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Preparation of PVA/TiO_2 Nanocomposite Films with Various TiO_2 Phases by Sol–Gel Technique

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Received: 14 June 2022 **Accepted: 17 July 2022**
DOI: https://dx.doi.org/10.24237/djps.1804.609B

Abstract

The titanium oxide (TiO_2) nanoparticles were prepared using the sol-gel technique. The calcination temperature (650, 850) C° has produced the different TiO_2 structures (anatase and rutile), and the effect of the calcination temperature of particles was studied. (TiO_2) on the structural properties of the prepared nanomaterial. Furthermore, at room-temperature casting process was used to create a PVA/TiO_2 nanocomposite with different TiO_2 phases. showed the results of X-ray diffraction (XRD) that a qualitative tetragonal crystal structure (antase, rutile) and scanning electron microscopy FE-SEM used to confirm the microstructure of TiO_2 nanoparticles and the effect of each of the calcinations (650, 850) and weight percentages (0.2, 0.4, 0.6, 0.8, 1 wt%) from titanium dioxide nanoparticles on electrical properties of the prepared polymeric (PVA) films. The A. C. conductivity, dielectric constant, and the influence of frequency on the value of A. C. conductivity have been investigated. The results of the electrical properties of alternate current have shown that the dielectric constant decreases with increasing the frequency of the applied field and that alternative conductivity and dielectric constantincrease by increasing the concentration of the nanoparticle.

Keywords: PVA/TiO_2 Thick films, Reinforced material, SEM, electrical properties, Sol-ge.

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تحضير اغشية بوليمرية للمتراكبات النانويةPVA/TiO2 بمراحل مختلفة لثنائي اوكسيد التيتانيوم (TiO2) النانوي بتقنية (Sol –Gol)

فراس حيدر إبراهيم والفت احمد محمود

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الخلاصة

تم استخدام طريقة محلول –هلام (Sol-Gol) لتحضير جزيئات أكسيد التيتانيوم (TiO2) النانوية. تم إنشاء التراكيب المختلفة لـنثائي اوكسيد التيتانيومTiO2 النانوي (anatase and rutile) بواسطة درجات حرارة التكليس ℃(650، 850) والتي تعتبر تقنية جديدة لتغيير الطور. بالإضافة الى ذلك، تم استخدام عملية صب المحلول في درجة حرارة الغرفة لإنشاء أغشية بوليمرية مركبة نانوي PVA / TiO2 بمراحل TiO2 مختلفة. تم استخدام حيود الأشعة السينية (XRD) والمسح المجهري الإلكتروني النافذFE (SEM-) لتأكيد البنية المجهرية للجسيمات النانويةTiO2 .تم دراسة تأثير الجسيمات TiO2النانوية على لغشاء PVA النقي. تم فحص كل من موصلية التيار المتناوب (σa.c) وثابت العزل الكهربائي (ε') وتأثير درجة حرارة التكليس وطور الجسيمات النانوية المضافة والتردد على قيمة ثابت العزل على موصلية المتناوبة. أظهرت نتائج الخواص الكهربائية للتيار المتناوب أن ثابت العزل الكهربائي يتناقص مع زيادة التردد المجال المسلط وأن الموصلية المتناوبة وثابت العزل الكهربائي يزدادان مع زيادة الجسيمات النانوية.

الكلمات المفتاحية: اغشية PAV/TiO_2، المواد المدعمة، SEM، الخواص الكهربائية، تقنية.

Introduction

Recently, polymer-based nanocomposites have gained attention as adaptable materials with a variety of scientific applications that will progress technology[1, 2]. Many different types of nanomaterials have been used to create organic and inorganic nanocomposites, including titanium oxide (TiO_2) nanoparticles, which have gotten a lot of attention because of their good electrical conductivity, high index of refraction, nontoxicity, UV absorbance, [3]. Titanium oxide TiO_2 is available in Three known forms that are proven in nature: anatase (tetragonal),

brookite (rhombic), and rutile (tetragonal)[4, 5]. TiO_2 is well known as a strong redox material that sought to refine cell air-water and photoelectrochemical processes [6]. The most important TiO_2 phases are typically rutile and anatase structures. Experimental estimates of their structural, optical, and electrical properties have been made using a variety of techniques[7, 8]. Due to its unique features such as low temperature processing, high uniformity of end products, and the ability to manufacture materials with regulated surface properties, the sol-gel technique is appealing for the preparation of nanocomposite materials[9, 10] .

PVA is one of the most importance water-soluble polymers returns to its excellent thermal and optical characteristics, return its film-forming abilities, biocompatibility, and cost-efficiency, polyvinyl alcohol has been globally utilized as a polymer matrix material to make nanocomposites. Various applications encompass sensors, supercapacitors and solar cells[11-14]. PVA is usually dimensionally stable and photo-stable under UV–vis light irradiation. Furthermore, due to the substantial inter-cohesive energy that affects polar alcohol (OH) films, they have a limited oxygen permeability [15]. When PVA polymer is combined with TiO_2, the amorphous and crystalline parts of the polymer may interact, resulting in changes in electrical, structural, and optical properties. As a result, any information about the effect of additives on a polymer can be used to characterize it for a certain purpose[16] . The creation of covalent bonds (Ti–O–C) between PVA and TiO_2 nanoparticles results in the production of TiO_2 clusters in the PVA matrix [17]. The establishment of a Ti–OH connection between TiO_2 nanoparticles and the OH groups present in PVA polymer also results in structural modification of the PVA matrix [19 ,18].The goal of this research is to use the sol-gel method offers several advantages including simplicity of equipment and ease of implementation of the material, low energy cost, high purity and better homogeneity of the material, and realization of multi-component deposits in a single operation [20]. Changing only the calcination temperature new and easy way to convert anatase TiO_2 to rutile. To assess the content, investigate the characteristics of alternating current across a broad frequency range, as well as the dielectric constant and the

features of different phases of TiO_2 nanoparticles, a PVA/TiO_2 nanocomposite thin film was created by solution casting.

Experimental details

Materials

The Polyvinyl Alcohol (PVA) polymer, made by Central Drug House, is the primary substance utilized to create the overlapping thick films. (P, Ltd. New Delhi INDIA). Molecular weight (125,000 - 60,000), purity 4 nitrogen 97% aqueous solution of Sigma Aldrich. Titanium Tetrachloride 99.99% $TiCl_4$ Origin BDH, Englan & Pure Ethanol (99.99% CH_3CH_2OH).

Synthesis of Titanium Dioxide TiO_2 nanoparticles

The following steps were used to make TiO_2 nanoparticles by using the Sol-Gel method: Using a graduated burette, 1 ml of titanium tetrachloride (99.99 percent TiCl4) was added. As reaction master solutions (15 ml) of pure ethanol at room temperature (25 C°), The development of white vapors arising from the hydrolysis of titanium tetrachloride was noted during the addition process, and the two solutions were then blended with constant stirring and without heat. To obtain a uniform yellow light solution, mix with a magnetic mixer at room temperature for an hour and a half. After stirring continuously until the pH (acidic) of the solution reaches (pH = 1.4), the homogenous solution in a dry oven for an hour and a half at a temperature below (100C°) to create a thick white gel, which was then calcined at different temperatures (650, 850) C° for two hours. The prepared material has been finely ground. The presence of titanium dioxide in two phases (anatas and rutile) was discovered using X-ray (Rigaku, Tokyo, Japan) diffraction. The Anatas phase was made at (650) C°, while the rutile phase was made at (850) C°.Using Debye–Scherrer Equation (1)[21], the average crystalline size of TiO2 nanoparticles.

$$D = \frac{K\lambda}{\beta\cos\theta} \quad \text{.....(1)}$$

Where K represents a Scherrer's factor, λ is the X-ray wavelength, β is the value of the FWHM and θ is the Bragg's angle.

Preparation of PVA /TiO_2 films

Solution casting technology was used to create polymeric thick films of the PVA/TiO2 nanocomposite, pure PVA film: a suitable weight of (1) g of polymers PVA was dissolved in 15 ml of deionized water. The mixture was magnetically agitated continuously for 1 hours while being heated to 75C°, the solution mixture appeared uniformly viscous at room temperature. The gel was placed onto a Petri plate and allowed to solidify at room temperature for three Days. PVA/TiO2 Naocomposites: 1 g of polymers PVA was dissolved in the same way as before. Weight ratios (0.2, 0.4, 0.6, 0.8, 1) wt% g of (TiO2Anatase) and (TiO2Rutile) nanoparticles were added to a polymer PVA and magnetically agitated strongly for 2 hours, followed by a half-hour ultrasonic bath.

To get a proper dispersion without clumping. The resulting PVA/TiO2 mixture was placed onto a glass Petri dish, shaken to eliminate air bubbles, and left to dry for three Days. The thickness of the prepared membranes was measured using a device (Micrometer) and measurements were taken from different places of the membrane surface in order to obtain the average thickness, which was calculated to be ($25\mu m$). checked Electrical Characterizations for values for pure polyvinyl alcohol (PVA) thick films reinforced with antase phase titanium dioxide nanoparticle (TiO2Anatase) and (TiO2Rutile) different weight ratios and calcined with temperatures (650 , 850) ℃ respectively, and using a type of device(LCR-8105G) the factory in the company (GWINSTEK) of English origin Within the range of frequencies, (1MHZ) to (5MHZ) at room temperature (25C°), Description The susceptibility of a substance to polarization and storage of electric charge is given by relative Permittivity or dielectric Constant (εr) it is defined as the ratio between vacuum permitvity to dielectric permitvity [22].

$$\frac{Ć}{Co} = \frac{\varepsilon}{\varepsilon o} = \varepsilon \quad \text{.....(2)}$$

The measured capacitance (Ć) is used to calculate the dielectric constant (ε′) using the following relationship:

$$\varepsilon' = C' d_{dis} / \varepsilon_o A \quad \text{.....(3)}$$

WhereC' represents a capacitance, d_{dis} is the Distance two plates, ε_o is the Permittivity constant and A is the Surface area of the plate.

And the dielectric loss it is given by the following relationship[23]:

$$\varepsilon''_r = \tan\delta * \varepsilon \quad \text{.....(4)}$$

Since:

tan δ: (Dissipation Factor).

So, it is clear from the above that the dielectric constant (ε_r) is an unreal quantity, but it is a complex quantity (Complex) that possesses a real part representing (ε′r), which is a measure of capacitance and polarization, and an imaginary part (ε''_r), which is the measure of loss in insulators.

The AC electrical conductivity (σa.c) can be calculated using the following relationship:

$$\sigma_{a.c} = \omega\, \varepsilon_o\, \varepsilon''_r \quad \text{.....(5)}$$

Where ω represents Anglar frequency $\omega = 2\pi f$, ε_o is the Permittivity constant and, ε''_r is the Dielectric loss.

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Results and Discussion

X-ray diffraction (XRD)

The XRD pattern of TiO_2 NPs is shown in Figure 1 and of calcined at two different temperatures (650 and 850) °C Tables 1 and 2, which summarize the crystal size values and a few constants for the prepared samples at various temperatures, illustrate.

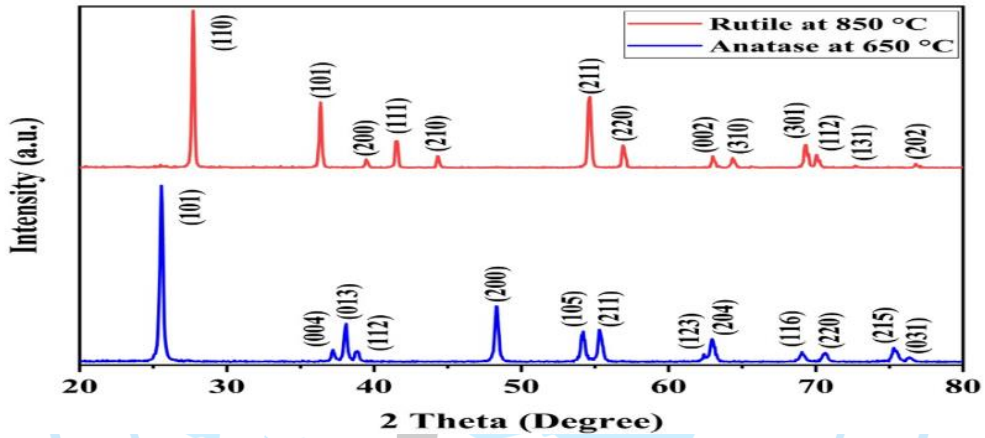

Figure 1: XRD pattern for TiO2 nanoparticles

Table 1: X-ray diffraction calculations for titanium oxide (TiO2), a type of calcined rutile at a temperature of (850 °).

2Θ (deg) Practical	2Θ (deg) Standard	FWHM (deg)	Crystalline size (nm)	d_{hkl} (°A) Practical	d_{hkl} (°A) Standard	(hkl)
27.65	27.506	0.2011	38.359	3.223	3.24	(110)
36.33	36.041	0.1971	38.29	2.47	2.49	(101)
39.44	39.312	0.2285	32.72	2.282	2.29	(200)
41.48	41.187	0.2336	31.8	2.175	2.19	(111)
44.37	44.142	0.1978	37.18	2.039	2.05	(210)
54.66	54.63	0.2691	26.22	1.677	1.678	(121)
57.008	56.783	0.2708	25.78	1.614	1.62	(220)
63.03	62.260	0.2675	25.31	1.473	1.49	(002)
64.42	64.197	0.2976	22.58	1.445	1.45	(310)
69.36	68.999	0.3203	20.39	1.353	1.36	(301)
70.11	70.12	0.3155	20.61	1.341	1.340	(112)
72.79	72.88	0.1654	38.66	1.298	1.296	(131)
76.81	76.084	0.1658	37.53	1.239	1.25	(202)

Table 2: X-ray diffraction calculations for titanium oxide (TiO2), anatase type, calcined at (650 °C).

2Θ (deg) Practical	2Θ (deg) Standard	FWHM (deg)	Crystalline size (nm)	d_{hkl} (°A) Practical	d_{hkl} (°A) Standard	(hkl)
25.58	25.625	0.28323	27.35	3.479	3.47	(101)
37.16	37.604	0.29378	25.63	2.417	2.39	(004)
38.12	38.269	0.28279	26.55	2.358	2. 35	(013)
38.87	38.958	0.25684	29.16	2.315	2.31	(112)
48.31	48.367	0.30896	23.46	1.882	1.88	(200)
54.21	54.233	0.35982	19.65	1.6905	1.69	(105)
55.38	55.660	0.3551	19.8	1.657	1.65	(211)
62.33	62.47	0.3746	23.07	1.488	1.485	(123)
63.04	63.204	0.41683	16.24	1.471	1.47	(204)
69.11	68.999	0.41195	15.88	1.358	1.36	(116)
70.65	70.785	0.40446	16.02	1.332	1.33	(220)
75.32	75.374	0.46583	13.5	1.2602	1.26	(125)
76.38	76.809	0.3845	21.94	1.245	1.24	(031)

The anatase phase at (650) C° of the produced nanoparticles was revealed by the diffraction peaks, as validated by JCPDS card No. 02-0406. Titanium dioxide-anatase type, with a tetragonal crystalline structure, Using Debye–Scherrer Equation the average crystalline size of TiO2 nanoparticles was calculated to be (21.4 nm).

The diffraction peaks showed that the formed nanoparticles exhibited rutile phase at (850) C°, These results are in in good agreement with the researcher investigation[24] .which was confirmed by the JCPDS card No. 01-1292. The average crystalline size of the TiO2 nanoparticles was calculated using Debye–Scherrer Equation (1), and was (30.42 nm) displayed that the particles were nanometer size. These results are in in good agreement with the researcher investigation[25]. It demonstrates a correlation between crystalline size and temperature due to an increase in crystalline growth with rising temperature and a corresponding increase in crystal size [26].

Scanning Electron Microscope (FE-SEM)

The antase phase titanium dioxide powder (TiO2Anatase) has an essentially spherical form and a polyhedral shape, as shown in Figure (2-a) at the calcination temperature (650C°)[27]. and

when the temperature rises to around 850°C, the particle diameters grow larger, cluster together, and become irregular particles ,these results are in in good agreement with the researcher investigation[24]. As shown in figure (3-a).

The volume equations of these particles were computed using (Imag j) programs, and the size distribution of the two-phase particles of (TiO2Anatase) and (TiO2Rutile) nanoparticles was calculated using the (Origin Pro 8.5) method, as shown in Figures (2-b) and (3-b). At 650 C°, at 850C°, the wavelength (52.78nm) increases to (59.57nm). Because of the increase in volume, calcination at a high temperature leads the grains to continue to expand and merge with one another, increasing the size of the grains [28] , On the one hand, when the temperature rises, the size of the grains grows due to crystal growth and atomic diffusivity. Particle agglomeration and granular growth are greatly aided by increasing the calcining temperature (the diffusion of small particles across large particles). These results (FE-SEM) are in agreement with the results(XRD) [29]

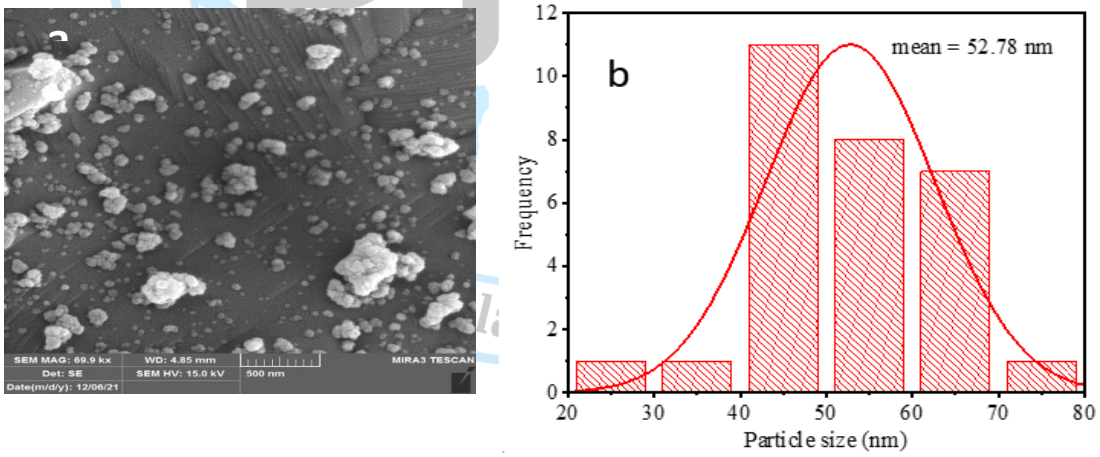

Figure 2: a- FE-SEM images. b- size distribution of calcined (TiO_2Anatase) nano titanium dioxide particles at (650C°).

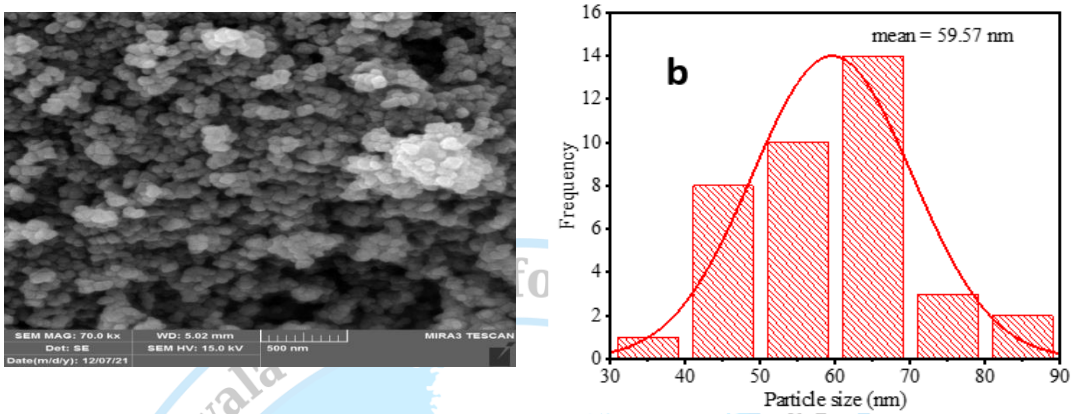

Figure 3: a- FE-SEM images. b- size distribution of calcined (TiO_2Rutile) nano titanium dioxide particles at (850C°).

Electrical Characterizations

Dielectric Constant

The values of the dielectric constants were computed('ε) According to the equation (3):

For pure polyvinyl alcohol (PVA) thick films reinforced with antase phase titanium dioxide nanoparticle (TiO_2Anatase) and (TiO2Rutile) different weight ratios(0.2 , 0.4 , 0.6 , 0.8 , 1)wt% and calcined with temperatures (650 , 850) ℃ respectively , Within the range of frequencies, (1MHZ) to (5MHZ) at room temperature (25C°) the two Figure (a-4) و (b-4) Shows the dielectric constant('ε) for Polyvinyl Alcohol pure (PVA) pure Supported by nanoparticles of titanium dioxide for two phases(TiO_2Anatase) and (TiO2Rutile) nano the dielectric constant values drop as a function of frequency applied field frequency is increased, as shown in the two Figures. The ratio of space charge polarization (interfacial polarization) Total polarization decreases as frequency rises. The ratio of space charge polarization (interfacial polarization) to total polarization decreases as frequencies rise. With the increase of the electric field frequency, at low frequencies, space charge polarization is the most important type of polarization, and as frequency increases, it becomes less important; this would result in a fall in dielectric constant

values for all samples of the material. (PVA/TiO_2Anatase) and (PVA/TiO2Rutile) nanocomposites with projected frequency (f). At high frequencies, the other forms of polarizations arise. In comparison to electronic polarization, ionic polarization reacts only little to changes in field frequency. This is due to the fact that the mass of an ion is higher than the mass of an electron. The electrons react to even the greatest frequencies of the field vibrations. Due to the electron's low mass, electronic polarization is the only type of polarization that occurs at higher frequencies. This causes the dielectric constant to be almost constant for all samples at high frequencies. This corresponds to the findings of the researcher [30]. In addition to that, in polar materials, the initial dielectric constant has a high value and then decreases with increasing frequency, a common behavior in many polymer materials [31]. The influence of titanium dioxide nanoparticles on the dielectric constant is seen in Figures (a-4) and (b-4). that as the concentration of titanium dioxide nanoparticles rises, the dielectric constant rises as well. The creation of a continuous network of titanium dioxide nanoparticles is responsible for the increase in dielectric constant. The dielectric constant of titanium dioxide nanoparticles becomes the reduction in ε1 with frequency: ε1 for polar materials at low frequencies is owing to the contribution of many forms of polarizability, (orientational electronic, ionic, and interfacial). When the frequency was raised, the dipole will no longer be able to rotate quickly enough. As a result, their oscillation is too far behind the field. The dipole will be totally unable to follow the field, and the orientation will be lost, therefore ε1decreases with a higher frequency, reaching a stable value owing to interfacial polarization relatively low at low concentrations because the nanoparticles form clusters or distinct groups. And, at high concentrations, titanium dioxide nanoparticles create a continuous network inside the nanocomposite, increasing the capacity to store charges, and, as a result, the value of the dielectric constant rises with the volumetric rate of the titanium dioxide nanoparticles [32].

Table3: Values of Dielectric Constant (ε') for a pure PVA film with weight ratio (PVA/TiO2 Anatase) and (PVA/TiO2 Rutile)

Weight Ratio (wt% g) of Sait(PVA/TiO2 Anatase) (ε')						Frequency (MHZ)
1	80.	0.6	0.4	0.2	Pure PVA	
41.1211	34.6568	30.6518	27.5743	24.7846	17.3499	1
38.6121	33.2856	29.2866	26.1435	23.9793	16.5230	2
38.1131	32.9980	28.9980	25.8990	23.6988	16.4655	3
37.8311	32.4156	28.1565	25.2232	22.9883	15.8903	4
39.1121	33.1856	29.1856	26.6044	23.6048	16.4909	5
Weight Ratio (wt% g) of Sait(PVA/ TiO_2 Rutile) (ε')						
1	80.	0.6	0.4	0.2	Pure PVA	Frequency (MHZ)
51.0647	42.2120	36.2518	32.4518	26.7846	17.3499	1
48.6057	39.7121	34.8856	31.0856	25.8354	16.5230	2
47.5127	39.3321	34.6434	30.8411	25.6930	16.4655	3
47.04431	38.7212	34.0156	30.2156	25.2962	15.8903	4
49.4901	40.6312	35.4824	31.6824	25.6048	16.4909	5

We notice through the table (3) that the highest value of the dielectric constant at a weight ratio (1wt% g) of composite (PVA/TiO2Rutile) polymer thick films its amount is equal to (ε'=49.4901). Figure (4-C) indicates that the dielectric constant of polymeric thick films changes with the TiO2 phase, with the dielectric constant of composite (PVA/TiO2Rutile) polymer thick films in the higher phase and the dielectric constant of composite (PVA/TiO_2Anatase) polymer thick films in the lower phase. This is due to the fact that increasing the calcination temperature causes a decrease in porosity and an increase in particle size, which is consistent with the results of (XRD) test, as the decrease in porosity causes the accumulation of charge carriers at the interface areas, which causes an increase in polarization, othus increasing the dielectric constant while increasing the size of the TiO_2 nanoparticles at a lower temperature [33]

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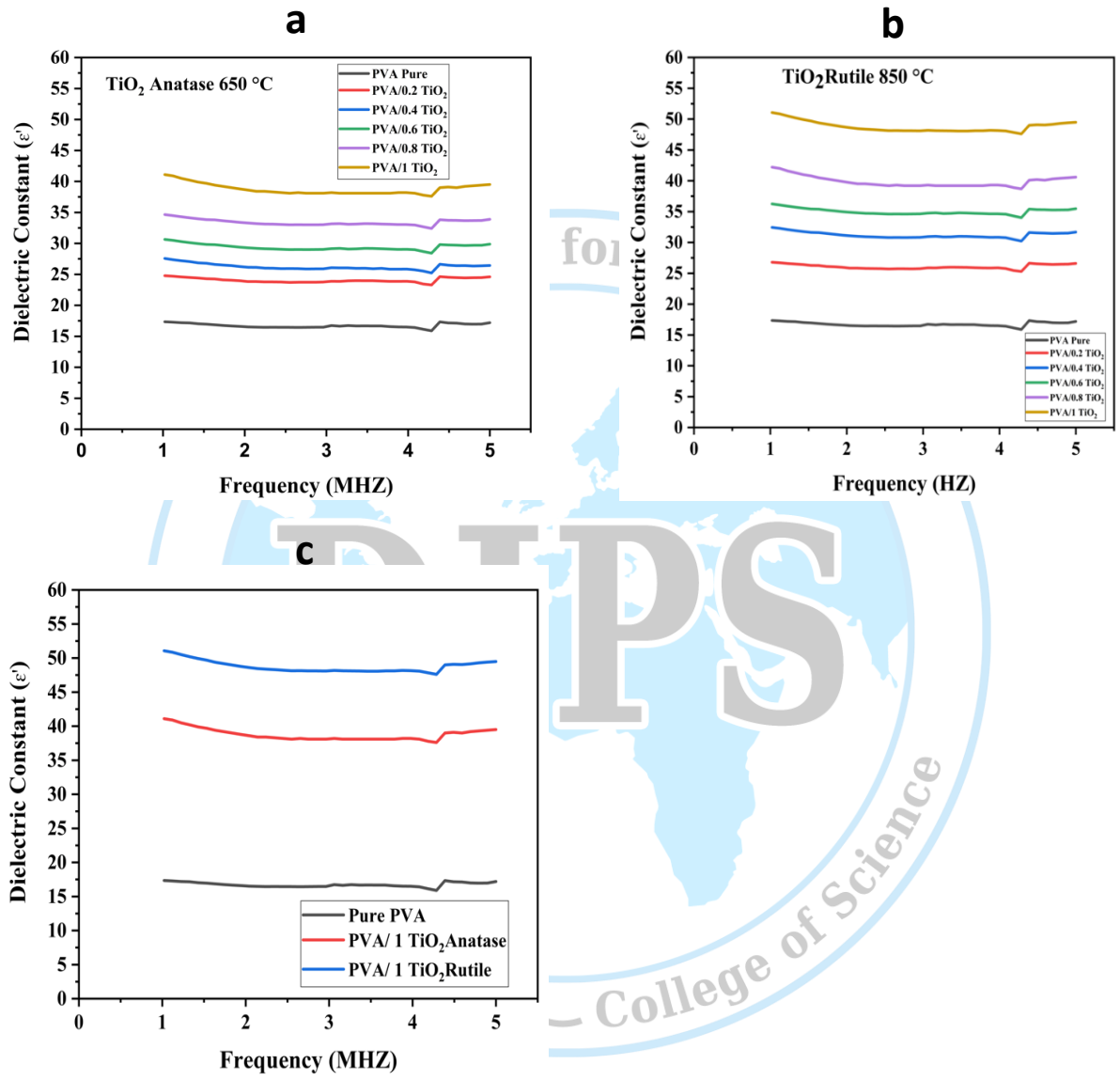

Figure 4: The Dielectric constant of the pure membrane (PVA) supported by titanium dioxide (a) particles. The rutile phase (TiO_2Rutile (b) TiO_2 anatase (c). Comparison between the two phases.

A.C Electrical Conductivity

Alternating electrical conductivity ($\sigma_{a.c}$) has been studied for pure polyvinyl alcohol (PVA)thick films reinforced with antase phase titanium dioxide nanoparticle (TiO2Anatase) and (TiO2Rutile) With different percentage and weight(0.2 , 0.4 , 0.6 , 0.8 , 1)wt% and calcined with temperatures (650 , 850 C˚ respectively , Within the frequency range of (1MHZ) to (5MHZ) at room temperature (25C˚) Using the equation (5)

the two figure, digram (a-5) و (b-5) The results show that the alternating conductivity increased with titanium dioxide nanoparticles for two phases (TiO2Anatase) and (TiO2Rutile) added to the (PVA) polymer the results reveal that when titanium dioxide nanoparticles (TiO2Anatase) and titanium dioxide nanoparticles (TiO2Rutile) are introduced to the (PVA) polymer, the alternating conductivity increases. at modest concentrations of titanium dioxide nanoparticles, the A.C conductivity increases slightlyas. The influence of the space charge is responsible for this increase. Clusters or discrete groups of TiO2nanoparticles exist. Because of the increase in charge carriers and the creation of a continuous network of TiO_2nanoparticles inside the nanocomposite. As a result, the conductivity of (TiO_2Anatase) and (TiO_2Rutile) nanocomposites increases as the concentration of titanium dioxide nanoparticles increases. That's agree with researchers [34]. In addition, it leads to the creation of conductive paths within the structure of the prepared reinforced films, which in turn increases the value of the alternating current conductivity (a.c) and reduces the voltage barrier between the conduction levels. Increase the number and movement of conductive particles[35].

From the other side figures (a-5) and (b-5) The alternating electrical conductivity (σa.c) of pure polyvinyl alcohol (PVA) thick films and the films of (PVA/TiO_2Anatase) and (PVA/TiO_2Rutile) complexes with frequency show the graphs illustrate that when the frequency rises, the A.C conductivity rises as well. This is due to the space charge polarization that happens at low frequencies, as well as the hopping motion of charge carriers. At high frequencies, the increase in conductivity is minimal; this is due to electronic polarization and

charge carriers that travel through hopping process [36]. As a result, raising the frequency increases conductivity for all various rates of titanium dioxide nanoparticles in (PVA/TiO2Anatase) and (PVA/TiO2Rutile) nanocomposites.

Table 4: Values of A.C Electrical Conductivity ($\sigma_{a.c}$) for a pure PVA film with weight ratio (PVA/TiO_2 Anatase) and (PVA/TiO_2 Rutile).

Weight Ratio (wt% g) of Sait (PVA/TiO_2 Rutile)						
1	80.	0.6	0.4	0.2	Pure PVA	Frequency (MHZ)
5.5007×10^{-4}	4.6790×10^{-4}	3.8864×10^{-4}	2.7469×10^{-4}	1.6971×10^{-4}	1.1741×10^{-4}	1
7.5106×10^{-4}	5.9686×10^{-4}	4.5709×10^{-4}	3.6584×10^{-4}	2.2817×10^{-4}	1.1611×10^{-4}	2
0.0012	8.3963×10^{-4}	6.3082×10^{-4}	5.3480×10^{-4}	3.3728×10^{-4}	2.1489×10^{-4}	3
0.0017	0.0011	8.3196×10^{-4}	7.9249×10^{-4}	4.6701×10^{-4}	2.7607×10^{-4}	4
0.0018	0.0012	8.6970×10^{-4}	8.3145×10^{-4}	4.6774×10^{-4}	2.7788×10^{-4}	5
Weight Ratio (wt% g) of Sait (PVA/TiO_2 Anatase)						
1	80.	0.6	0.4	0.2	Pure PVA	Frequency (MHZ)
6.5072×10^{-4}	3.735×10^{-4}1	2.8594×10^{-4}	2.3059×10^{-4}	1.7794×10^{-4}	1.1741×10^{-4}	1
8.9644×10^{-4}	4.9516×10^{-4}	3.9304×10^{-4}	3.3829×10^{-4}	2.3149×10^{-4}	1.1611×10^{-4}	2
0.0013	6.5982×10^{-4}	5.5492×10^{-4}	4.5025×10^{-4}	3.5136×10^{-4}	2.1489×10^{-4}	3
0.00183	8.5023×10^{-4}	6.8111	5.5189	4.1497×10^{-4}	2.7607×10^{-4}	4
0.0020	9.5023×10^{-4}	7.6401×10^{-4}	5.9842×10^{-4}	4.4637×10^{-4}	2.7788×10^{-4}	5

Preparation of PVA/TiO_2 Nanocomposite Films with Various TiO_2 Phases by Sol–Gel Technique

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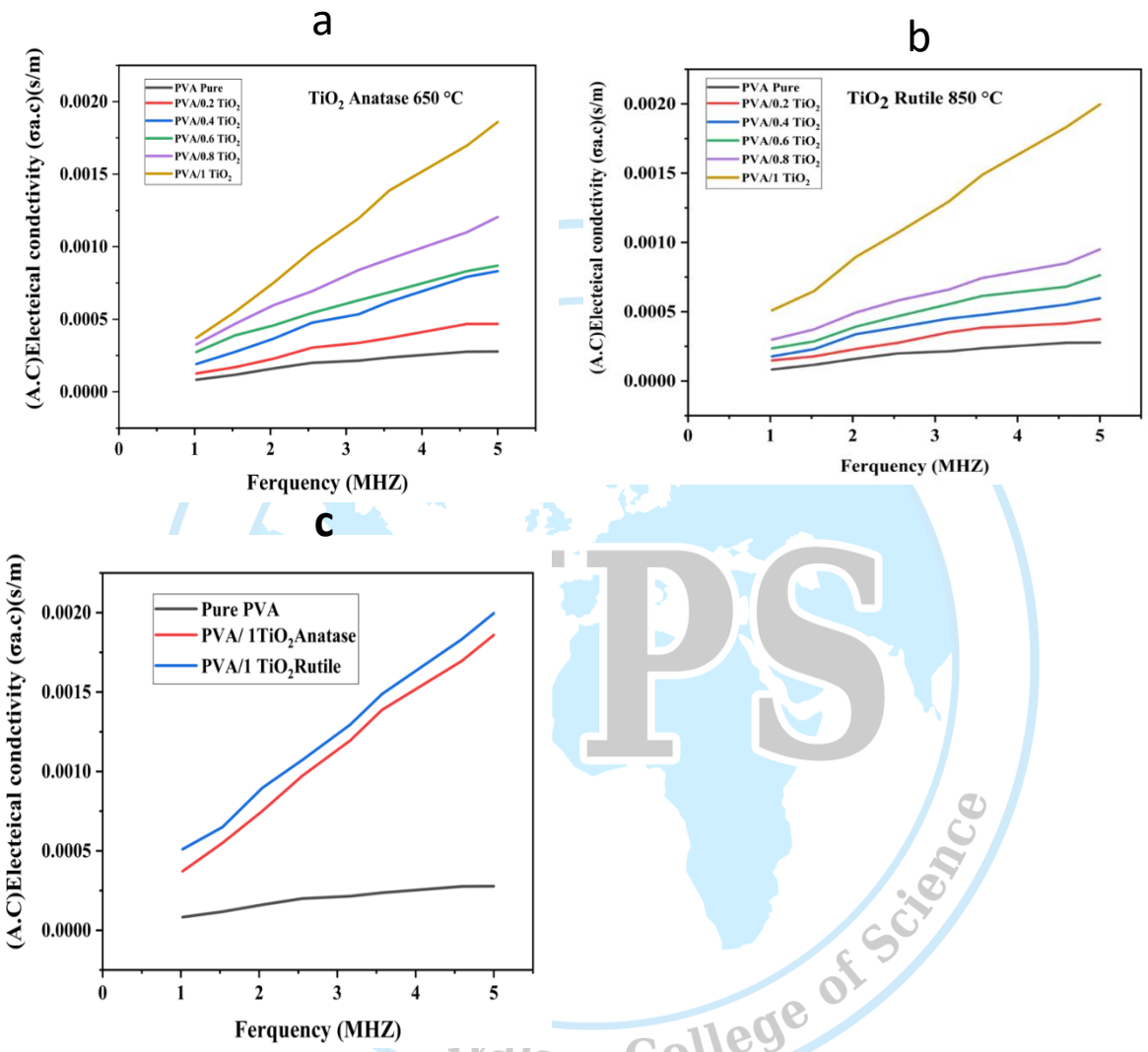

Figure 5: A.C Electrical Conductivity of the pure PVA film (a) PVA / TiO_2 anatase (b) PVA /TiO_2 Rutile (c). Comparison between the two phases.

Figure (5-C) shows that the A.C Electrical Conductivity of the polymeric thick films changes with the phase of TiO_2, with A.C Electrical Conductivityof the polymer thick films of the composite (PVA/TiO2Rutile) greater than of the polymer thick films of the composite (PVA/TiO2Anatase) , these results are in in good agreement with the researcher investigation[24] In addition, we note from Table (3) that the highest value of the electrical

conductivity of alternating current by weight (1 wt% g) for thick polymer composite films (PVA / TiO2Rutile) is equal to ($\sigma_{a.c}$ = 0.0020) s/m . This tendency could be linked to a structural change between the rutile and anatase phases, which causes the rutile phase to have the maximum density and the gap between the ions to decrease[35, 37]. The reason is that the increase in the calcination temperature leads to an increase in the crystallization degree of the titanium oxide particles TiO2Rutile Additive and reduce crystal defects and improve the electronic structure of the added particles And then increasing the polarization ratio, that is, by increasing the number of charge carriers and the ease of their movement within the crystalline structure of nanoparticles inside the prepared films, which leads to an increase in the values of alternating electrical conductivity (σa.c)[38].

Conclusions

Titanium oxide TiO_2 nanomaterials were synthesized using as sol gel. Achieving different phases of TiO2 nanoparticles by only controlling the calcination temperature, X-ray diffraction (XRD) confirmed the two-phase formation of TiO2 nanoparticles It was shown through (FE-SEM) the spherical shape of the nanoparticles (TiO_2) and that the effect of calcination temperature on the crystal body and the particle size . Polymeric thick films (PVA/TiO_2) it was shown the effect of incorporating different TiO_2 phases in the PVA matrix.The dielectric constant and AC electrical conductivity are improved the PVA matrix were improved by adding different phases of TiO_2. The PVA/TiO_2Rutile nanocomposite sample is the distinguishing feature, featuring the highest dielectric Constant, and highest A.C electrical Conductivity. The existence of dipole polarization processes can be seen in the difference in dielectric constant with frequency. the AC conductivity rose with increasing frequency, and 1 wt% g TiO2/ PVA showed dielectric qualities as well as high conductivity, suggesting that it could be used in future studies.

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