Synthesis and Characterization of (PMMA-PS-ANI) Composite

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Abstract

The aim of this paper, synthesis of (PMMA-PS-ANI) composite because many uses for new composite in industries applications. The casting method was use to prepared sample of composites. The optical and electrical properties of composites for different volumetric percentages of aniline was studied. The results show that the optical properties are changed with increasing of the volumetric concentration of aniline. The electrical conductivity of (polymethyl methacrylate-polystyrene) composites was increased with increasing the volumetric concentration of aniline and temperature. The activation energy of (polymethyl methacrylate-polystyrene) composites was decreased with increasing the volumetric percentages of aniline.

Key words: composites**,** aniline**,** conductivity, polymethyl methacrylate**,** optical properties

Introduction

Polymer material is widely being used in various devices as insulating material and for optoelectronic applications. This is due to their unique properties such as light weight, high flexibility, and ability to be fabricated at low temperature and low cost [Lyly *et al., 2012*]. The study of the optical absorption spectra in solids provides essential information about the band structure and the energy gap in the crystalline and non-crystalline materials. Analysis of the absorption spectra in the lower energy part gives information about atomic vibrations while the higher energy part of the spectrum gives knowledge about the electronic states in the atom [Omed and Sarkawt, 2010]. The polymethyl methacrylate (PMMA) may be considered as a typical amorphous polymer, which is viscoelastic. For most of the polymers, they are almost perfectly elastic solids at low enough temperatures, but change to viscous liquids at high temperatures, and exhibit viscoelasticity in the intermediate range [Zhang *et al.*, 1994]. One of the main characteristics required for electrical and or/optical activities to occur in a polymer is a conjugated backbone which can be subject to oxidation or reduction by electron acceptors or donors. Due to delocalization of the electrons in conjugated polymers, chain rigidity is very often a predominant property and, as a result of this, an aggregated character of the chains is typical in such material [Hossein, 2008]. polymers with different optical properties have been attracted much attentions due to their applications in the sensors, light-emitting diodes, and others. Polystyrene (PS) is amorphous polymer with bulky side groups. General purposes PS are hard, rigid, and transparent at room temperature and glass like thermoplastic material which can be soften and distort under heat. It is soluble in aromatic hydrocarbon solvents, cyclohexane and chlorinated hydrocarbons [Tariq, 2010].

Materials and Methods

The polymethyl methacrylate(PMMA) and polystyrene are dissolved in chloroform by using magnetic stirrer in mixing process to get homogeneous solution. The volumetric percentages of aniline are (0,5,10,15 and 20) Vol.%

were added and mixed for 30 minute, after which solution was transferred to clean glass peterdish of 4 cm in diameter placed on plate form.

The optical properties of (PMMA-PS-ANI) composites were measured by using UV/160/Shimadzu spectrophotometer. Absorptance (A) is the ratio between absorbed light intensity (IA) by material and the incident intensity of light (I_o).

$A = IA / I_o$ …….. (1)

Absorption coefficient (α) is defined as the ability of a material to absorb the light of a given wavelength [Kurt and Demirelli, 2010] :

$\alpha=2.303A/t$ ………. (2)

Where t: the thickness of sample thickness.

According to the generally accepted non-direct transition model for amorphous semiconductors proposed by:

$$\alpha h\upsilon = B(h\upsilon - E_g)^r \text{.....(3)}$$

Where B is a constant, hυ is the photon energy , E_g is the optical energy band gap, r=2,or 3 for allowed and forbidden indirect transition

The Refractive index (n) is given by [Bakauskas and Vinslovaite, 2003]:

$n= (1+R^{1/2})/ (1-R^{1/2})$ ……… (4)

The extinction coefficient (k) was calculated by:

$K=\alpha\lambda/4\pi$ ………… (5)

The real and imaginary parts of dielectric constant can be calculated b:

$\varepsilon_1 =n^2-k^2$ (real part) …..... (6)

$\varepsilon_2 =2nk$ (imaginary part) …… (7)

The resistivity was measured over range of temperature from (50 to 80)^{o}C using Keithly electrometer type (616C) .The electrical conductivity σ_v defined by [Ahmad *et al*., 2007] :

$$\sigma_v = \frac{1}{\rho_v} = \frac{tV}{SI} \text{.......... (8)}$$

Where :

S = guard electrode effective area.

V/I=R = volume resistance (Ohm) .

t = average thickness of sample (cm) .

In this model the electrodes have circular area $A= D^2\pi/4$ where D= 0.5 cm^2 .

The activation energy was calculated using equation [Ramaiah and Raja, 1999]:

$\sigma = \sigma_o \exp(-E_a/k_BT)$ ……..(9)

σ = electrical conductivity at T temperature

σ_0 = electrical conductivity at absolute zero of temperature

K_B = Boltzmann constant

E_a = Activation Energy

Results and Discussion

1. The optical Properties of (PMMA-PS-ANI) composites

- **The absorbance of (PMMA-PS-ANI) composites**

Fig.(1) shows that the absorbance of the (PMMA-PS-ANI) composites with wavelength for different volumetric percentages of aniline. From this figure, we can see that the absorbance of (PMMA-PS-ANI) composites is increased with increasing the volumetric percentages of aniline. The increase of absorbance of (PMMA-PS-ANI) composites attribute to increase the number of carries charges [Kurt, 2010].

- **The absorption coefficient and energy band gap of (PMMA-PS-ANI) composites**

Fig. (2) shows the variation of the absorption coefficient of the(PMMA-PS-ANI) composites with photon energy. The absorption coefficient has high values in high energy of photon because electron excitation from the valence band to conduction band, also, the absorption coefficient of the (PMMA-PS-ANI) composites is increased with increase of aniline volumetric percentages which related to increase the absorbance [Jordan *et al.*, 2005]. From the value of absorption coefficient, we can be determine the nature and value of the optical band gap, E_g which calculated by using Eq. 3 where the material has indirect transition if the value of absorption coefficient less than 10^4 cm^{-1}. The (PMMA-PS-ANI) composites which are used in this paper have indirect transition.

Fig.3 and Fig.4 show the allowed and forbidden indirect transition of (PMMA-PS-ANI) composites. The energy band gap (PMMA-PS-ANI) composites is decreased with increasing aniline volumetric percentages, this attributed to increase the local levels in band gap [Nahida and Marwa , 2011], hence the distant between the conduction band and valance band is decreased.

- **The extinction coefficient and refractive index of (PMMA-PS-ANI) composites**

The variation of the extinction coefficient (K) of (PMMA-PS-ANI) composites with the photon energy is shown in Fig. (5). The extinction coefficient is increased with increasing of volumetric percentages of aniline, this behavior related to increase absorption of (PMMA-PS-ANI) composites with increase the aniline concentration [Saurav *et al.*, 2010]. Also, from this Fig., we can see the extinction coefficient has high value in high energy of photon which attribute to the absorbance of polymer composites.

Fig.6 shows the variation of the refractive index of (PMMA-PS-ANI) composites with photon energy. The refractive index of (PMMA-PS-ANI) composites is increased with increase the aniline volumetric concentration, this may be attributed to increase the density of (PMMA-PS-ANI) composites .

- **dielectric constants of (PMMA-PS-ANI) composites**

The variation of real and imaginary parts of dielectric constants of (PMMA-PS-ANI) composites with energy photon are shown in Figs. (7 and 8). The real and imaginary parts of dielectric constants are increasing with increase the aniline volumetric concentration, this attributed to increase the refractive index and extinction coefficient of (PMMA-PS-ANI) with increasing the aniline concentration (as shown in Figs. (5 and 6)). Also, the increase of real and imaginary parts of dielectric constants of (PMMA-PS-ANI) composites with energy photon can be due to the absence the resonance between the frequencies of the incident photon energy (electromagnetic and the induced dipoles in the composite) [Ahmad *et.al*, 2007], while in the imaginary part there was an absorption to the energy of the incident photon energy, so the variation nearly constant until it reaches to the high photon energy.

2. The Electrical Properties of (PMMA-PS-ANI) Composites

- **The Effect of volumetric percentages of aniline on D.C electrical conductivity of (PMMA-PS) composites**

Fig.(9) shows the variation of D.C electrical conductivity of (PMMA-PS-ANI) composite with different volumetric concentrations of aniline. The electrical conductivity of (PMMA-PS) composites is increased with increase of the volumetric concentration of aniline. The behavior of electrical conductivity with concentration of aniline attribute to increase the carries charges in composites [Srivsatava *et al.*, 2003].

- **The Effect of temperature on D.C electrical conductivity of (PMMA-PS-ANI) composites**

Fig.(10) shows the effect of temperature on the D.C electrical conductivity of (PMMA-PS-ANI) composites with different volumetric percentages of aniline, from the figure, the electrical conductivity of (PMMA-PS-ANI) composites is increased with increasing the temperature this attributed to increase the mobility of polymer chain and the charge carriers are releasing, hence, the electrical conductivity is increased a result for the increase of the number and mobility of charge carriers [Ibrahim, 2011].

- **The activation energy of (PMMA-PS-ANI) composites**

The activation energy of (PMMA-PS-ANI) composites is calculated by using Eq.9 as shown in Fig.11.The high values of activation energy of (PMMA-PS-ANI) composites are attributed to the existence of free ions in the commercial polymers [Ahmed and Zihilif, 1992]. By adding volumetric concentrations of aniline, the activation energy of (PMMA-PS-ANI) composites is decreased as a result of the effect of space charge as shown in Fig. (12).

- **The physical properties of (PMMA-PS-ANI) composites**

The variation of weight again with time of (PS-PMMA-ANI) for different concentrations of aniline is shown in Fig. (13). The figure shows that the weight again increased with increasing the time, this attributed to amorphous structure of polymer which used in this paper. The addition of different volumetric percentages of aniline will be increase the weight again which attribute to form of pass in composite, thus the diffusion coefficient ($D = \pi \left[\frac{Kb}{4M\infty} \right]^2$ where M_∞ is the higher value of weight gain, k is weight gain and b is thickness of sample) will be increases as shown in Fig. (14) [Sux, 2001]

Conclusions

The absorbance of (PMMA-PS) composites was increased with increasing the volumetric concentration of aniline.

1. The optical constants of (PMMA-PS) composites (absorption coefficient, extinction coefficient, refractive index and dielectric constants) are increasing with increase the volumetric percentages of aniline.
2. The energy band gap of (PMMA-PS) composites is decreased with increasing of the volumetric concentration of aniline.
3. The electrical conductivity of (PMMA-PS) composites is increased with increasing the volumetric concentration of aniline and temperature

4. The activation energy of (PMMA-PS) composites is decreased with increasing of the volumetric concentration of aniline.
5. The weight gain and diffusion coefficient are decreasing with increase the concentration of aniline.

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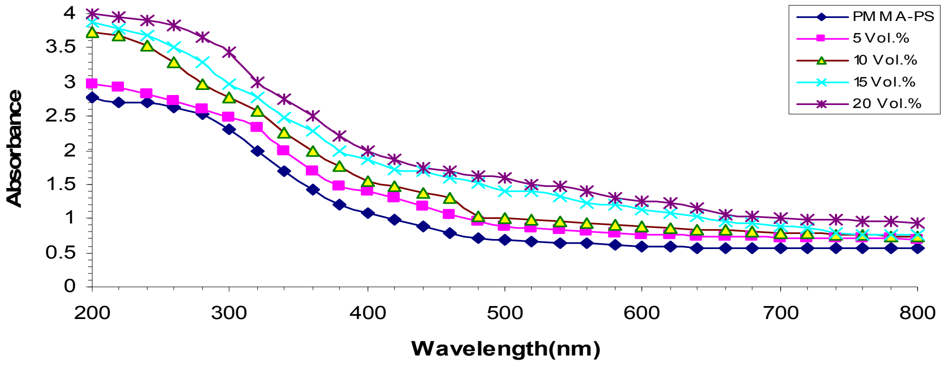

FIG.1
The variation of optical absorbance for (PMMA-PS-ANI) composite with wavelength

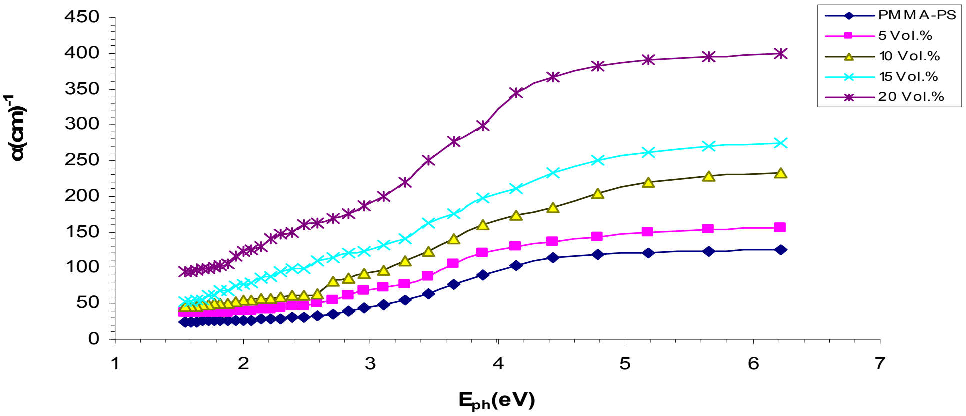

FIG.2
The absorption coefficient for composite with various photon energy

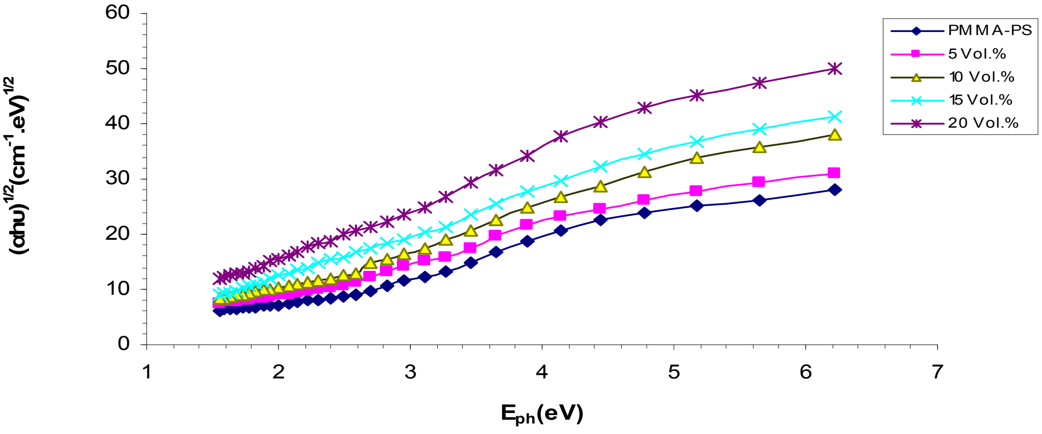

FIG.3
The relationship between $(\alpha h\upsilon)^{1/2}(cm^{-1}.eV)^{1/2}$ and photon energy of composite.

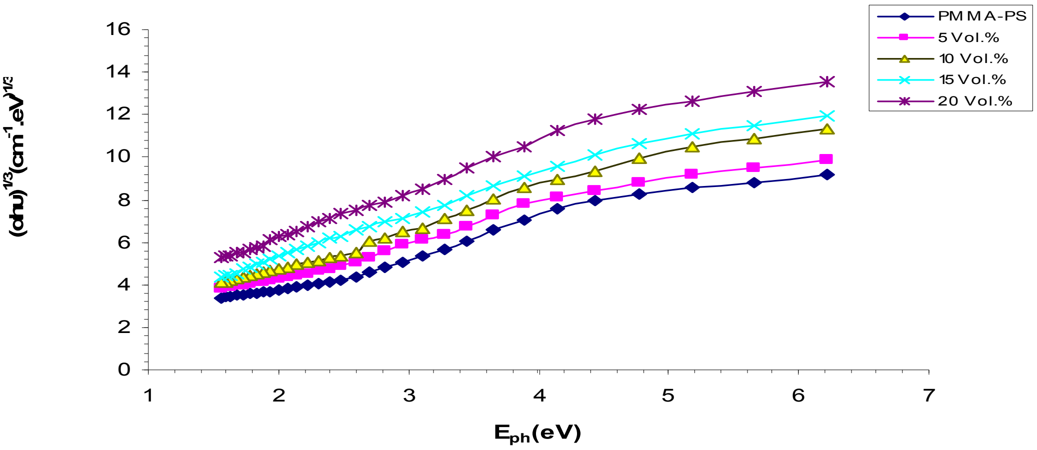

FIG.4

the relationship between $(\alpha h\upsilon)^{1/3}(cm^{-1}.eV)^{1/3}$ and photon energy of composite.

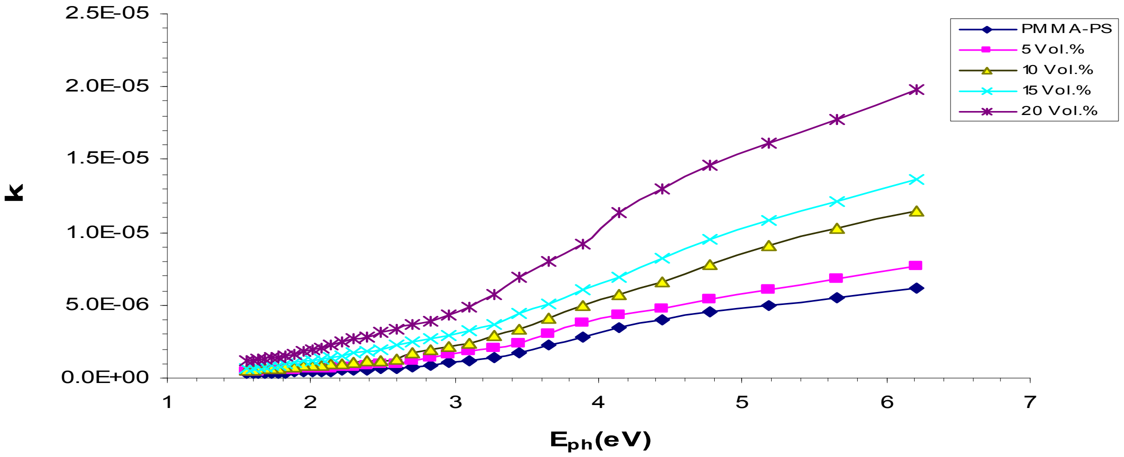

FIG.5

The extinction coefficient for composite with various photon energy

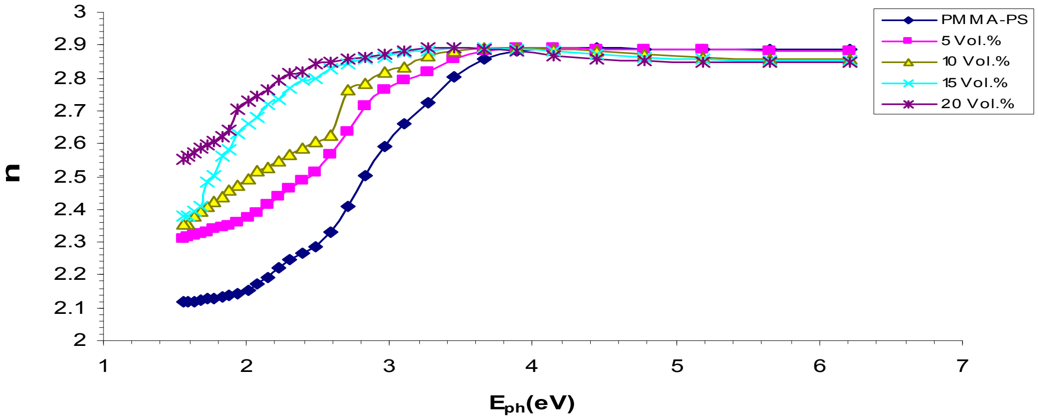

FIG.6

The relationship between refractive index for composite with photon energy

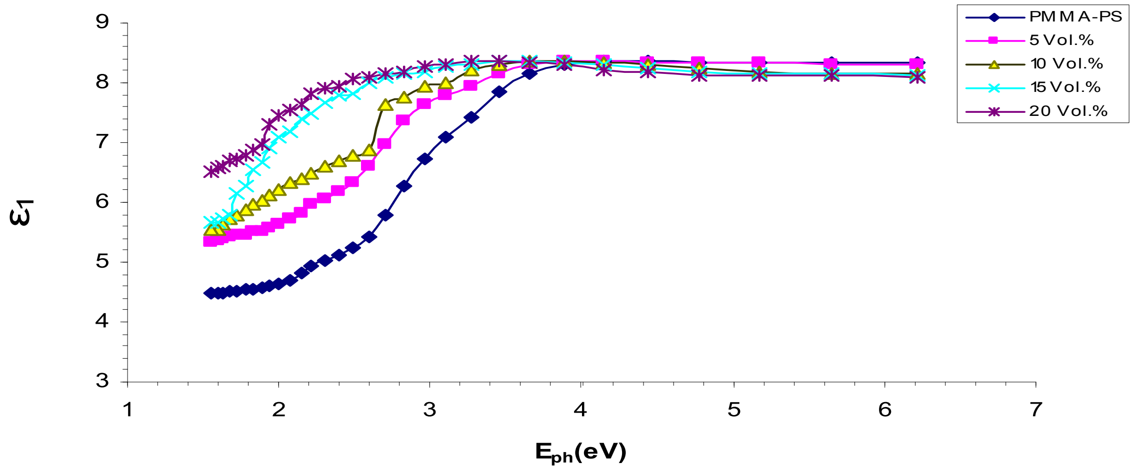

FIG.7
The variation of real part of dielectric constant composite with photon energy

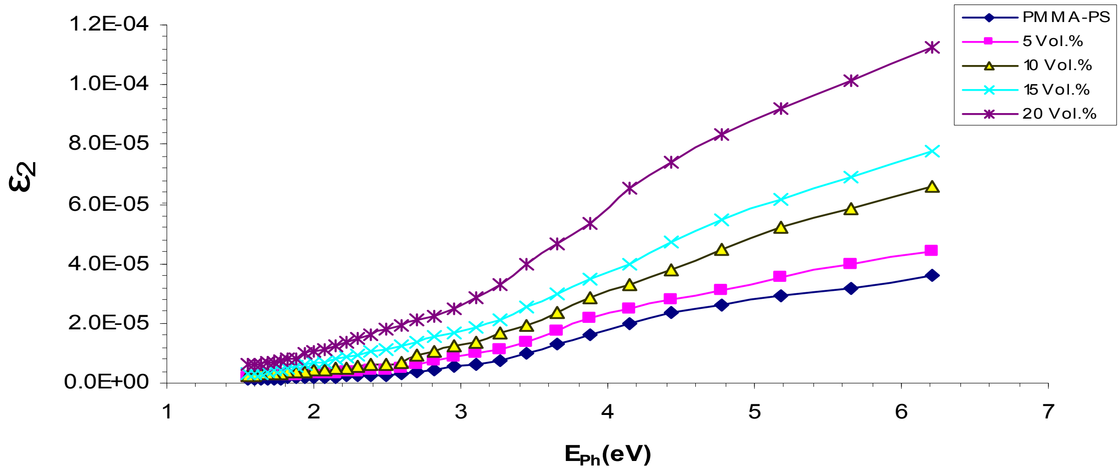

FIG.8
The variation of imaginary part of dielectric constant composite with photon energy

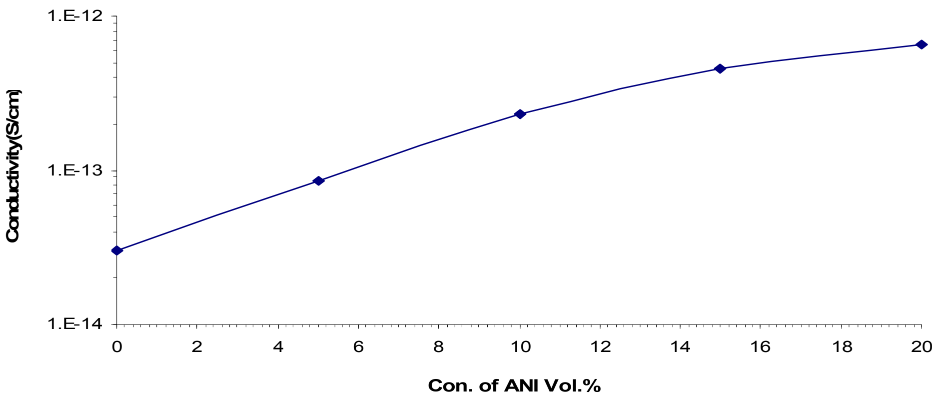

FIG.9
Variation of D.C electrical conductivity with ANI Vol.% concentration of composite.

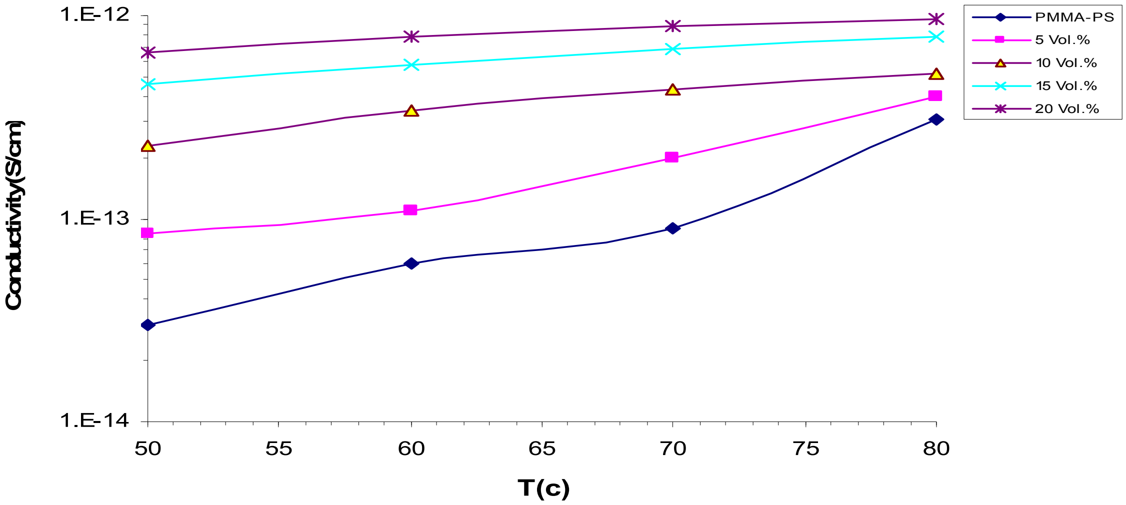

FIG.10
Variation of D.C electrical conductivity with temperature for composite

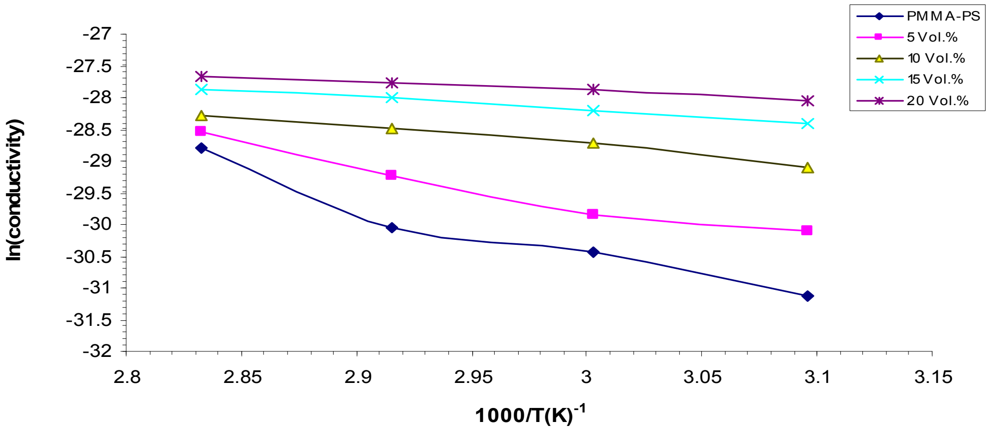

FIG.11
Variation of D.C electrical conductivity with resprocal absoute temperature for composite.

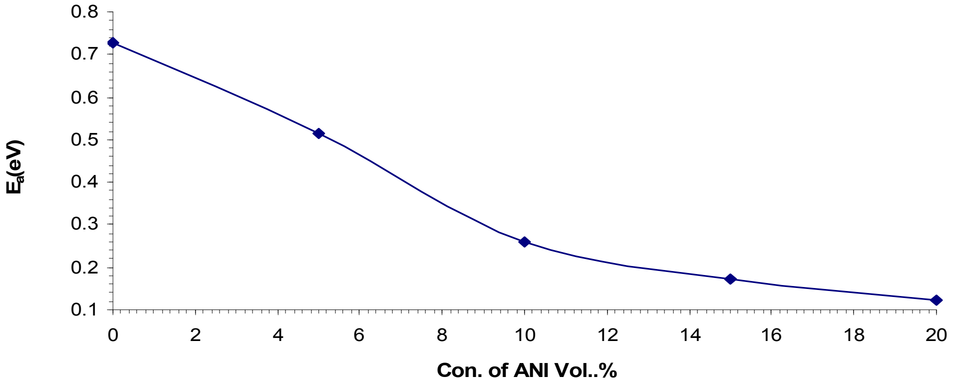

FIG.12
Variation of activation energy with ANI Vol.% of composite

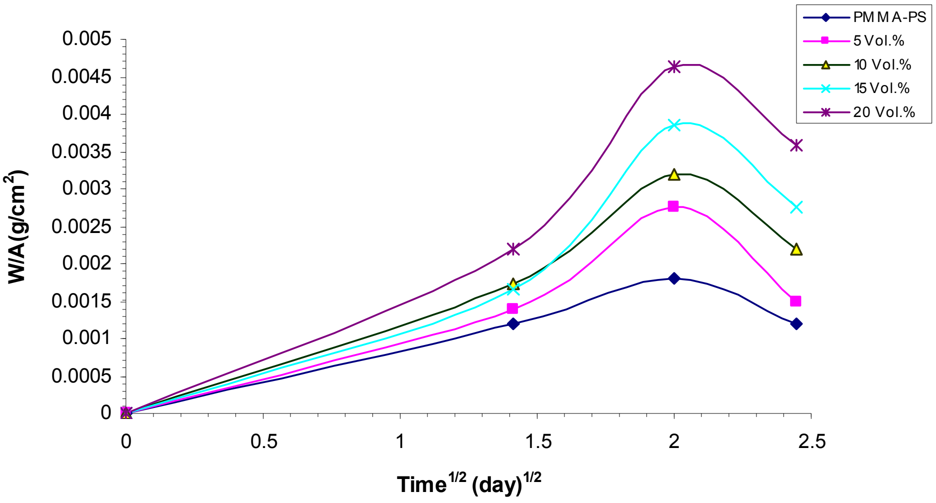

FIG. 13
Variation of the weight gain with the time

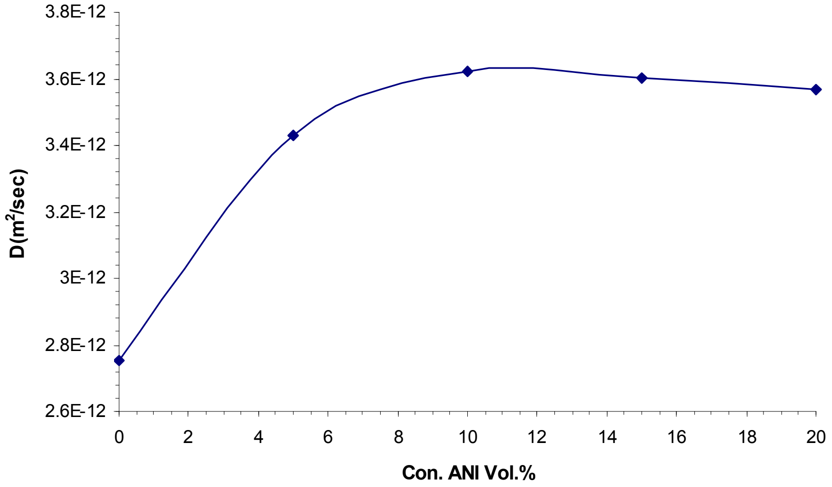

FIG. 14
Variation of the diffusion coefficient with volumetric concentration of aniline

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