Indian Journal Of Natural Sciences *www.tnsroindia.org. © IJONS*

Vol.7 / Issue 37 / August 2016 *International Bimonthly* *ISSN: 0976 – 0997*

RESEARCH ARTICLE

Study of Tensile Strength, Impact Strength, and Thermal Stability of Epoxy – TEOS Hybrids

Seenaa Ibrahim Hussein

Department of Physics, College of Science, University of baghdad,Iraq.

Received: 28 May 2016 Revised: 20 June 2016 Accepted: 31 July 2016

***Address for correspondence**
Seenaa Ibrahim Hussein
Department of Physics,
College of Science,
University of baghdad,Iraq.
Email: sinna633@gmail.com

ABSTRACT

In this research prepared hybrid organic – inorganic (epoxy – TEOS) using sol- gel method with different ratios of Tetraethylorthosilicate (TEOS) (0,4,6,8,10)% .Make mechanical tests the tensile strength and impact strength to find out carrying hybrid component with tensile , impact and the best ratio in applications To find the best ratio (4%) compared with other ratios the good bond between epoxy and inorganic material. To choose the best ratio 4% to study thermal gravimetric analysis (TGA). The thermal degradation of hybrid(epoxy + 4% TEOS) take place at higher temperatures than the epoxy pure.

Key words :- Tensile strength , Impact strength , TGA, Epoxy , TEOS

INTRODUCTION

The mechanical behavior refers to the response of materials to forces. Under load, a material may either deform or break. The factors that govern a materials resistance to deformation and very different from these governing its resistance to fracture [1]. Fractures can classify in several ways. A fracture is described as ductile or brittle depending on the amount of deformation that precedes it failures may also be described as intergranular or transgranular depending on the fracture path [2] .Failure in a tensile test of a ductile material occurs well after the maximum load is reached and a neck has formed [2]. In this case, fracture usually starts by nucleation of voids in the center of the neck, where the hydrostatic tension is the greatest [2]. Impact test are often used to assess the toughness of materials. The most common of this is the charpy test. A notched bar is broken by a swinging pendulum. The energy absorbed in fracture is measured by recoding by how high the pendulum swings after the bar breaks [1].

Polymer materials available today, especially the plastics, are the result of decades of evolution. Their production is extremely efficient in terms of utilization of raw materials and energy, as well as of waste release. The products present a series of excellent properties such as impermeability to water and microorganisms, high mechanical strength, low density, and low cost due to manufacturing scale and process optimization [3].Organic–Inorganic hybrids materials are important in a variety of fields as they combine the desirable properties of the organic phase (flexibility, process ability, ductility) with that of the inorganic phase (thermal stability, rigidity) [4]. Polymer–silica hybrids with enhanced thermal and mechanical properties (because of the silica component), better flexibility (due to the polymer content), and various tailored properties have attracted a lot of attention for a variety of applications including catalysis. [5]

The sol-gel process is of interest in preparing these materials due to its mild conditions such as low temperature and pressure [6]. This process provides a convenient route to combine inorganic and organic components as a homogeneous hybrid material. Many researchers have demonstrated that, monolithic transparent hybrid materials without macroscopic phase separations can be prepared by controlling properly the conditions of hydrolysis and condensation of sol-gel materials such as tetraethoxysilane (TEOS)[6]. Silica-polymer hybrid materials have received much attention, due to their wide application in adhesion, biomaterials, protective coatings, composites, microelectronics, thin-films [7]. Polymers can be divided into type thermoplastics and thermosets, according to their behaviour under temperature rise. Thermoplastics become softer when they are heated and harden back when they are cooled. This is a reversible process. When thermosets are heated, they become permanently hard[8].

Bandyopadhyay et al. ***(2005)*** described effect of polymer–filler interaction on solvent swelling and dynamic mechanical properties of the sol–gel derived acrylic rubber (ACM)/silica, epoxidized natural rubber (ENR)/silica, and poly (vinyl alcohol) (PVA)/silica hybrid nano composites .Tetraethoxysilane (TEOS) at three different concentrations (10, 30, and 50 wt %) was used as the precursor for *in situ* silica generation. Equilibrium swelling of the hybrid nano composites in respective solvents at ambient condition showed highest volume fraction of the polymer in the swollen gel in PVA/silica system and least in ACM/silica, with ENR/silica recording an intermediate value [9]

Experimental part

MATERIALS AND METHODS

TEOS :was a silica precursor was produce from sigma-aldrich (Germany company) . ethonal England company

Ethonal : Ethanol (EtOH) ,GCC/Gainland chemical company ,C_2H_5OH Molecular Weight (g/mol) =46.07 ,density= 0.785, purity= 99.9% Liquid
H_2O: Deionized Water (H_2O) ,University of Baghdad/ College of Science/Laboratory of service , Molecular Weight (g/mol) = 18, density = 1 ,high degree of purity/empty of additional ions ,Liquid

Epoxy : epoxy (105) Don construction products (DCP) , Amman –Jordan The ratio of hardener to epoxy used in this study was approximately 3:1.

Hydrochloric Acid (HCl) ,BDH , Molecular Weight (g/mol) =36.46, density= 1.19 ,purity= 37% , Liquid.

Preparation of alkoxysilane solution and epoxy matrix materials solution

To prepared silica using sol-gel method to use TEOS and ethonal and H_2o with HCL (PH=1) the value in table (1) was stirred at 50 °c unit it become homogenous solution The composition of the matrix materials epoxy and hardener the ratio (3:1) the liquid hardener was slowly added epoxy resin at room temp. , this mixture was stirred at 10 min.

Preparation of epoxy –silica hybrid materials

To added the alkoxysilane solution to the epoxy and stirred solution in a glass tube was prepared using different concentration alkoxysilane -epoxy -hardener solution composition of which in table (2)

Preparation of Tensile and Impact Test Samples

Epoxy –silica hybrid solutions casting into molds at 24 hours to dry out and cutting the ASTM of tensile (D638) and impact test (Iso-179).

5-Thermogravimetric analysis (TGA)
TGA use helium as inert gas in rate 20ml/min ,at temperature range of 0 to 1000_{o} c at a heating rate of 10˚ c/min. the samples were ground into fine powder .the measurements were taken using 3-5mg samples.

RESULTS AND DISCUSSION

Tensile strength

Tensile strength of the hybrids are mostly affected by the materials, specimen condition , method , preparation of sample ,and percentage of the reinforcement [10]. The results of the tensile strength of the hybrids at different percentages of TEOS figure (3) shows that the strength high in ratio 4% TEOS this is due to good bonding between Epoxy and TEOS and that strongly affect the properties of the hybrid materials. but the ratio (6,8,10%) less the values of tensile strength which agree with [11].If the epoxy and TEOS not properly mixed ,cause voids and increase level of porosity in the system .this is the reason the one ratio (4%) exhibited highest value compared with other ratio .

Impact strength

TEOS –polymer hybrid materials can be obtained by simply mixing organic –inorganic components ,however ,it is usually difficult to obtained homogenous mixture of TEOS and organic polymer, due to the formation interpenetrating network of the organic-inorganic hybrid system. this is duo to formation of hydrogen bonds between epoxy and TEOS [12].

Figure (2) shows the values of impact strength the highest value the ratio 4% due to the good bonding between epoxy and TEOS and the good bonding between them duo to the good impact strength .As the amount of TEOS in the hybrids increased the impact strength decreased which agree with [11].

Thermo gravimetric analysis (TGA)

Figure (3) and figure (4) shows the TGA curve of epoxy pure and hybrid epoxy +4% TEOS .it can be observed that the thermal degradation of hybrid take place at higher temperatures than the epoxy pure. The initial degradation temperature of epoxy pure that occurred around (~106.60 ºC) and hybrid epoxy +4%TEOS (~104.99 ºC),due to elimination of water from the systems . for the temperature around (~366.23ºC) ,the decomposition of the polymer matrix occurred which degraded the chemical bonds of the epoxy and hybrid (~559.71 ºC).The slightly improved thermal stability for the hybrids compared to the pure epoxy may be caused by the interactions between the polymer chains and SiO_2, and hydrogen bonding should be the main source of such interactions. Figure (4) has been observed that the area of the curve smaller than the area of curve figure (3) because for this to occur dehydration from the sample.

CONCLUSION

The tensile strength and impact strength high values of only ratio 4% because the good bonding between epoxy and TEOS, this is duo to formation of hydrogen bonds between epoxy and TEOS . The slightly improved thermal stability for the hybrids compared to the pure epoxy may be caused by the interactions between the polymer chains and SiO_2,

REFERENCES

1. William F. Hosford " mechanical behavior material", Cambridge university press, 2005 ,published in the united states of American by Cambridge university press, New York.
2. F. Mc Clintock and A. Argon " mechanical behavior of materials ", Addison –wesley ,1966.
3. F. Ylmaz" Polymer Science"published by InTech Janeza Trdine 9, 51000 Rijeka, Croatia , (2013)
4. G. Larsen, R. Velarde-Ortiz, K. Minchow, A. Barrero, and I. Loscertales, "A Method for Making Inorganic and Hybrid (Organic/Inorganic) Fibers and Vesicles with Diameters in the Submicrometer and Micrometer Range via Sol-Gel Chemistry and Electrically Forced Liquid Jets ",J. Am. Chem. Soc ,vol. 125 (2003) 1154-1155.
5. S. Wu , F. Li , Y. Wu , R. Xu,and G. Li, "Preparation of Novel Poly(vinyl alcohol)/SiO2 Composite Nanofiber Membranes with Mesostructure and their Application for Removal of Cu^{2+} From Waste Water".Chem. Commun.vol. 46 (2010) 1694–1696.
6. Nazanin Farhadyar, Azam Rahimi, and Amir Ershad Langroudi " Preparation and Characterization of Aromatic Amine Cured Epoxy-Silica Hybrid Inorganic-Organic Coating via In Situ Sol-gel Process ", Iranian Polymer Journal 14 (2), 155-162,(2005)
7. Tânia Ribeiro, Carlos Baleizão and José Paulo S. Farinha " Functional Films from Silica/Polymer Nanoparticles", J. of Materials ,7, 3881-3900 ,(2014).
8. Callister, W. D., Jr. Materials Science and Engineering: An Introduction. 7th Edition. John Wiley & Sonsp.p. 721, 2007.
9. A. Bandyopadhyay, M. de Sarkar, and A. Bhowmick " Polymer–filler interactions in sol–gel derived polymer/silica hybrid nanocomposites",journal of Polymer Science Part B: Polymer PhysicsVol.43 (2005) 2399–2412.
10. American standard of tensile material (ASTM),Standard test method for tensile properties of reinforced thermosetting plastics using straight sided specimen ASTM International ,USA.p.p.32-37,2004.
11. Mustafa Cakir,Llyas Kartal, Halil Demirer and Ramazan Samur " Effect of water absorption on the wear behavior of Sol-gel processed epoxy –silica hybrids", scientific research and essays, vol. 7,7,p.p.805-812,2012.
12. Nazir , T. ,Afzal A., Siddiai , H. " thermally and mechanically superior hybrid epoxy –silica polymer films via sol-gel method ", 69,p.p. 100-106, 2010.

Table 1: The Reagent volumes used in silica preparation

TEOS(ml)	H_2O(PH=1)(ml)	Ethonal (ml)
5	20	5

Table 2: Composition of epoxy –silica hybrid materials

Sample	S1	S2	S3	S4	S5
By weight TEOS %	0	4	6	8	10

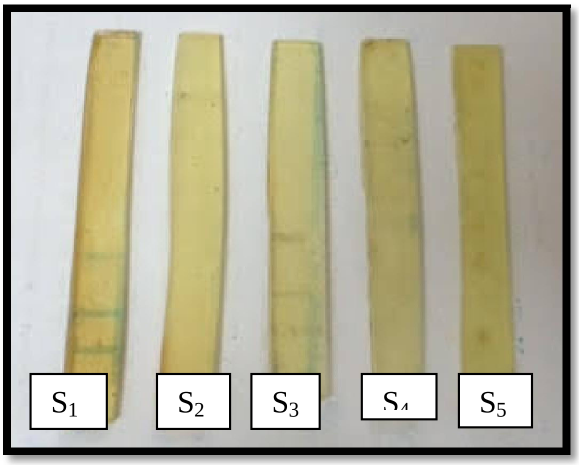

Figure (1) sample of tensile

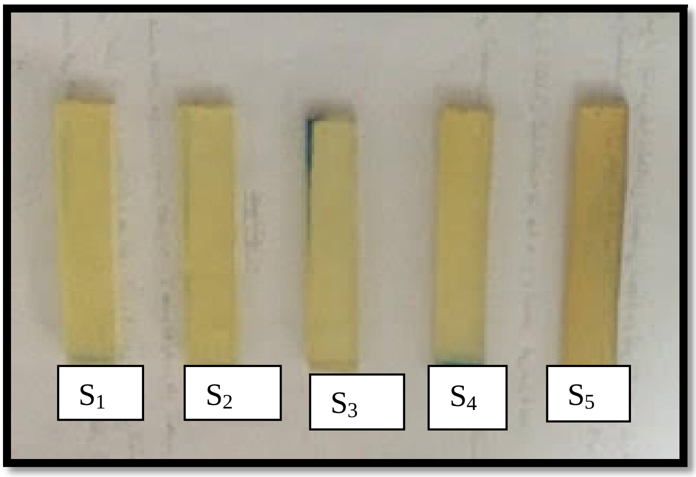

Figure (2) sample of impact test

Table 3. Values of tensile strength

Sample	(TEOS- Epoxy)%	Max. forces(N)	Tensile strength(Mpa)
S_0	0%	575.45	11.3
S_1	4%	1819.4	25.5
S_2	6%	664	10.3
S_3	8%	443	7.8
S_4	10%	302	4.8

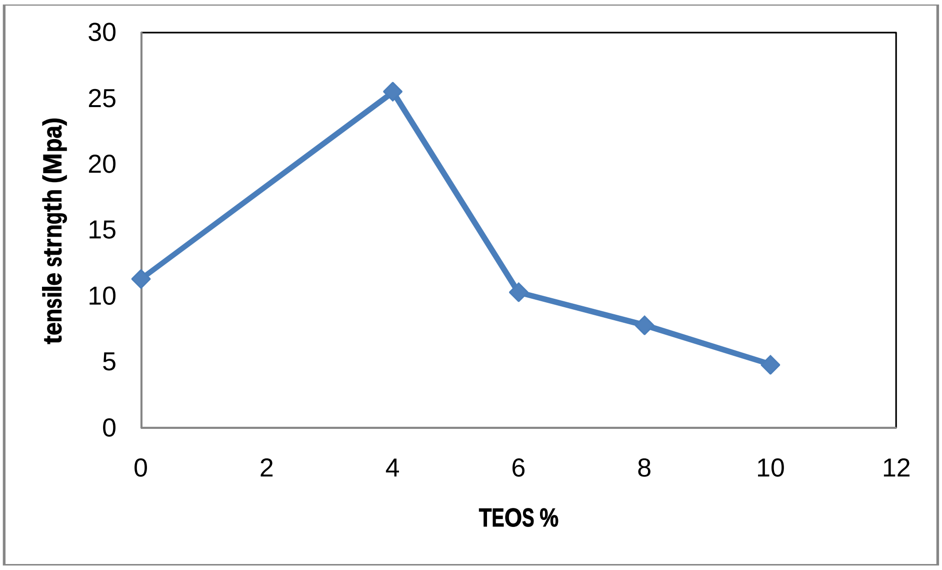

Figure.3 Tensile strength of hybrids materials

Table 4: Values of Impact Strength

Sample	(TEOS- Epoxy)%	Impact strength (KJ/m²)
S_0	0%	30.3
S_1	4%	38.85
S_2	6%	29.09
S_3	8%	18.79
S_4	10%	7.88

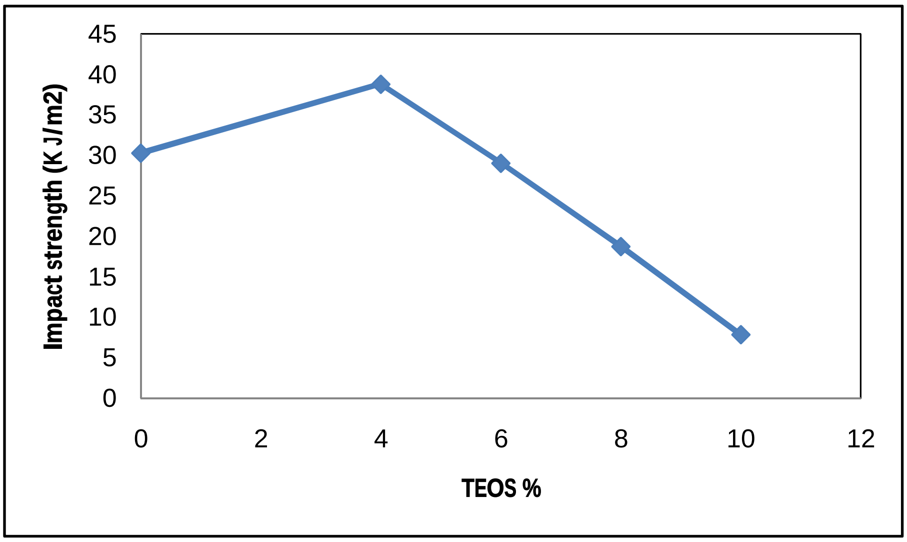

Figure 4. Impact strength of hybrids materials

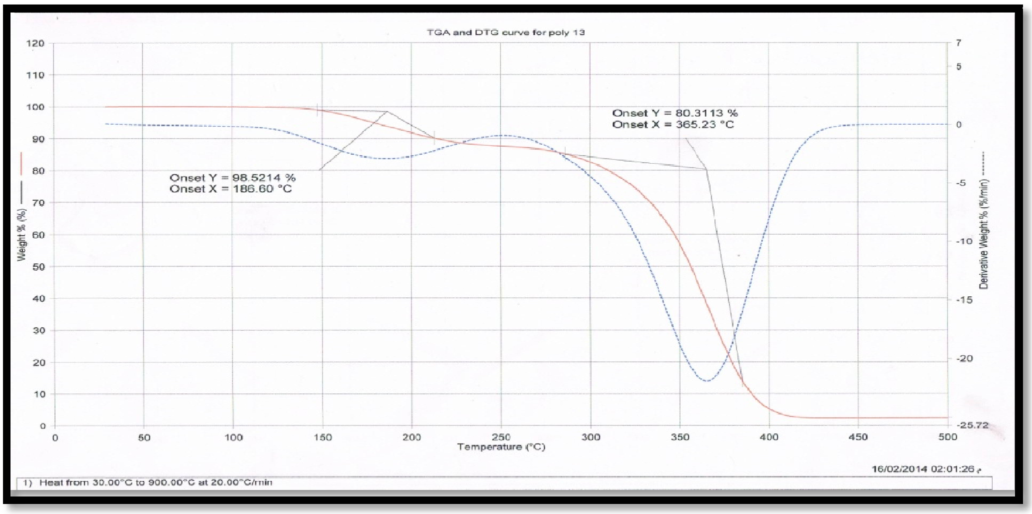

Figure 5:TGA &DTG of epoxy pure

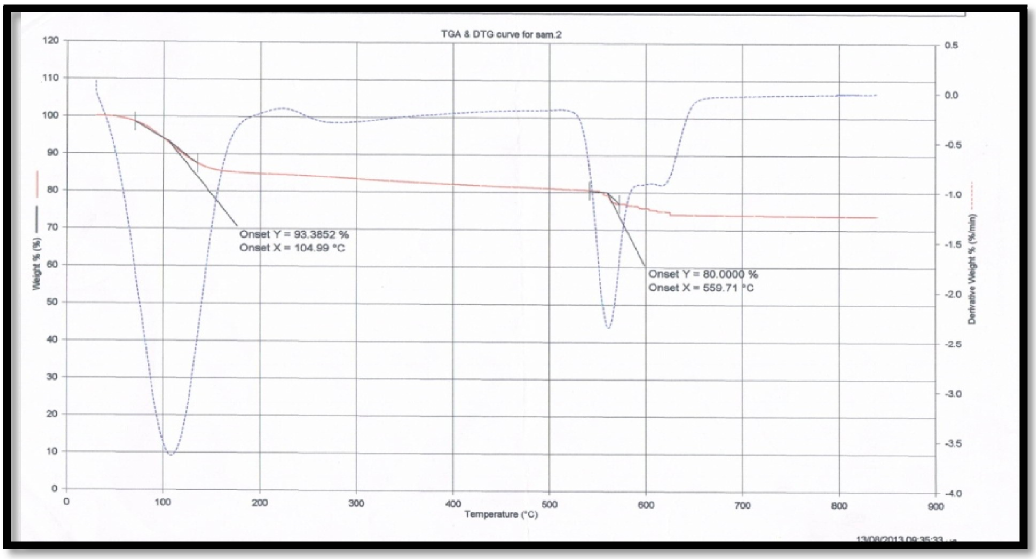

Figure 6: TGA &DTG of epoxy + 4% TEOS