The Effect of Ferrous Chloride ($FeCl_2$) on Some Optical Properties of Polystyrene

Hussein Neama[1], Najeeb AL-Khegani[2]

College of Science for Women, Babylon University, IRAQ.

[1] neama.hussein@yahoo.com

ABSTRACT

In the present work, the effect of ferrous chloride $FeCl_2$ addition on some optical properties of polystyrene has been studied. For that purpose, many films have been prepared by adding $FeCl_2$ to the polystyrene with different weight percentages from ($FeCl_2$) with polymer using casting method. The absorbance and transmittance spectrum have been recorded in the wavelength range (190-800) nm. The absorption coefficient, extinction coefficient, refractive index, real and imaginary dielectric constant and energy gap of the indirect allowed transition have been determined.

Keywords: Polystyrene, polymer, ferrous chloride, $FeCl_2$

INTRODUCTION

Generally, the use of most polymers was limited to the manufacture of cheap products which were used for simple purposes. However, the speedy technical development has required the replacement of some materials being used in industry with others having better specifications, consequently, polymers have replaced Aluminum and Iron for some purposes that require stress and high temperature [G. A. Kontos et.al 2007, S. Mustafa 2008]. Later, the development of polymer science has started to increase by leaps and bounds. Nowadays, scientists seek to produce, cheap, flexible, and multi-purpose. They are used in housing, automobiles polymers that can be used for different industrial applications.

Plastics are the most versatile materials used in different chemical industries. They are solid, aircraft, packaging, electrical equipment, and as electrical insulators. They have increasingly important role in the manufacture of satellites, space researches, and thermal barriers [G. A. Kontos et.al 2007, S. Mustafa 2008]. Plastics have replaced metals in many applications. They have superseded steel and many other metals in being erosion resistant and chemically inert. Having higher temperature extension and specific heat than metals, plastics have been used for constructing and lining of reactors and absorption towers, and the manufacture of pipes and valves.

Most of plastics are currently manufactured as light, rigid and foamy materials and used as insulators due to their low thermal and electrical conductivity. Plastics have almost no free electrons but recent scientific and technical breakthroughs have succeeded in making some modifications on regular plastics and brought into existence a new generation of plastics that combine the electrical features of the conductive and semi-conductive materials and the crystal, mechanical, and chemical feature of plastics. The modified plastics have many applications in the industry of airplanes and spaceships [S. Mustafa 2008, M. Dahshan 2002]. Polystyrene is one of the most widely used kinds of plastics. It was first produced commercially in late 1930. It is a thermoplastic made from the aromatic monomer styrene as its basic unit. It is a transparent glass-like substance which does not dissolve in acids, bases, or alcohol, but dissolve in aromatic hydrocarbons, benzene, and esters. Its melting point is 239oC, glass transition temperature is 100oC, density is 1.05g/cm3 and its random crystallization [T. M . Beraada and G. A. al- Adam 1989, G. A. Al - Adam and H. A 1983].

ISSN: 2223-9944, eISSN: 2223-9553

It is commercially manufactured from styrene which is prepared from benzene and the ethylene by passing ethylene through benzene under pressure use of Aluminum Chloride as a catalyst. The resulting Ethyl Benzene undergoes a process by which a hydrogen atom is removed by passing Ethyl Benzene over a catalyst such as Iron oxide or magnesium oxide at 600oC. ̊The resultant of this process is styrene which is in turn refined before being polymerized. Polystyrene is synthesized under different polymerization conditions depending on the final application of the polymer[A. H. Muheisin 2009].

There are other industrial techniques for the preparation of polystyrene such as emulsion polymerization, suspension polymerization, mass polymerization, and solution polymerization. As polystyrene does not stretch or shrink, it is used in the manufacture of plates and cables because it is a good electrical insulator; it is also used in the manufacture of rubber and household articles [T. M . Beraada and G. A. al- Adam 1989, S. Mustafa 2008].

EXPERIMENTAL PART

The materials used in this paper is polystyrene (PS) as matrix and $FeCl_2$ as a filler. The electronic balanced of accuracy 10^{-4} have been used to obtain a weight amount of $FeCl_2$ powder and polymer powder. The weight percentages of $FeCl_2$ are (0, 5 and 10) wt%. The transmittance & absorbance spectra of (PS- $FeCl_2$) composites have been record in the wavelength range (190-800) nm using double-beam spectrophotometer (UV-210^{o}A shimedza).

The extinction coefficient (k) is calculated by using the following equation [J . Tauce, 1972]:

$$k = \alpha\lambda/4\pi \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where α is absorption coefficient and λ is wave length.

The absorption coefficient (α) is calculated by using the following equation:

$$\alpha = 2.303(A/t) \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where A is absorption and t is the thickness of films

The refractive index (n) is calculated by using the following equation:

$$n = \sqrt{\frac{4R}{(R-1)^2}} - \frac{R+1}{R-1} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Real (ε_1) and imaginary (ε_2) dielectric constant is calculated by using the following equations:

$$\varepsilon_1 = n^2 - k^2 \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\varepsilon_2 = 2nk \qquad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

The allowed indirect transition energy gap is calculated by using the following equation [J. Tauce, 1972]:

$$\alpha h\upsilon = A(h\upsilon - E_g)^m \qquad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

RESULTS AND DISCUSSION

Figure 1 shows the absorptance spectrum as function of the wavelength of the incident light. It is shown that the adding of the filler to the polymer lead to increase the intensity of the peak. There is no shift in the position of the peak for all amounts of filler adding to the polymer.

ISSN: 2223-9944, eISSN: 2223-9553
www.journals.savap.org.pk

Chemically that means this addition do not change the structure of the PS-$FeCl_2$ composites. The increase of absorbance with the increase of weight percentage of the added ferrous chloride ($FeCl_2$) can be explained by the fact ferrous chloride ions absorbed the light incident on them, in other words ions absorb the incident light by the free electrons [M. Dahshan, 2002, A. Abdul Munaim and A. Hashim 2010].

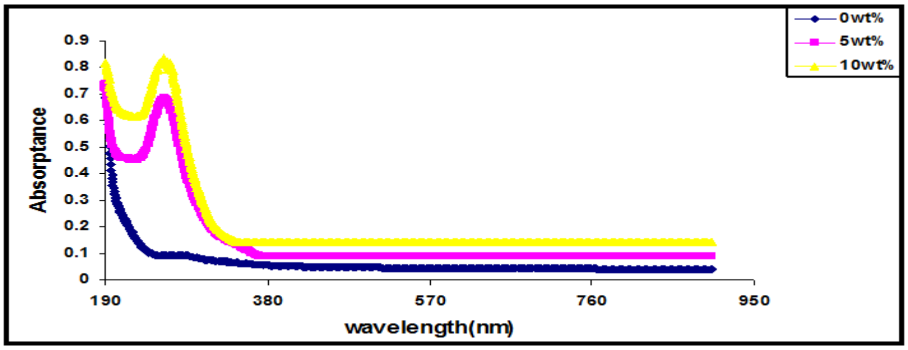

Figure 1. The absorptance spectrum for (PS-$FeCl_2$) composites as function of incident wavelength

Figure 2 shows the optical transmittance spectrum as function of wavelength of incident light by adding different rate of the added ions ,the figure shows that the transmittance decrease with the increase of the added ions concentration ,this is due to the added ferrous chloride $FeCl_2$ that contains in it is outer orbits, these electrons absorb the electromagnetic energy of the incident light ,resulting in the transition of electrons to higher energy levels, this process is not accompanied by emission of radiation because the electron that moved to higher levels have occupied vacant positions of energy bands ,thus part of the incident light is absorbed by the substance and does not penetrate through it ,on the other hand the pure polystyrene has high transmittance because there are no free electron (i.e .electrons are linked to atoms by covalent bonds) ,this is because the breaking of electron linkage and moving it to the conduction band need photon with high energy [M. Dahshan,2002].

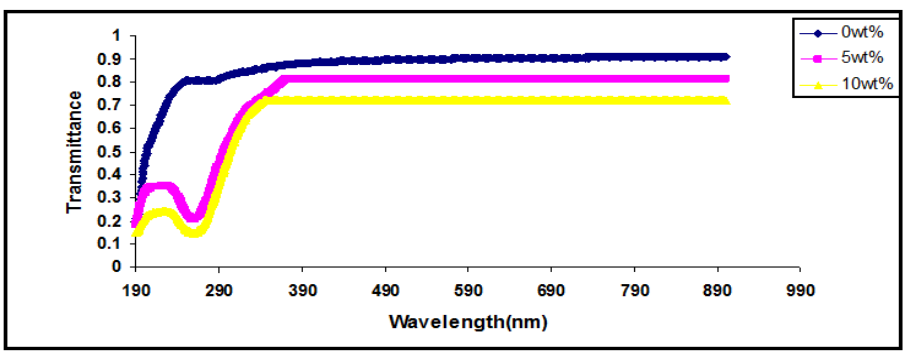

Figure 2. The transmittance spectrum for (PS-$FeCl_2$) composites as a function of incident wavelength

The absorption coefficient (α) is calculated by using the equation (2). Figure 3 shows that the absorption coefficient (α) as a function of the photon energy, it can be noted that absorption is little at low energy. This means that the possibility of electron transition are little because the energy of the incident photon is not sufficient to move the electron from the valence band to the conduction band ($h\upsilon < Eg$).

At high energies, absorption is greater, this shows that there is great possibility for electron transitions consequently, the energy of incident photon is enough to move the electron from the valence band to conduction band, and this means that the energy of the incident photon is greater than the forbidden energy gap [M. Dahshan, 2002]. This shows that the absorption coefficient assists in figuring out the nature of electron transition ,when the values of the absorption coefficient is high ($\alpha > 10^4$) cm^{-1} at high energies, it is expected that direct transition of electron occur, the energy and moment are maintained by the electrons and photons, on the other hand when the values of the absorption coefficient is low ($\alpha < 10^4$)cm^{-1} at low energies, it is expected that indirect transition of electron occur ,and the electronic momentum is maintained with the assistance of the photon [M. A. Crane, 1989]. Among other results is that the coefficient of absorption for the PS-$FeCl_2$ composites is less than 10^4 cm^{-1}, this explains that the electron transition is indirect.

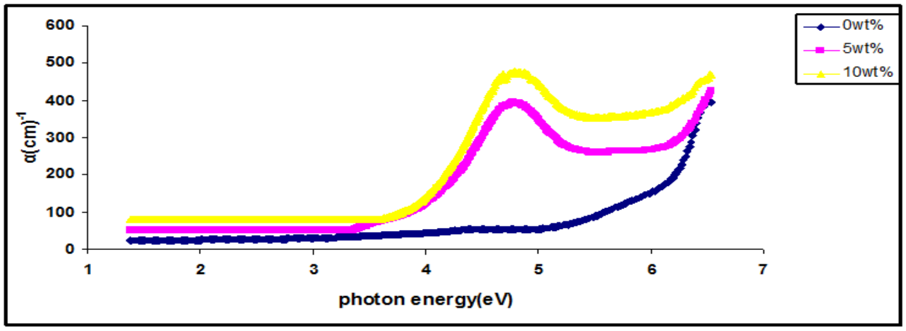

Figure 3. The absorption coefficient for PS-$FeCl_2$ composites as a function of photon energy

The allowed indirect transition energy gap has been calculated by using equation (6). Figure 4 shows the relationship between $(\alpha hv)^{1/2}$ and the photon energy of pure polymer (PS) , will get the value of energy gap of the allowed indirect transition , which is equal to 5eV.

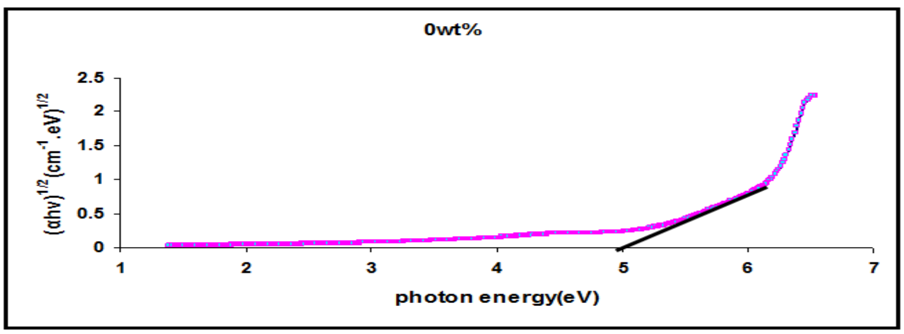

Figure 4. The Variation $(\alpha hv)^{1/2}$ with photon energy of pure polymer (PS)

Figure 5 shows the variations of extinction coefficient (k) with wavelength for pure and doped PS with $FeCl_2$. This figure shows that k value increases with increasing of the weight percentage of $FeCl_2$. The behavior of extinction coefficient (k) can be described according to high absorption coefficient. This result indicates that the doping atoms of $FeCl_2$ will modify the structure of the host polymer [R. Ahmed, 2008].

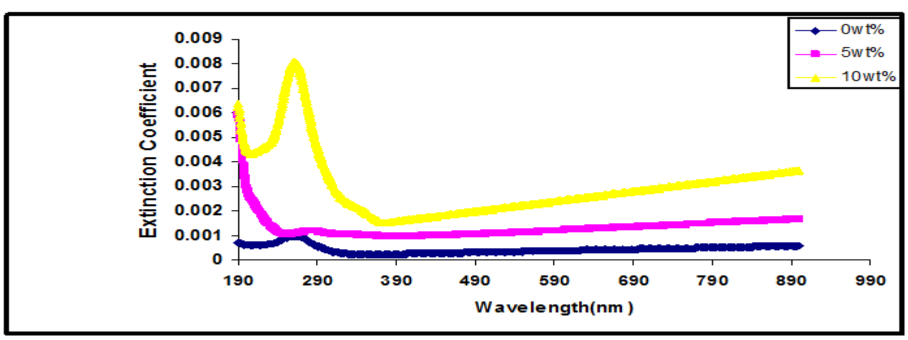

Figure 5. The variation of the extinction coefficient (k) with wave length of the PS- $FeCl_2$ composites

The refractive index was found from equation (3). Figure (6) shows the variation of refraction coefficient for PS-$FeCl_2$ composites as a function of wavelength .From the figure we can see that the refraction coefficient is increase with increasing the weight percentage of the added $FeCl_2$ to the polystyrene. The reason of this result is from the increased intensity of the resulting composite, in other wards due to increase the number of free electrons. Figure (6) also shows that the pure polystyrene has low refraction coefficient because polystyrene is amorphous crystalline substance with low density.

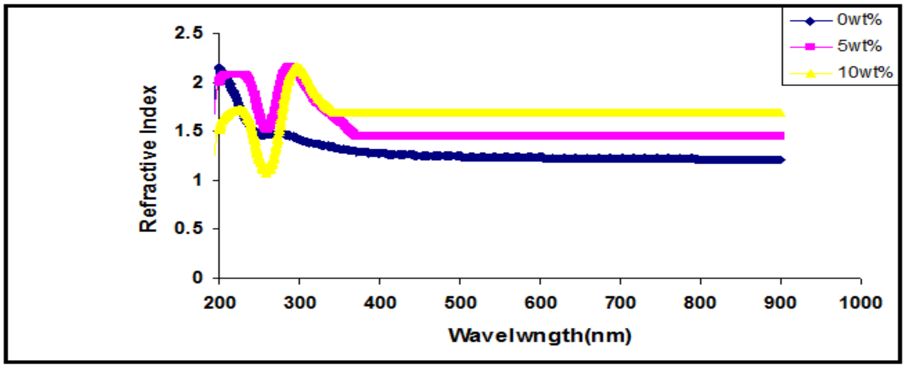

Figure 6. The variation of refractive index for PS-$FeCl_2$ composites wavelength

The real and imaginary dielectric constant (ε_1, ε_2) for (PS-$FeCl_2$) composites have been calculated from equations (4) and (5), respectively. The figures (7) and (9) show the change of ε_1 and ε_2 as a function of the wavelength. It can be seen that ε_1 is considerably depends on n^2 due to low value of k^2, while ε_2 is dependent on k values that change with the change of the absorption coefficient due to the relation between n and k.

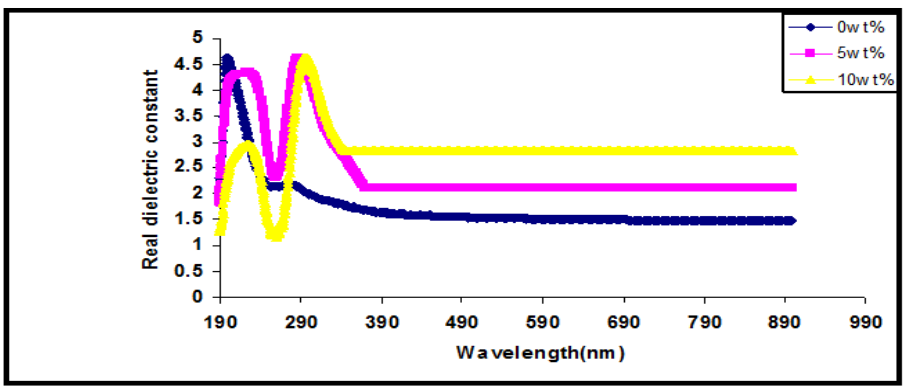

Figure 7. The real dielectric constant for PS-$FeCl_2$ composites as a function of incident wavelength

CONCLUSION

1. The absorption coefficient is increasing with increasing of the filler wt.% content.
2. The experimental results showed that the absorption coefficient less than $10^4 cm^{-1}$ this is indicates to allowed indirect electronic transitions.
3. The $FeCl_2$ additive not changes the nature of electronic transfers of PS samples.
4. The refractive index and extinction coefficient are increasing with increasing of the filler wt.% content.

REFERENCES

[1] Abdul Munaim and A. Hashim. (2010). "Electronic Transitions For (PS –LiF) composites" Sixth Science Conference of College of Science, Al-Mustansiriyah University.

[2] H. Muheisin, (2009). "Study of Electrical Conductivity for Amorphous and Semi crystalline Polymers Filled with Lithum Fluoride Additive." M.Sc. Thesis, University of Mustansiriah, College of Science.

[3] Kontos et al. (2007). Electrical relaxation dynamics in TiO2 – polymer matrix Composites. *eXPRESS Polymer Letters, 1*(12), 781-789.

[4] Adam, G. A. and AL-Gatta, H. K., (1981). *Chemistry and Technology of polymers*. Basrah University. p. 643.

[5] Tauc, J., Menth, A. (1972). States in the Gap. *Journal of Non-Crystalline Solids, 8-10*, 569–585.

[6] M. Dahshan, (2002)," Introduction to Material Science and Engineering" ,2nd Ed.

[7] Crane, M. A., Translationty, Y. M. Hassan. (1989). "Solar Cells." Collage of Education, University of Mosul.

[8] Ahmed, R. M. (2008). "*Optical Study on Poly (methyl Methacrylate)/Poly(vinyl acetate).*" Zagazig Uni., Zagazig, Egypt. E-mail: rania8_7@hotmail.com

[9] Mustafa, S. (2008). "*Engineering Chemistry*." Library of Arab Society for Publication and Distribution, Jordan.

[10] Beraada, T. M., and Al-Adam, G. A. (1989). The Updated Chemistry of Large Molecules", University of Basrah, College of Science.

ISSN: 2223-9944, eISSN: 2223-9553