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MECHANICAL AND PHYSICAL PROPERTIES OF HIGH DENSITY POLYETHYLENE FILLED WITH CARBON BLACK AND TITANIUM DIOXIDE

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ABSTRACT:- In this work composite material composed of high density polyethylene and inorganic pigment (carbon black and titanium dioxide) was prepared. Different amounts of carbon black and titanium dioxide (2– 15) wt% were added as filler. The preparation of filled and unfilled (High density polyethylene /Carbon black and titanium dioxide) composite was carried out using a single – screw extruder operated at a temperature of (170 – 190)^{o}C.The incorporation was performed in a single screw extruder and sheets specimens were obtained by hot compression from extruded materials.

Many mechanical and physical tests were used to determine the properties of the prepared composite material which involved compression strength, impact strength and modulus of elasticity for all the preparation composite. An untreated HDPE sheet is used for the purpose of comparison. In this study, the influence of addition of Carbon black and titanium dioxide, on the mechanical ,electrical and thermal a properties test of high-density polyethylene (HDPE). The results show that the use of pigments, carbon black and TiO_2 in appropriate concentration ratios give a reliable improvement in the mechanical properties. The weight fraction of the carbon blacks and titanium dioxide ranged from 0.0 up to 15 wt % with the high density polyethylene. By discharging a high voltage through the composite it was found that the resistivity of the composite decreased. Carbon black and titanium dioxide –high-density polyethylene composites show significant differences from the neat high-density polyethylene measured in the frequency range.

It was found that the carbon black and titanium dioxide/ high-density polyethylene composites have better thermal properties than the neat high-density polyethylene.

Keyword: high density polyethylene. Titanium dioxide, Carbon black, Electrical properties, Thermal conductivity, Mechanical properties

1- INTRODUCTION

During the last years a considerable effort has been devoted to improve the properties and quality of the composite materials to meet engineering requirements. Various technical demands of the modern technology of such materials depend on their structure and physical and mechanical behavior. The characterization of such composite materials needs knowledge of a number of physical parameters. However, for a two-phase composite material, the electrical and mechanical behavior depends on both the type and weight fraction of the filler and the matrix and their interaction. Additives for polymer composites have been variously classified as reinforcements, fillers or reinforcing fillers. Reinforcements, being much stiffer and strong than the polymer, usually increase its modulus and strength [(1)] .The primary reasons for using additives are: property modification or enhancement; overall cost reduction; improving and controlling of processing characteristics. Important types of modified polymer

systems include polymer composites, polymer– polymer blends, and polymeric foams. Polymer composites are mixtures of polymers with inorganic or organic additives having certain geometries (fibers, flakes, spheres, particulates).Additives for polymer composites have been variously classified as reinforcements, fillers or reinforcing fillers. Reinforcements, being much stiffer and stronger than the polymer, usually increase its modulus and strength. Thus, mechanical property modification may be considered as their primary function, although their presence may significantly affect thermal expansion, transparency, thermal stability, In general, parameters affecting the properties of polymer composites, whether continuous or discontinuous, include: the properties of the additives (inherent properties, size, shape); composition; the interaction of components at the phase boundaries, which is also associated with the existence of a thick interface, known also as the interphase; this is often considered as a separate phase, controlling adhesion between the components; the method of fabrication. An additional example of a family of fillers imparting distinct new properties is given by the pearlescent pigments produced by platelet core-shell technologies. These comprise platelets of mica, silica, alumina or glass substrates coated with films of oxide nan particles,e.g.TiO_2,Fe_2O_3,$Fe_3O_4Cr_2O_3$ [1,2] .The application of polymeric materials has been widened by the incorporation of various additives into the polymer [2,3] .These additives, when incorporated into a thermoplastic, modify certain properties such as modulus, tensile strength, mold ability, etc [4], with an accompanying reduction in cost [4] .For particulate fillers such as carbon black and particle shape have profound influence on the properties of the end product. Carbon black has uses similar to some inorganic compounds. For example, Carbon black is a black pigment, and lampblack, which has a larger particle size, is used for tinting to produce shades of gray. Carbon black is very opaque and has excellent durability, resistance it is the most widely used black pigment.Pigments are divided according to their origin, as inorganic, organic, and metlic (powdered metals). Synthetic inorganic pigments one may cite titanium oxide, chrome and cadmium yellows iron oxides, etc. Titanium dioxide is the principal white pigment of commerce. Titanium dioxide (TiO_2, density: 4.26) occurs in two crystalline forms, anatase and the more stable rutile. anatase can be converted to rutile by heating to 700 to 950^oC[4,5]

Published literature is rich with investigations of mechanical and physical properties of composites. Alexandru [6] studied the morphological of polymer/ C.B. composites on roll extruded. Mather [7] studied the mechanical and electrical properties of Carbon black/polymer composites. This study has involved modifying the structure and surface functionality of carbon black by gasification with carbon dioxide, thereby allowing the properties of the corresponding composite to be modified systematically. The results are discussed in terms of a carbon black structure modification and its relation to mechanical and electrical properties. Ueki and Zanin [8] studied the influence of chemical additives (antioxidant and UV stabilizer) and pigments (TiO_2 and C.B) on the short-term dielectric breakdown test of (HDPE). These results showed that the carbon black is the component that affects the dielectric strength, that the β shape parameter from the graphic method can be used to evaluate additive mixing conditions, and that the weakest point for formation of the rupture channel is on the carbon black agglomerate .Yihu et.al [9] studied the Conduction stability of (HDPE/CB) composites with CB. It is found that resistance of the composites shows considerable changes after the electric field is switched off. Influence of irradiation cross linking of HDPE on the conduction stability is also discussed. Salem [10] studied the mechanical properties of UV-irradiated LDPE with TiO_2 and C.B. mechanical properties of LDPE with (TiO_2 and C.B.) before exposure time. Also,studied.it was found that mechanical properties increase with increase of weight fraction of TiO_2 and C.B Tibor et al [11]studied the effect of colorants on the mechanical properties of HDPE. They investigated five type of pigment (titanium dioxide white, cadmium yellow, iron oxide red, carbon black and phthalocyanine blue).pigment and HDPE

were mixed by use mixer or compounded with a single screw extruder. It was found that the increasing of wt % pigment content loads to a decrease in the compressive strength, while impact strength was increases. Therefore, the aim of this paper is to study the mechanical properties (compression, modulus of elasticity, and impact properties) of the composite of HDPE with (C.B. and TiO_2) that were prepared under different ratio.

Plastics and polymers are inherently low in thermal and electrical conductivity. For this reason applications that require conductive properties, which could also benefit from the use of polymer because of their light weight, high strength/weight ratio, easy mold ability, etc, cannot take advantage of this desirable material. Research is in progress on inherently conductive polymers, and some polymers with reasonable conductivity values are commercially available.. However, at the present time admixing inert, conductive fillers into non-conductive polymers remains very effective and economical way to produce an electrically or thermally conductive polymer component.

Electrical conductivity can be achieved by incorporation of highly conductive fillers, such as carbon-black (CB) particles, carbon fibers, metallic fillers, or intrinsically conducting polymers. Several publications like Caruso et al [12], Muralidhar[13] addressing different theoretical approaches for predicting thermal conductivity of composite materials have been noted. However, one of the publications has discussed both transverse and axial thermal conductivity of a carbon black composite. A non-linear increase in the thermal conductivity was reported with the increase of carbon black volume fraction and no theoretical models are able to predict this non-linearity. Carlos Alberto Baldan et al [14] prepared carbon black-filled polymer composites using different carbon black ratios below and above the percolation limit and the samples were characterized during the cure process by dielectric impedance spectroscopy and by DC conductivity. The results present distinct behavior during the cure process because of the effect of the conducting filler on the matrix microstructure. Filled samples below the conductive percolation threshold should be monitored by dielectric spectroscopy analysis whereas samples above that limit displays conductive behavior during all the curing stages.

2. EXPERIMENTAL WORK

2.1 Materials

A commercial grade of high-density polyethylene, (density 0.963 g/ cm^3; MFI 8.4 g/10 min; *Mn* 145,000 g/ mol) was used throughout this study and was supplied by Petrochemical Industry Basra. carbon black used in this work was produced by Iraqi Asala company with particle size 66.21 μm .This carbon black is a high structure, relatively porous material characterized by highly extended .Rutile type of TiO_2 with particle size (60.40) μm were selected as the fillers. Its physical and relative chemical stability.

2.2 Method

After the HDPE and pigment (C.B and TiO_2) were mixed simply, they were blended in the molten state of the HDPE by means of a single -screw extruder (Brabender, Betol BM 1820 extruder) in a temperature range from 150 to 170^0C and a screw speed of about 60 rpm to produce the composites. The length–diameter ratio (L=10 D), corresponding to a torque output of 400 Nm carbon black and titanium dioxide at 0.2 wt % of polymer was added at the compounding stage. The compounding ingredients are added to the matrix polymer mass as it passes between the rolls. The roll mill has been supplanted in many operations by the compound or mixer-extruder, an extruder in which the function of the mixing section of the screw-extruder. For each run, after steady state operation for a sufficient period of time, the process variables were recorded, and the barrel was quickly cooled with tap water circulation as soon as the machine and feeder were stopped. Samples were taken along the screw length,

beginning with the solid particles at the feed zone to the fully homogenized melt region. After compounding process was completed. The mixture was then pressed in the hydraulic press by applying temperature and pressure at same time, then compression molded (100 kg/cm^2,150^oC), and slow –cooled to room temperature in the press.

2.3 Mechanical and Physical properties

Standard test of most mechanical properties of the prepared samples of (Carbon black) and (Titanium dioxide) filled HDPE and unfilled samples were carried out as follows:

A. Compression Test

The compression was determined by using Hydraulic- piston type leybold Harris No.36110.It was used to measure the compressive strength of specimens at room temperature. The specimens are fixed between the surfaces of the piston, and the load is applied. The test was carried out according to the test specification of ASTM (D695) [15] .

B. Impact Test

Charpy test was used to determine the impact strength of the polymeric material;the samples of impact test were notched by notch instrument according to ASTM (D256-87) [16] .

C. Modulus of Elasticity Test

Three point system was used to determine the modulus of elasticity of high-density polyethylene with TiO_2 and C.B.According to ASTM (D790m-86) [16].

D. Density Test

The density of composite materials was determined by a buoyancy test (Archimedes Principles) according to (ASTM- 3800). Several samples were taken from each material type. The dry weight of each sample was measured on an electronic balance. Then the samples were weighed, and then submerged in isopropanol. If one knows the density of the matrix, filler, isopropanol, the density of composite can be calculated with the following equations:

$$\rho_c = \frac{W_{air}}{W_{air} - W_{iso}} * \rho_{iso} \quad -----(1)$$

ρ_{isc} = Density of isopropanol (gm/cm^3).

W_{air} = Weight of composition air (gm).

ρ_c = Density of composite (gm/cm^3).

W_{iso}= Weight of composite in isopropanol (gm).

2.4 Electrical and thermal conductivity measurements

The electrical properties of an high density polyethylene resin filled with Carbon black were studied, by discharging a high voltage through the composite. DC Electrical conductivity was measured by the standard four-probe method at ambient conditions [17]. in this method; four equally spaced probes are placed on the sample. A current source provides constantly increasing current I_0. When I_0 is passing though the two outer probes, the

resulting voltage drop ΔV across the two inner probes is measured by the voltmeter. The electrical resistance was obtained as the slope of voltage vs. current. The specimens had 10 mm diameter and 1 mm thickness.

The resistance of the sample can be obtained by the following equation:

$$R = \frac{\Delta V}{I_o} \text{ ---------(2)}$$

The thermal conductivity measured in this work
using Lee's disc apparatus[18] . Lee's have determined the conductivity of small thick disc of material by a method, which is applicable over a wide range of temperatures. The arrangement is shown in Fig. (1)

The substance S is put between two copper discs B and A, and the heater between B and a third copper disc C. The temperature of all the copper discs was measured with a thermometer.

When the discs were assembled they are varnishes to give them the same emissive, and the whole apparatus was suspended in an enclosure of constant temperature.

In the theory given below, the following symbols are used:
IV = rate of energy supply to the heater, after the steady state has been reached.
The heat received per second by disc A Q_{rA} and given up to the air is:

$$\boldsymbol{Q_{rA} = = \left(\pi r^2 + 2\pi r d_A\right) \cdot e \cdot T_A} \quad \text{..... (3)}$$

Where:-
Q = heat loss per second per sq. cm for ^{0}1 excess of temperature of discs over that of enclosure.
T = excess of temperature over that of enclosure.
d = thickness of disc
r = radius of disc

The heat received per second by S Q_{rS} and given up to the air from its exposed surface or passed on to A is:

$$\boldsymbol{Q_{rS} = \left(\pi r^2 + 2\pi r d_A\right) \cdot e \cdot T_A + 2\pi r ds \cdot e \cdot \frac{1}{2} \cdot \left(T_A + T_B\right)} \text{ ..... (4)}$$

Q can be obtained in terms of IV, since the total heat supplied must be equal to that given up by the various surfaces:

$$\boldsymbol{H = I \cdot V = \pi r^2 \cdot e \cdot (T_A + T_B) + 2\pi r \cdot e \cdot (d_A \cdot T_A + \frac{ds}{2}(T_A + T_B) + d_B \cdot T_B + d_c \cdot T_c}$$

..... (5)
So, thermal conductivity coefficient becomes:

$$K \text{ x} \left(\frac{T_B - T_A}{ds} \right) = e \cdot \left(T_A + \frac{2}{r} \left(d_A + \frac{1}{4} ds \right) T_A + \frac{1}{2r} \cdot ds \cdot T_B \right) \text{-----(6)}$$

3. RESULT AND DISCUSSION

3.1 Effect on compressive strength

The ability of a material to resist forces that tend to crush or compress it is called compressive strength [2]. Compression properties describe the behavior of a material when it is subjected to a compression load at a relatively low and uniform rate of loading. In spite of numerous applications of plastic products that are subjected to compression loads, the compression strength of plastics has limited design value. the compressive strength is calculated as follows:

$$\textbf{Compressive Strength} = \frac{\textbf{Compressive stress at breaking point}}{\textbf{strain}} \quad \ldots\ldots (7)$$

Compressive tests are used when a materials "s behavior under large and permanent strains desired as in manufacturing application or when the brittle material is in tension. The tension resistance to these materials depends on the distribution of the defects which act as regions of stress concentrations and vertically to the tensile strength while compression resistance depends upon suppressing these cracks and for this reason we see that these materials have high compression résistance. These micro cracks collectively join to attain a macro-size which, at critical stress levels, becomes un stable. and this lead obstacles the transition of the stress, hence this decrease from the efficiency of particles in the composite .The variation in compressive strength of HDPE with different wt.%.for samples with TiO_2 / C.B, indicated in Fig.(1). From this figure, it is clearly seen that the increasing of % CB and TiO_2 content leads to decrease the compressive strength. This may be attributed to the softening of polymers (matrix) which lead to relaxation of the polymer chains and weakening of the bond of the polymer chains involved in composite. Also, may be due to the formation of voids which has an effect on the compression test. With increasing weight fraction the matrix will be changed from stiff state to elastic state at the interface region were the matrix will be wakened then the chains of polymer are expected to slip on each other, consequently it increases the ability of such substance to absorb a higher quantity of energy to which the sample is exposed. These results are in good agreement with result obtained by Tibor [11] .

3.2 Impact strength Test:-

Impact tests measure the energy expended up to failure under conditions of rapid loading [1]. Figure (3) shows the relation between the impact strength of HDPE with different weight fraction before and after reinforcement of TiO_2/C.B fillers. From this figure is clearly seen, that increasing of C.B and TiO_2 content leads to increase the impact strength. Carbon black and titanium dioxide are stiffer than the matrix and deform less, causing an overall reduction in the matrix strain, especially in the vicin of the particle as result of the particle /matrix interface. This behavior suggests that mechanical strength or elasticity of the formulated HDPE sheet is strongly dependent on the concentration of both C.B and TiO_2.Thus, complementary function of both C.B and TiO_2 pigments as stabilizers for HDPE sheets is an advantageous and therefore, the use of these pigments in proper amounts give an excellent improvement in the mechanical properties. increasing of C.B from (2-15)% and at constant TiO_2 weight percent (15)% causes an increase in the impact strength greater than the values when of TiO_2 from (2-15)% and constant C.B weight percent (15)%. also, Carbon black is probably the most important filler. It improves the mechanical properties. Many inorganic pigments such as titanium dioxides are also widely used as stabilizer in plastic industry. These results are in good agreement with result obtained byTibor (11) .

3-3 Modulus of elasticity

Modulus measure the resistance of material to elastic deformation for linear elastic material the stress (Ɛ) is the related to the strain (ε). Hooke's law for an ideal elastic solid provides a relation ship between stress and strain for tensile deformation as: $\zeta = E\varepsilon$ …… (1), Where the proportionality factor, E ,is called the (young's modulus). $E = \left(\frac{mass}{deflection}\right)\left(\frac{gL3}{48I}\right)$ ….. (2) , $I = \frac{DB3}{12}$ ……(3)

Where: I = Engineering bending momentum, D= Width of samples (mm)
B = Thickness of samples (mm), G = Gravity (m/sec^2) , L = Sample length (mm)

$\left[\frac{mass}{deflection}\right]$: is the slope of linear part of mass deflection curve obtained from three points bending loads tests (1).

Figure (4) shows the relation between the modulus of elasticity of HDPE and the weight fraction before and after reinforcement of TiO_2/C.B fillers. From this figure it is clearly seen that increasing of (C.B) from (2-15) % wt and at constant (TiO_2) weight percent (15)%causes an increase in the modulus of elasticity greater than the the values when increasing of TiO_2 from (2-15)%wt at constant C.B (15)%wt. This may be attributed to the fact that Young's modulus of composite depends on many factors, such as the nature of reinforcing particles, the weight fraction and particle size of filler and the adhesion between the particles filler and matrix. The cracks in composite materials depend on the quality of composite in it form and one the quality and direction of controlled stress on the composite and the quality of bond between practical and matrix. These results are in good agreement with result obtained by Salem [10] and Tibor [11].

In the present study a good modify modulus of elasticity was found HDPE through the addition of particulate pigment. Such result is related to the good adhesion between the matrix and filler because the interface plays an important role in adhesion between matrix material and particles [19]. The value of elastic modulus increase because the partical material is form the brittle materials therefore it decrease strain value that happen because of tensile stress, this lead to increase elastic modulus according to Hook's law. On the other hand , when the weight fraction of the polymer composite is increase this lead to block, consequently, the distributions of tensile stress will be irregular [2,19] .

4.3 Density

Table (2) shows the values of density for HDPE and (carbon black and titanium dioxide) composite samples. It is clear from this table all values agree the role of mixture. The calculated values of the composite density using the law of mixtures.

$$\rho c = \frac{1}{\frac{Wf}{\rho f} + \frac{Wm}{\rho m}}$$

Where: - ρ_c =Density of composite (gm/cm^3).

W_f, and W_m= weight of composite material, filler, and the matrix respectively.
ρ_f and ρ_m= density of composite material, filler, and the matrix respectively.

The two have the same general trend though the experimental results are lower than the calculated values. This difference between the two values is attributed to the presence of void in the samples, which are an inevitable side effect of the sample production process. Effect of pigment concentration on density based on the law of mixtures, an increase in the weight

fraction of the denser pigment should result in higher composite density as seen in the experimental results. However, the increase in density was found to be statistically in significant .

Electrical conductivity

Figure (5) shows the relation between the volume resistivity of HDPE and the weight fraction before and after reinforcement of TiO_2/C.B filler. From this figure it is clearly seen that increasing of (C.B) from (2-15) % wt and at constant (TiO_2) weight percent (15)%causes an increase in the volume resistivity greater than the values when increasing of TiO_2 from (2-15)%wt at constant C.B(15)%wt.. At very low concentrations of CB and TiO_2 the resistivity gradually decreases with increasing CB and TiO_2 content. From this figure it is clearly seen that increasing of (C.B) from (2-15) % wt and at constant (TiO_2) weight percent (15)%causes an increase in the electrical conductivity greater than the values when increasing of TiO_2 from (2-15)%wt at constant C.B (15)%wt..

The critical volume fraction v_c, also called the percolation threshold, is the lowest concentration of filler that forms continuous conductive pathways throughout the polymer matrix. The composite conductivity decrease slowly with increasing filler concentration until the critical volume fraction is reached. At a very sharp jump in conductivity is obtained over a very small concentration range, referred to as the critical region. The critical region ends when all the filler particles are involved in at least one conductive pathway and higher filler concentrations only achieve moderate changes in conductivity. The resistivity lower is caused by enrichment of higher conductive material components (According to percolation theory, electrical paths are made up of conductive inclusions in the direct-contact structure based on Ohmic behaviour and the percolation threshold values strongly depend on the shape of particles) [20] . However, at 2 wt%, a sizeable reduction in resistivity is observed. This stepwise change in resistivity is a result of the formation of an interconnected structure of carbon black and can be regarded as an electrical percolation threshold. the resistivity's are low and decrease marginally with increasing CBs content [21,22] .

Thermal conductivity

Figure (6) shows the relation between the thermal conductivity of HDPE and the weight fraction before and after reinforcement of TiO_2/C.B fille. Figures (6) Addition of carbon black and titanium dioxide significantly increases the thermal conductivity. The thermal conductivity of a composite depends on many parameters including 1) Type of additives; 2) Additives percentage; and 3) Resin type. The parameters of major influence on thermal conductivity are Additives percentage and conductivity properties of both resin and additives.

4. CONCLUSIONS

Composite materials compose of HDPE with carbon black and titanium dioxide has been prepared .Certain test were carried out on the prepared samples to determine the performance of this composite,The modulus of elasticity and impact strength increase with increasing the weight fraction of (carbon black and titanium dioxide) wt% composite. The compressive strength Values were observed to be the highest in pure HDPE, and these values decrease with increasing (carbon black and titanium dioxide) wt% composite .Electrical, and thermal properties of CB and TiO_2/ HDPE composites were experimentally examined as the CB and TiO_2 loading was increased up to 15 wt. %. A percolation threshold less than 2.0 wt.-percent are obtained. Addition of carbon black and TiO_2 significantly increases the thermal conductivity. The CB and TiO_2 yield much higher electrical and thermal conductivity than the neat HDPE.

1. Joel, R. F, (2003),2nd Ed," Polymer science and Technology ",Fred. Mc-Graw Hill Company, New York.
2. Bhatnagar M..S., (2004),1nd Ed.."Text book of polymers ", chemistry and technology of polymers, Vol 3.,
3. William D.Cr, Jr, (2003),"Materials Science and Engineering An Introduction", John Wiley and Inc,.
4. Mascia, L.,R,(1974) "The Role of Additives in Plastics ", Edward Arnold, London.
5. Temple C.P., (1973), "Pigment Hand book ", Applications and markets, Vol. II, John Wiley and sons,.
6. Alexandra, L., J, (1991)," morphological of polymer/ C.B. composites "Applied Polymer Science, Vol. 75, No. 93.pg(121-123).
7. **Thomas ,P.J,(1997);** mechanical and electrical properties of Carbon black/high-density polyethylene **"Journal of Materials Science",** , **Volume 32, Number 2, pp. 401-407(7),**
8. Ueki, M.M,. (2000).; ".Electrical Insulation and Dielectric Phenomena", Report., Conference on Volume 1, Digital Object Identifier Publ., Toronto, Ont., Canada,.Issue , 19-22, Oct 1997 Page(s):173-176.
9. Yihu,S, Z, (2005)" Department of Polymer Science and Engineering", Institute of Polymer Composite, Zhejiang University, .
10. Salem, M.A., 2001;" Mechanical properties of UV– Irradiated LDPE films formulated with carbon black and titanium dioxide ", Azhar University , Nasr-city , Cairo, Egypt .J. Sol., Vol.(24), No.(2), .
11. Tibor N, L., (1996). "the effect of colorants on the properties of rot molded polyethylene parts ", Vol. 36, issue 7, pages 1010-10181
12. Caruso, J. C, (1986) Chamis Assessment of simplified composite micromechanics using three dimensional finite element analysis, J. Composites Technology and Research, Vol.8, No.3, 77-83..
13. Muralidhar, K. (1989), "Equivalent conduction of a heterogeneous medium", International Journal of Heat Mass Transfer, Vol.33, No.8, 1759-1766.
14. http://www.sbpmat.org.br/5encontro/IndexPosterE.pdf.
15. Ives, M and R, (1971), "Handbook of Plastics Test Methods", some details of standers test, London.
16. Annual book of ASTM, (1989), Section 8, Vol. 08.01 Plastic, "Am. Soc. Test. Mat.", Philadelphia.
17. Sheng W,G" characterization and analysis of electrical conductivity properties of nanotube composites" Msc thesis Department of Industrial Engineering, The Florida State University (2005).
18. Wood, N,K , (1997) ," Measurement of thermal conductivity of polymers using an improved Lee's Disc apparatus" Polymer Testing 16 203-223.
19. WYPYCh,G.,(2000),Hand book of fillers ,chem Tec ubl,Toronto,ont.,Ganada.
20. Sandler, J. K , (2003), Kirk, I. A. Kinloch, M. S. P. Shaffer, A. H Windle,.; Polymer, 44, 5893.
21. http://www.sbpmat.org.br/5encontro/IndexPosterE.pdf
22. Philippe Gonnet, "Thermal Conductivity and Coefficients of Thermal Expansion of SWNTs/Epoxy Nanocomposites", The Florida State University, master's thesis, (2004)

Table (1): Different Formulation of HDPE with pigments.

Formulate no FORMULATIONS	CB % TiO_2%	TiO_2 %
1	2	15
2	5	15
3	10	15
4	15	15
5	15	2
6	15	5
7	15	10
Unformulated.	-	_

Table (2): Density result of HDPE composite at different Wt % (TiO_2 and CB) filler contents.

Samples	Composition	Density (g/cm^3)	
		Calculated	Experimental
HDPE	100	0.9454	0.9450
HDPE/TiO_2/CB	83/15/2	0.9558	0.9550
HDPE/TiO_2/CB	80/15/5	0.9626	0.9621
HDPE/TiO_2/CB	75/15/10	0.9687	0.9680
HDPE/TiO_2/CB	80/2/15	0.9704	0.9701
HDPE/TiO_2/CB	75/5/15	0.9891	0.9841
HDPE/TiO_2/CB	75/10/15	0.9945	0.9943

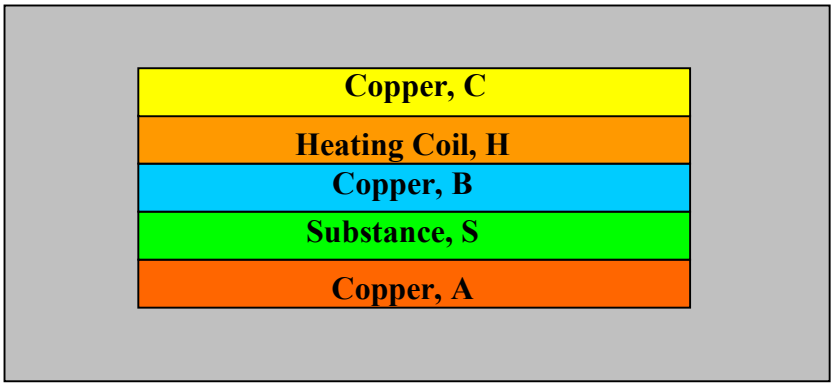

Fig (1): Schematic arrangement diagram of Lee's disc method [18].

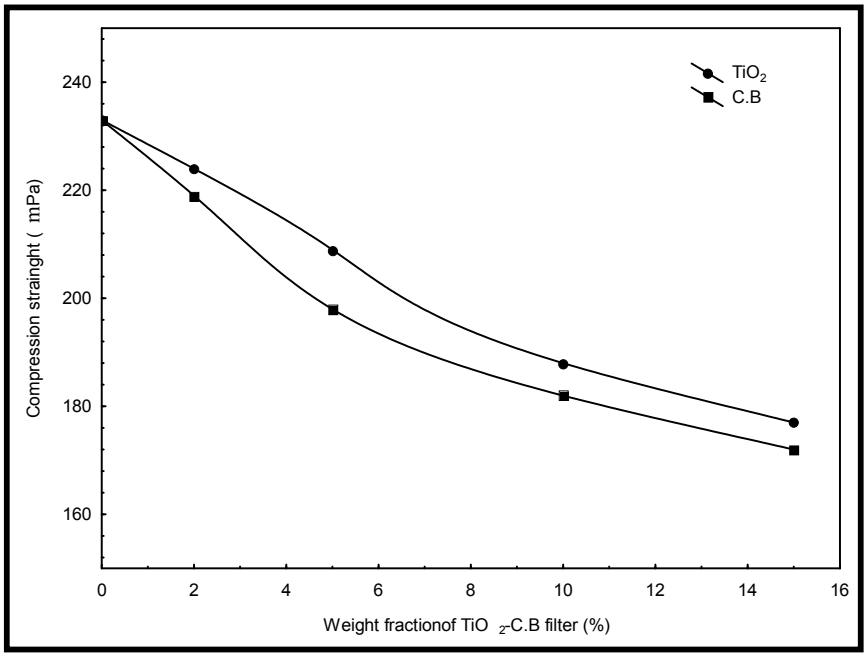

Fig.(2): The relation between the compression strength of HDPE sample with weight fraction of TiO_2 -C.B.fillers{ } at different wt.% of C.B and constant TiO_2 content (15% wt) and{. }at different wt.% of $TiO_2$and constant C.B content (15% wt)}.

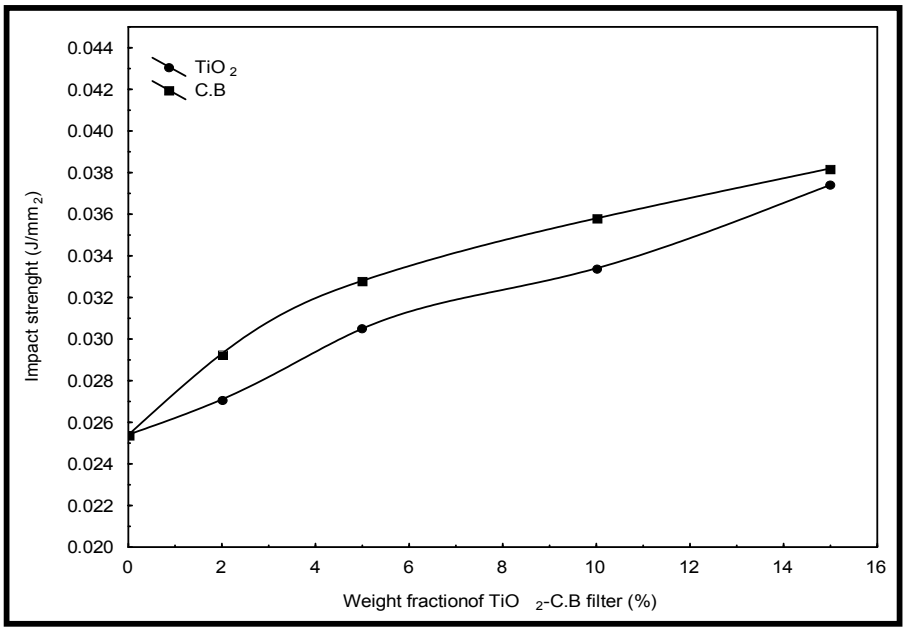

Fig.(3): The relation between the impact strength of HDPE sample with weight fraction of TiO_2-C.B.fillers{ } at different wt.% of C.B and constant TiO_2 content (15% wt) and{. }at different wt.% of $TiO_2$and constant C.B content (15% wt)}.

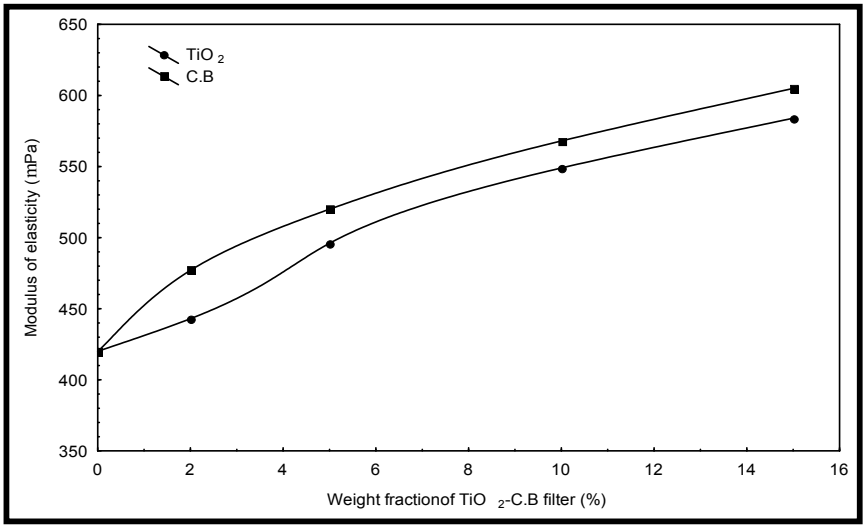

Fig.(4): The relation between the Modulus of elasticity of HDPE sample with weight fraction of TiO_2-C.B.fillers{ } at different wt.% of C.B and constant TiO_2 content (15% wt) and. { }at different wt.% of $TiO_2$and constant C.B content (15% wt)}.

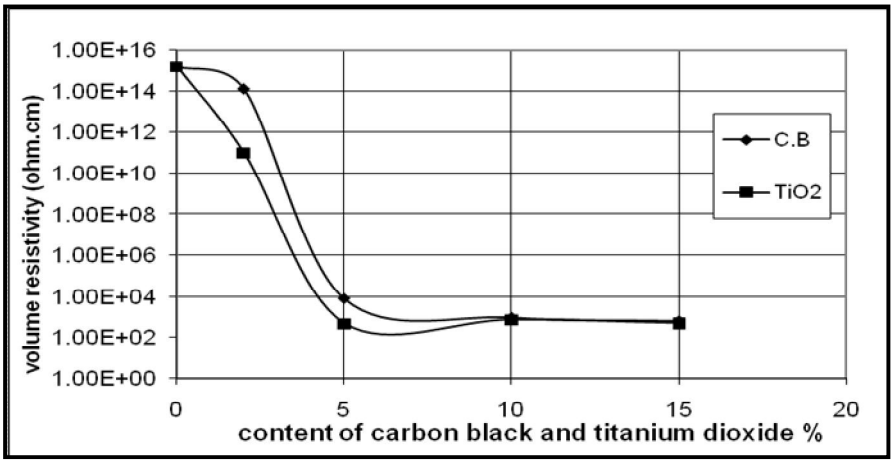

Fig.(5): Effect of C.B content on volume resistivity.

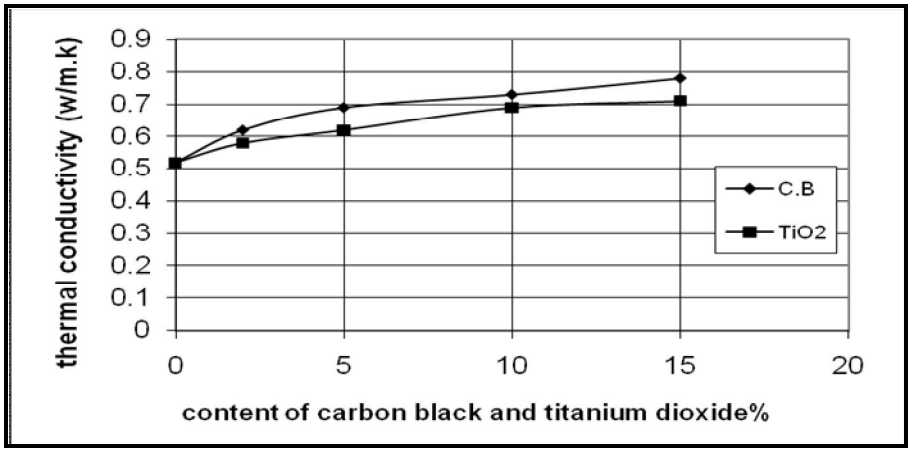

Fig.(6): Effect of C.B content on thermal conductivity.

الصفات الميكانيكية و الفيزياوية لمزيج البولي اثلين العالي الكثافة مع ثاني اوكسيد التيتانيوم – اسود الكاربون

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الخلاصة

في البحث الحالي تم تحضيرالمواد المتراكبة بواسطة مزج البولي اثلين العالي الكثافة مع نسب وزنية مختلفة من الاصباغ لاعضوية(ثنائي اوكسيد التيتانيوم–اسود الكاربون) wt% (15 – 2) كحشوة. باستخدام جهاز الباثقة الاحادية بدرجة حرارة تتراوح بين (190–170) م o في هدا البحث تم دراسة تاثير اضافة ثنائي اوكسيد التيتانيوم , اسود الكاربون على الخصائص الميكانيكية لبولي اثلين العالي الكثافة .تم أجراء العديد من الاختبارات الميكانيكية والفيزيائية لغرض تحديد خواص المادة المتراكبة المحضرة، حيث تضمنت تلك الاختبارات: مثل مقاومة الانضقاطية ومقاومة الصدم ومعامل المرونة ، ولجميع المتراكبات المحضرة وقورنت النتائج المستحصلة مع تلك التي تعود لمادة الأساس بمفردة . من النتائج التي تم الحصول عليها تبين ان استخدام الاصباغ لاعضوية (ثنائي اوكسيد التيتانيوم،اسود الكربون) أعطى تحسن في الخصائص الميكانيكية . في هذا البحث تم دراسه خواص التوصيل الحراري والكهربائي لبولي الاثلين العالي الكثافه المدعم باسود الكاربون واوكسيد التيتانيوم بنسب مئويه وزنيه تتراوح من ٠ الى ١٥ % وجد عند امرار فولتيه عاليه خلال النماذج المدعمة حدوث انخفاض واضح في المقاومه النوعيه مقارنه بنماذج البولي الاثلين العالي الكثافه غير المدعمه باسود الكاربون واوكسيد التيتانيوم .. ووجد تحسن في خواص التوصيل الحراري لمتراكبات البولي الاثلين العالي الكثافه المدعم باسود الكاربون واوكسيد التيتانيوم مقارنه باالبولي الاثلين العالي الكثافه غير المدعم .