{-5}$	-.013 $x10^{2}$				

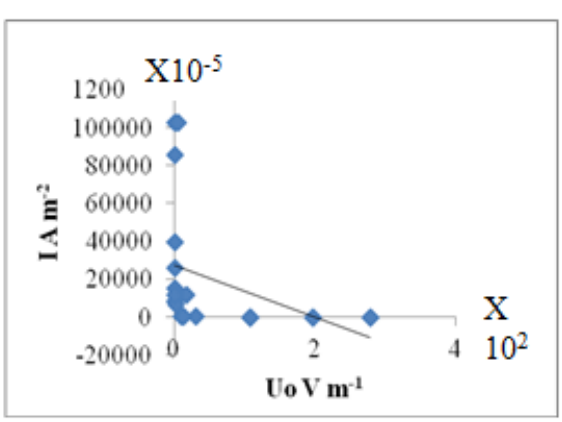

Fig.(10).Dependence of the current density passing through the bulk sample on applied field strength. At 5wt%SPF.

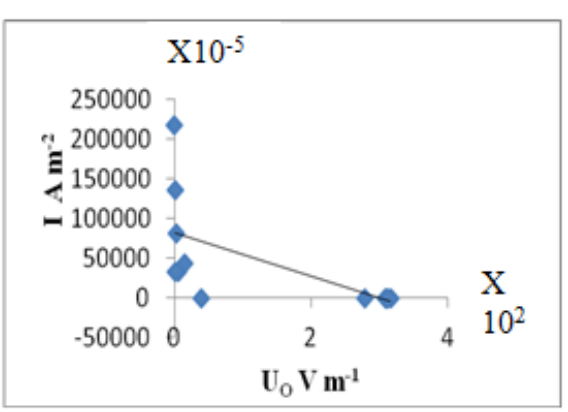

Fig.(11). Dependence of the current density passing through the bulk sample on applied field strength. At 10wt%SPF.

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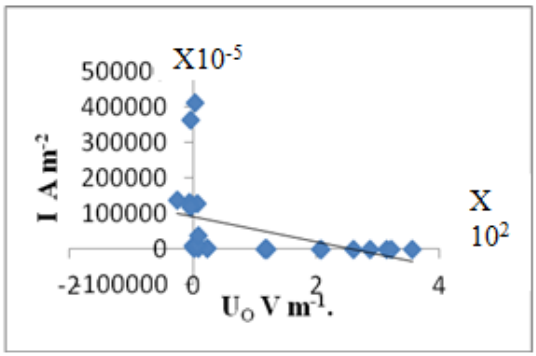

Fig.(12).dependence of the current density passing through the bulk sample on the applied field strength. At 15wt%SPF.

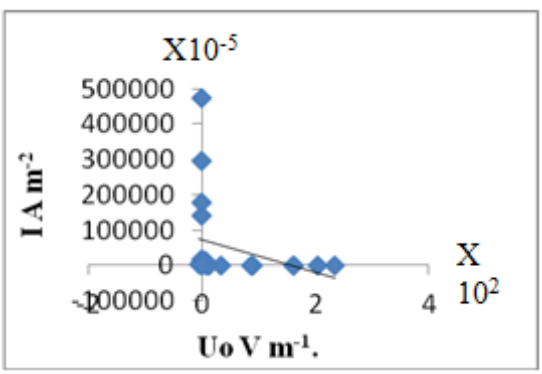

Fig.(13).dependence of the current density passing through the bulk sample on the applied field strength. At 20wt%SPF.

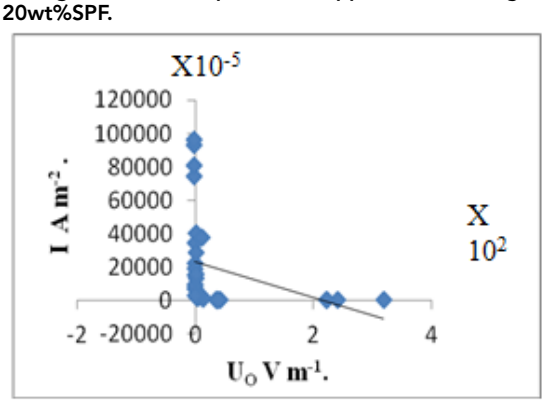

Fig.(14).dependence of the current density passing through the bulk film on the applied field strength. At 30wt%SPF.

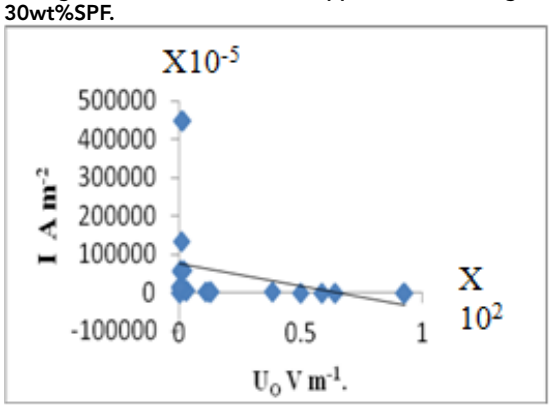

Fig.(15).dependence of the current density passing through the bulk film on the applied field strength. At 40wt%SPF.

Results and Discussions:

The shapes of plots obtained from Table-3-. The I-V characteristics depends on applied field the linearity of the graph obtained, there are points shifted from the straight line for the bulk sample of PVA-Polyol with 5wt% SPF in time of measurements 3480 sec. as shown in Figure (4), because of the instability of low current passes through the sample. The increase to 10wt% SPF, the linearity of the graph was rather instable cause sharp rise of some points, and there are points become more close to the straight line obtained, as shown in Figure (5). With 15wt% SPF, the current passes through the sample was affected by weak van der Waals interaction so there is no decrease in stability in the composite[J. N. Coleman, et al (1998)], at the beginning of the measurements and the current increased rapidly with time after 2520 sec., the experiment controlled by the source measurement unit allowing the measurement of the currents in nA to μA range, as in shown Figure (6). The current passes through the sample become rather instable at 20wt% SPF and increased with time of measurements 55 min. in the range indicated a straight line was obtained with voltage across the sample as shown in Figure (7).

Increased current at time of measurement 2820 sec. at 30wt% SPF of sample and thickness $0.17x10^{-2}$ m. gives a significant dependant of random distribution obtained on sample thickness as shown in Figure (8). Electric measurements of polymeric composites, these materials are typically disordered structures consisting randomly arranged filler dispersed in polymer medium[J. Vilcakova, et al (2000)]. Figure (9), shows that the prepared SPF was increased to 40wt%SPF, this is more convenient of current and voltage measurements across the bulk sample. The current was increased with increasing voltage at time 4320 sec. The thickness of the sample was increased to $0.18x10^{-2}$ m. also reflects dependencies of current on potential and there is jump in current rather than electron transfer[T. F. Otero, et al (2010)].

Table-4-. According to shape geometry of the bulk samples, the current density passes through the samples were plotted as a function of applied field strength. Figure (10), shows the dependence of current density passes through the bulk samples on the applied field strength, causes shift of the points from linearity. Conduction is predominantly achieved through the sample with 5wt% SPF and was controlled by the resistance of sample against the current which passes through under certain applied field. The increase to 10wt% SPF, the dependence of the current density on the applied field strength, as the applied field strength was decreased, the current density have increased as shown in Figure (11)[J. Vilcakova, et al (2000)], the dependence of current density on the electric field strength in the range of applied field strength $(3.15\text{-}0.002)x10^2$ V m^{-1}. The system needs to overcome the resistance so that increase the transferred electron and the current is low even with high electric voltage. Figure (12), shows that more stable current density through the sample depend on the applied field strength at 15wt% SPF, this was a result in increase the electrical current. The electrical conduction depends on the shape geometry and structure of the composite this reflects the graph distribution of current density dependent on the electric field strength[D. D. L. Chung (2001)]. The increase of SPF to 20wt%SPF, the current density is no longer be random depending on electrical field strength and have decreased as the current density have increased, as shown in Figure (13). This behavior is indicative of percolative character in composite systems. Percolation theory deals with the effect of varying, in random system, the interconnections in this case are the highly conductive polymer composite. In Figure (14), the increase to 30wt%SPF of the sample the behavior as the electric field have decreased, the current density was increased, the conduction is predominantly achieved through the sample with increasing to 30wt%SPF at critical concentration of SPF, beyond this the polymer composite becomes conductive is referred to as the percolation threshold at this point the conductive network

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is formed through composite constituents. This permits the movement of charge carriers in the SPF through the polymer composite constituents, and so the composite achieves a certain degree of electrical conductivity[J. N. Coleman, et al (1998)]. Figure (15), shows the dependence of current density passing through the bulk sample on the applied strength at 40wt%SPF, due to the effects SPF on PVA-Polyol molecular structures on their electrical conductivity, this is increased with increasing SPF[L. Bokobza (2012)]. Polymer composite are intensively studied for the new properties these are given by the combination of the properties of both polymer matrix (SPF) and binds together a cluster or fragments of a much stronger material (the reinforcement) respectively. If the concentration of the binds in the composite reaches the percolation value, the continues bulk network structure is formed. If (SPF) binder becomes electrically conductive the composite properties can change from insulator to conductive ones[Y. P. Mamunya, et al (2002)]. Electrical conductivity can change in the magnitude of the several orders. From Table-3-, by using the formula (1 and 2) the calculated electrical conductivity from the reciprocal of the resistivity was increased by many orders of magnitude was increased from ($1.743x10^{-6}$, $6.756x10^{-3}$) S m^{-1} to (3.7, 185.8) S m^{-1}. The minimum values at (15, 40) wt%SPF and the maximum values are at (15, 30) wt%SPF[Yun-Ze Long and etal, (2010)]. The dependence of conductivity on (SPF) shows sharp rise (percolation threshold)[S. Bhagat, (2013), J. Lptack, etal (2010)]. The electrical conductivity is a sensitive probe of composite, the percolation behavior in the electrical conductivity of composite at relatively loading percentages by weight (5 and 10) wt% SPF [E. S. Choi, etal, (2003)].

Conclusions:

The investigation was carried out in order to evaluate the effect of the prepared SPF on the electrical characteristics of PVA-polyol. On the basis of obtained results the following conclusions were drawn:

1- The effect of SPF on polymer blending PVA-Polyol was investigated. Improved electrical conductivity approached with increasing SPFwt%.

2- Dry SPF can influence the resulting structure in the composite by the effect of the polymer and the SPF network formation is van der Waals interaction between SPF surrounds and binds.

3- Thicknesses of bulk samples were given a significant dependant of linear graphs obtained on samples thicknesses rather than the voltage across the sample.

4- Effect of external field-electrical, when applied SPF particles agglomerations preferred in the direction of the electric field force lines results to the SPF chains.

5- Conductive polymers have many advantages over metallic conductors; they can be easily shaped with low cost technologies: they have light weight; they provide corrosion resistance and they can offer wide range of electrical conductivities.

6- At critical concentration of SPF, conductivity around percolation threshold is formed through the polymer composite.

7- The increase of SPF wt% will alter the dependencies of current density passing through the bulk samples on the applied field strength due its effect on PVA-Polyol molecular structures on their electrical conductivity.

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