Studying the Hardness Properties of (ZnxTeCd1-x/PS) Hybrid Composites

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Abstract

The hand moulding method was used in preparing composite samples (ZnxTeCd1-x/PS). Polystyrene was used as a matrix material. And the elements (Zn, Te and Cd) in the compound as a reinforced materials by using three different ratios (4%, 8 %, 12%) and different (X) for Zinc & Cadmium, but Tellurium is constant at (2gm). To study the hardness property by using Shore D Device (0-100) HD. It was found that there is gradual increase in the hardness values when the ratios increase.

Key Words: Polystyrene, ZnxTeCd1-x/PS, Hardness.

DOI Number: 10.14704/nq.2020.18.7.NQ20186 **NeuroQuantology 2020; 18(7):09-15**

Introduction

Polymeric matrix composites (PMC) reinforced by fibers, fillers, particles, used to increase hardness, impact strength and improve the physical properties of polymers and increase the temperature of polymers deformation. [1][2]. In this study using polystyrene resin as matrix material is hydrocarbon aromatic consist of styrene monomer it could be solid or foamed it hard and brittle at the same timeclear and transparent it have low resistance against oxygen and water vapor it is one more used for plastics it is naturally transparent [3] Polystyrene is made from growth chains polymers by polymerization process.

The materials that work on reinforcement the matrix materials and recognize by high elasticity modulus, high shear modulus, high resistance, and more solid from matrix materials the ductility of it high or low dependent on the kind of reinforcement matrix and the purpose that use for it. Reinforcement materials can be classification by shape and dimension to: Fibers, Particles, Flakes or as net of glass or metals or carbon materials [4] in this research used Zn, Cd, and Te particles. [5].

Theoretical Part

The hardness of a material is its resistance to penetration under a localized pressure, or is a measure of a material's resistance to plastic deformation [6]

Hardness techniques very important which have been developed over the years Hardness is a complex combination of three absolute properties that are expressed in units of stress, strain and elastic modulus. Hardness tests have been developed to all classes of solid materials [7]. There are many hardness- testing techniques:

1. (Rockwell)
2. (Brinell)
3. (Shore Durometer Hardness)
4. (Vickers)
5. (Scleroscope Hardness).
6. Micro Hardness (Knoop).

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Received: 04 June 2020 **Accepted:** 03 July 2020

Hardness tests very important for following reasons:

- The test device is simple and not expensive. The test can be done easily and simply and does not need to prepare a special sample.
- The test is nondestructive a small indentation is the only deformation.

There are two types of hardness Shore namely:

1. Shore A: used for soft plastic and have needle parallel both sides
2. Shore D: used for hard & soft plastic and have a sharp needle tool.[7].

The Shore D hardness test is advanced and advanced technology to numeric for plastics hardness test. It is non-destructive test. This device is made from stitched spring prominent from a hole in the base when the samples put opposite the base and periodically stitched is established samples push by spring the testing device is a small and beautiful in appearance and can be carried (light weight) and moved it easily to job sites it is easy to operate and gives very fast results and high accuracy values and it can be connected with computer.

It is handheld apparatus called Durometer it is used to check materials that are characterized by hardness and brittle in same time. It is mainly used to test the hard plastic, hard rubbers like epoxy resin, and soft plastic and soft rubbers like soft polyurethane and thermoplastics such as nylon, polystyrene, hard polyurethane. The field of measurement for this device ranges between (0-100) shore if it indicate the number 100 that is mean the penetration of needle in the sample (0mm) but if it indicate (0) it will be the amount of penetration (2.54mm) and the reading without units.

The principle of Shore D device work: When perpendicular force is applied to the sample surface pointed stiches it is a needle with a fine tip and by penetration the tool fully inside the surface of sample under the influence of projected stress will deflected the scale of instrument the amount of deflection represented the amount of scratching of samples surface (Hardness). The figure (1) show the Schematic of Shore D device.

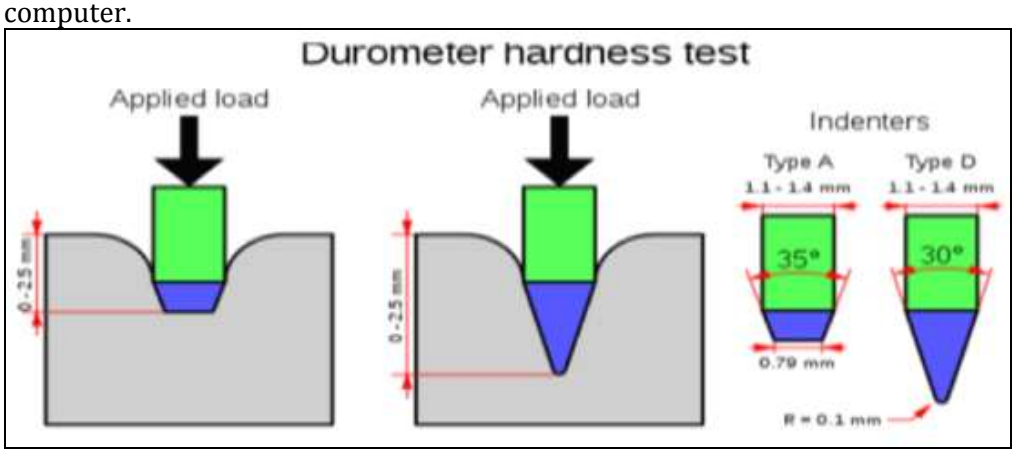

Figure 1. Hardness Scheme [6]

Experimental Part

Polystyrene as a Matrix

Polystyrene can be classified into three types depending on the distribution of phenyl group of polymer chains the first type is take planer Zig – Zag of chains polymer called isotactic the second type if the phenyl group random disruption of chains polymer so it is called a tactic the third type if the phenyl group alternating of sides of polymer chains it called syndioatactic this type due to the higher degree of crystalline quickly and gives higher properties suitable at high melting temperature and chemical resistance these types illustrated in figure (2)[8][9].

Polystyrene classified into three types (at, iso, syn) depending Stereoregularity sometimes called tactility that is more influence on polystyrene properties so the (tactic polystyrene) used widely in industry, (Syndiotactic polystyrene) it made with high regularity so used as catalyst to gives enhance properties like high rsistance to heat and tensile strength, (iso polystyrene) show diastereoisomers characterization such as tetramers and pentamers. There are two main types of polystyrene:

1. **GPPS**: it is homopolymer, brilliant and clear have highly various uses applications.
2. **HIPS**: it is rigidity, dimensional stability and clarity .elastomer modified polystyrene thermoplastic.

These two phase system conclude rubber phase and continuous phase.

The noncrystalline plastic very easy in processing so Provided polystyrene with very good characterization and a variety applications. Such as automotive, disposable, medical tools, house wares and telecommunications electronic computers parts. [10] Polystyrene is a brittle thermoplastic material. The addition of rubber increases impact strength.

Systems that application needs of toughness, rigidity, heat distortion resistance and flow behavior. PS polymerization processes, this is witty with raw material selection, formulation and operating conditions. The reinforcing or additional materials with polystyrene enhancement many properties such as rapid fabrication and improved environmental stress crack resistance polystyrene with specialty additives that provide additional properties, such as ignition resistance, scratch resistance and enhanced chemical resistance.[11]

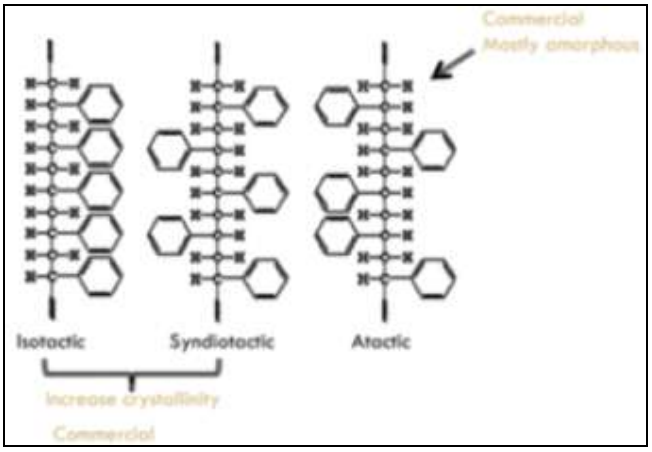

Figure 2. Types of polystyrene. [3]

Zinc Element Properties

Zinc element have the symbol (Zn) and its atomic number (30)its brittle metal at room temperature but its melting if heated between (100-150) [12]but after 210 becomes brittle again. It's have blue – silver color and its first element in 12 group from [13] period tab

le have oxidation state (+2) Zinc good conductive metal have low poiling and melting points and its reactive and strong metal have pure surface fast deformation, Zinc burn in air with green flame, Zinc react with acids and alkalis and nonmetals materials [14]

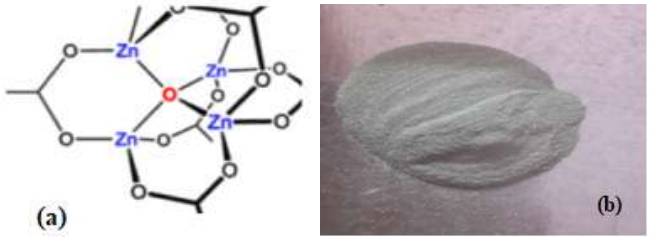

Figure 3. (a) Zinc Structure and (b) Appearance [14]

Table 1. Properties of Zinc Element :[15]

Chemical formula	Zn
Appearance	Silver -gray
Atomic number	30
Phase	Solid
Melting point	692.68k
Boiling point	1180 k
Density	7.14g/cm3
Crystal structure	hexagnol
Thermal conductivity	116w/mk
Young modulus	108 Gpa

Cadmium Element

Cadmium element have symbol (Cd) and atomic number (48) with silver –white color metal soft it is Chemically like Zinc also lies in 12 group from period table like Zinc and mercury elements,has low melting point but insoluble in water [16]. Cadmium burn in air and convert to brown color as CdO amorphous Cadmium using in electric batteries and in aircraft industry to less the corrosion of steel component [17]

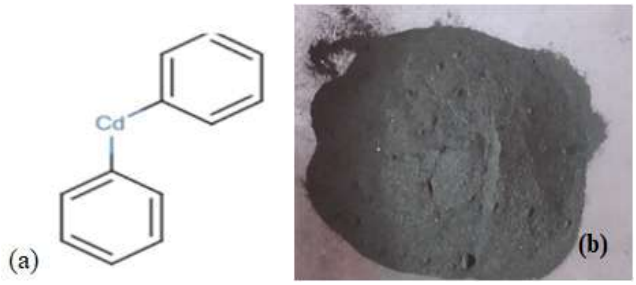

Figure 4. (a) Cadmium structure and (b) appearance[18]

Table 2. Properties of cadmium element[15]

Chemical formula	Cd
Appearance	Silvery bluish -gray
Atomic number	48
Phase	Solid
Melting point	594.22k
Boiling point	1040 k
Density	8.65g/cm3
Crystal structure	Hexagonal
Thermal conductivity	96.6w/mk
young modulus	50 Gpa

Tellurium Element

Is chemical element have (Te) symbols and high atomic number (52)brittle metal and mildly toxic it is usually found as native form related with Selenium and Sulfur and as a gas in space generated from volatile hydride [19] [20]. The principle Sources of (Te) generated is anode sludges from electrolytic refining of blister copper. (Te) founded as powders, Slabs, ingots and Sticks and Lumps [21] (Te) may be Amorphous and may be Crystalline when it is Crystallin have Silver – White color bright and brittle easy to pulverized but at Amorphous case have black-brown color. [22] (Te) is a semiconductors have a high electrical conductivity. And high melting and poiling point. Easy to adopt with polymeric structure consisting of Zig-Zag chains of Te atoms consist gray material resists oxidation by air. [23].the largest consumer of tellurium is metallurgy in iron. Stainless Steel, copper, and lead alloys tellurium used in telluride (CdTe) solar panels for solar cell electric power generates .instead of some of cadmium in CdTe by zinc producing (Cd, Zn)Te., to product a solid state X-ray detector .[24]

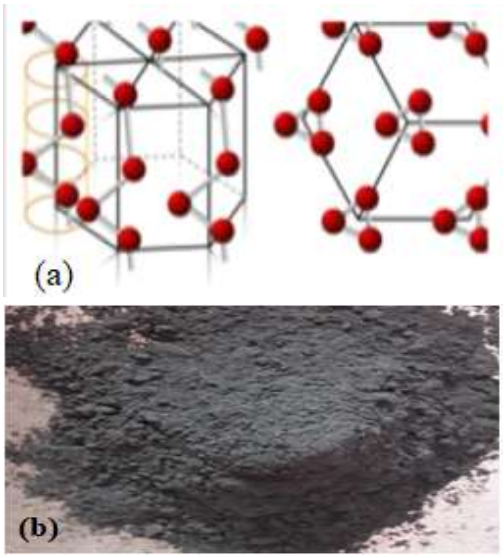

Figure 5. (a)Tellurium structure and (b) appearance[24]

Table 3. Properties of Tellurium element[15]

Chemical formula	Te
Appearance	Silvery-gray
Atomic number	52
Phase	Solid
Melting point	722.66k
Boiling point	1261k
density	6.24 g/cm3
Crystal structure	hexagonal
Thermal conductivity	1.97-3.38 w/m.k
Young modulus	43Gpa

Technique of Preparation

1. Prepare the molds in dimension (12.7x 15x 1) cm.
2. Grinding of polystyrene beads by German windmill
3. Mix the matrix and reinforced materials manually with a mechanical mixer
4. Put the mixer in the oven for an two hours, (240°C)
5. Leave it to cool at room temperature
6. Cut models as according standard specifications in the picture followed:

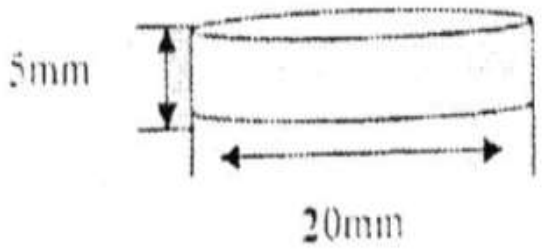

Figure 6. Hardness Samples Test

Hardness Test Device

Shore D Device that shown in figure (3-7) digital pocket size (0-100)HD shore durometer (HT-6600D) made in Beijing, Huatec the measured of hardness by this device is being when the needle penetrates the surface of sample by press it and reading directly with three different points from the surface of sample then takes the average

Figure 7. Hardness test instrument (Shore D)

Table 4. Hardness of (PS/Zn_xTeCd_{1-x})

Group Number	Weight Fraction	S.N	Sample Composition	Hardness (N/m^2)
G_3	$\Psi_1=0.04$	1	Zn(0%)Te(2gm)Cd(4%)+94%PS	60.8
		2	Zn(0.8%)Te(2gm)Cd(3.2%)+94%PS	62.3
		3	Zn(1.6%)Te(2gm)Cd(2.4%)+94%PS	63
		4	Zn(2.4%)Te(2gm)Cd(1.6%)+94%PS	65.2
		5	Zn(3.2%)Te(2gm)Cd(0.8%)+94%PS	67
		6	Zn(4%)Te(2gm)Cd(0%)+94%PS	69.36

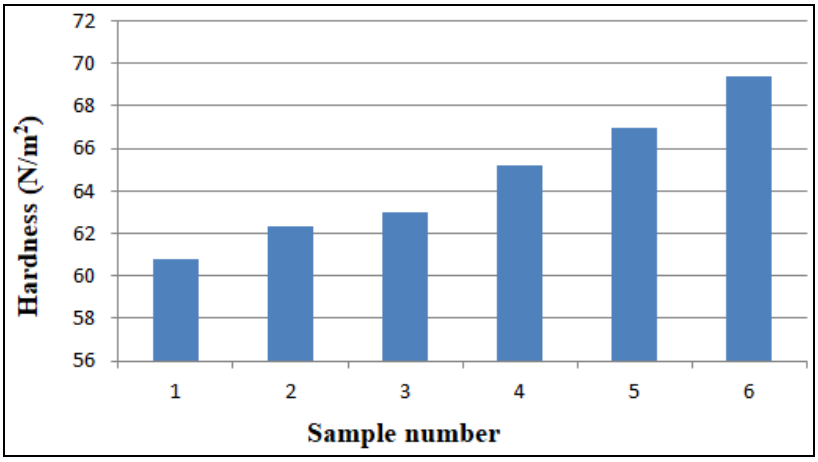

Figure 8. Hardness of (Zn_xTeCd_{1-x}) /PS with Sample Number

Table 5. Hardness of (PS/Zn_xTeCd_{1-x})

Group Number	Weight Fraction	S.N	Sample Composition	Hardness (N/m^2)
G_3	$\Psi_2=0.08$	1	Zn(0%)Te(2gm)Cd(8%)+90%PS	69.55
		2	Zn(1.6%)Te(2gm)Cd(6.4%)+90%PS	72.6
		3	Zn(3.2%)Te(2gm)Cd(4.8%)+90%PS	75.6
		4	Zn(4.8%)Te(2gm)Cd(3.2%)+90%PS	78.23
		5	Zn(6.4%)Te(2gm)Cd(1.6%)+90%PS	79
		6	Zn(8%)Te(2gm)Cd(0%)+90%PS	80.1

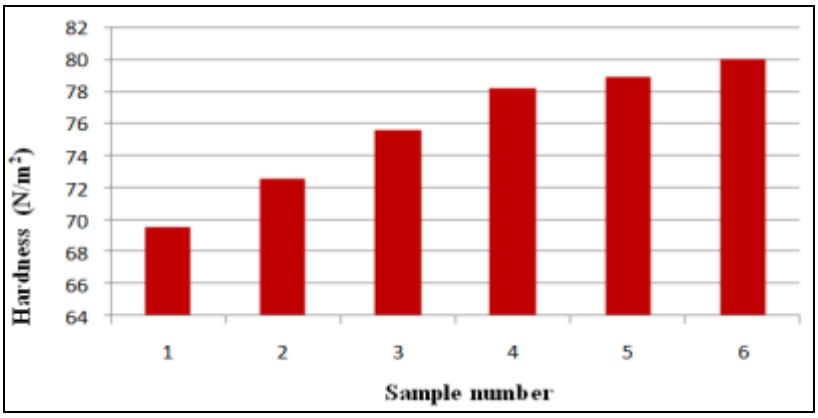

Figure 9. Hardness of (Zn_xTeCd_{1-x}) /PS with Sample Number

Table 6. Hardness of (Zn_xTeCd_{1-x}) /PS

Group Number	Weight Fraction	Sample Number	Sample Composition	Hardness (N/m^2)
G_3	$\Psi_3=0.12$	1	Zn(0%)Te(2gm)Cd(12%)+86%PS	84
		2	Zn(2.4%)Te(2gm)Cd(9.6%)+86%PS	84.7
		3	Zn(4.8%)Te(2gm)Cd(7.2%)+86%PS	86.4
		4	Zn(7.2%)Te(2gm)Cd(4.8%)+86%PS	87.8
		5	Zn(9.6%)Te(2gm)Cd(2.4%)+86%PS	88.4
		6	Zn(12%)Te(2gm)Cd(0%)+86%PS	90.8

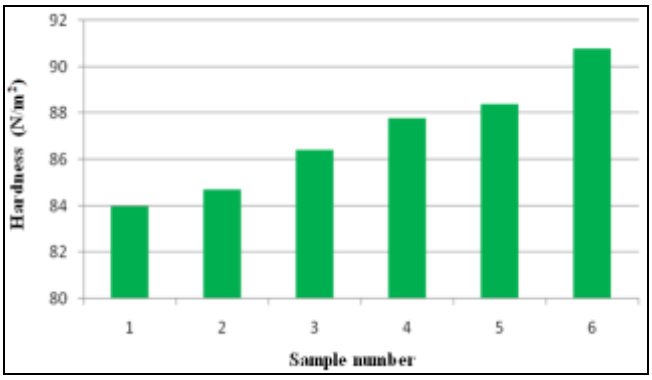

Figure 10. Hardness of (Zn_xTeCd_{1-x}/PS) with Sample Number

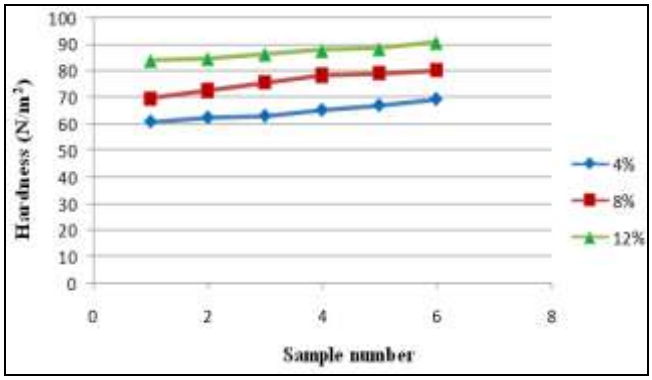

Figure 11. Hardness test for weight fraction Ψ_1,Ψ_2,Ψ_3,G_3

Discussion

In the third group the hardness has (60.8) at the ratio (4%) gradually increasing with the ratio increasing to become (69.36) but at the ratio (8%) has (69.55) become (80.1) finally at the ratio (12%) the value of hardness (84) at the first sample but at the sixth sample become (90.8) .due to the increase in the strengthen materials that lead to a further increase in tangles and stacking the forces that link the molecules of the matrix materials and reinforced materials increase that lead to retardation polymers molecules thus the scratch resistance of material increase that is the hardness increase. The tables (4) (5)(6) and the figures (8)(9)(10)(11). This is agree with [**25**].

Conclusion

We conclude from the above that adding (Zn, Te, Cd) with different proportions and for (x) different leads to an increase in the hardness values gradually by increasing the percentage of weight fraction and increasing the (x) of zinc and decreasing it of cadmium with tellurium constant at 2 gm. Where the highest value of hardness was at the sixth sample and third ratio .Ψ3=12% was ($90.8N/m^2$).

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