iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** VII **Month of publication:** July 2022

DOI: https://doi.org/10.22214/ijraset.2022.46064

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VII July 2022- Available at www.ijraset.com

Study of High Density Polyethylene with Nanoparticle Silica Composite Thermal and Mechanical Properties

Ms Akansha Srivastava
Mechanical Engineering Department Dr APJ Abdul Kalam Technical University Lucknow

Abstract: ***For the creation of composite materials based on high density polyethylene, silica nanoparticles are utilised as fillers. Due to their low cost, high aspect ratio, and rather acceptable mechanical qualities, silica nanoparticles are recommended for reinforcement of high density polyethylene and may be found in a variety of sources. Compression moulding and a stirrer were used to prepare the composite. Tensile and Impact tests are used to examine the composite's mechanical characteristics. Thermo-Gravimetric Analysis (TGA) and Differential Scanning Calorimetry are used to assess the composite's thermal characteristics (DSC). The results of the composite's testing show that adding silica nanoparticle reinforcement has enhanced the mechanical and thermal characteristics of the HDPE composite.***
Keywords: HDPE (High Density Polyethylene); reinforcement; Impact test; TGA; DSC.

I. INTRODUCTION

Due to its characteristics, including high stiffness and strength, corrosion and chemical resistance, ease of manufacturing, economic efficiency, and environmentally benign behaviour, composite materials are becoming more and more used in industries today. The mechanical and thermal characteristics of the produced composite materials are now the main focus of study [1-3]. The majority of thermoplastic-based composites are made of polypropylene and polyethylene[4].

Very Dense Due to its qualities, including outstanding adhesion, great mechanical characteristics, chemical stability, cheap cost, high hardness and adhesive strength, and high damping properties, polyethylene is the most commonly utilised matrix material for the production of composite materials.

It may be combined with other inorganic fillers to broaden the range of its applications. It has been shown that increasing the tensile strength of composites requires substantial loadings of macro-sized fillers, whilst increasing their toughness only requires low loadings of nano-sized fillers like titanium, CaCo3, and silica[7].

In this study, silica nanoparticle reinforcement of high density polyethylene is evaluated. There are rumours that India wastes a lot of silica.

A composite material is a mixture of two or more constituent elements that, when combined, create a material with unique qualities from the sum of the parts [5–6]. These constituent materials must have significantly different chemical or physical properties. To find uses in industry, the discarded silica is combined with high density polyethylene. To create high density polyethylene composite, high density polyethylene is combined with silica nanoparticles at a weight-per-percentage of 3%. Compression moulding of the composite takes place at a given temperature and time. The mechanical and thermal characteristics of the high density polyethylene and silica nanoparticle reinforced composite are superior than other materials. Colom et al. created HDPE composite by combining it at 200 degrees Celsius in a crucible and moulding it at 150 degrees Celsius in a compression vessel. For chilling in air, you can perish for up to 50 minutes and 4 hours[8].

According to Chrissafis et alresearch, .'s SiO2 nanoparticles improve the mechanical and thermal characteristics of composite materials. PMCs are strong and rigid in the direction of the reinforcement while being light in weight. As a result, they are helpful in moving constructions such as cars and aeroplanes [10].

II. TESTING PROCEDURE

To strengthen HDPE, silica nanoparticles have been used. Silica nanoparticles have unique binding characteristics. So, silica nanoparticles were our material of choice. To create a composite sample, a homogenous HDPE liquid and SiO2 nanoparticles were combined. The composite is put through the following tests to examine its thermal and mechanical characteristics.

A. Mechanical Evaluation

1) *Test of Tensile strength:* Flat specimens are often used for the tensile test. Dog bone shapes and straight side compositions with end tabs are the most often used example geometries. The ASTM D-3039 standard on an electronic Universal Testing Machine lead the ductile testing. *Testing apparatus.* The example's range measured 120 mm. Crosshead speed throughout the experiments was 9.7 mm/min.

Figure 2.1.1 shows the UTM machine with the sample loaded for tensile testing.

2) *Impact Test:* The ability of a substance to absorb applied energy is referred to as impact strength. J/m is its unit. A computerised impact testing equipment was used to carry out the impact test in accordance with ASTM D-256A standard.

Fig. 2.1.2 Impact testing machine with Sample loaded condition

B. Thermal Analysis

1) *Testing Thermal Conductivity with a Laser Flash:* The well-known flash technique is the foundation of the LFA 447 NanoFlash. In this procedure, a brief light pulse is used to heat the front side of a sample that is plane-parallel. An infrared detector is used to measure the temperature increase that results on the back surface. The thermal diffusivity can be found by analysing the temperature versus-time curve that results. In order to accommodate a wide range of applications and temperatures between -125°C and 2800°C, LFA 447 provides a number of flash systems. The LFA 447 is a highly accurate, affordable, and user-friendly device for evaluating materials between room temperature and 300°C. ASTM E 1461 was followed in conducting the testing

Fig. 2.2.1 LFA 447 used for thermal conductivity, thermal diffusivity and bulk density

2) *Thermo-Gravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSG) (TGA)*: STA 6000 provides simultaneous weight change and heat flow measurements and analyses of sample pharmaceutical tablet or polymer materials. The STA 6000's flexible differential temperature analysis (DTA or DSC) and tried-and-true thermo gravimetry (TG) technology enable it to produce findings that are accurate and dependable while making data interpretation easier. ASTM E 1269 was followed in conducting the testing.

Fig. 2.2.2 STA 6000 used for DSC and TGA test

III.RESULT AND CONVERSATION

The prepared sample has undergone mechanical and thermal testing; the findings are detailed below.

A. Tensile Test

The force and elongation curve for sample A, B, and C's maximum tensile strength is depicted in the accompanying figures.

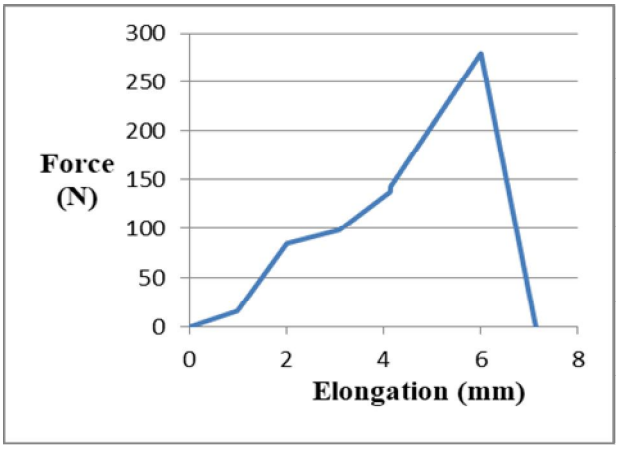


Fig. 3.1.1 Force V/s Elongation curve with 0% Silica nanoparticles

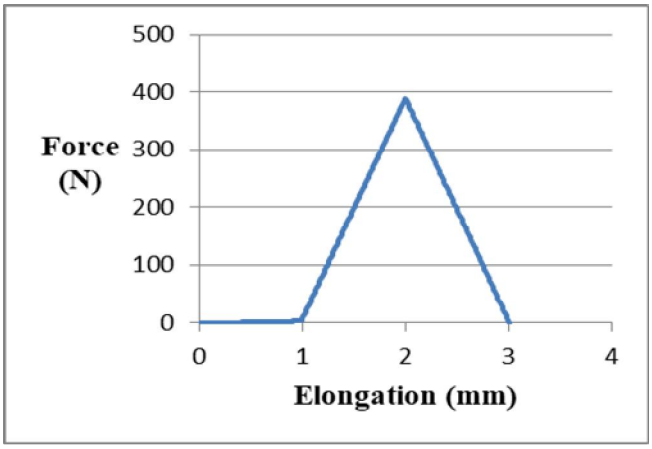


Fig. 3.1.2 Force V/s Elongation curve with 5% Silica nanoparticles

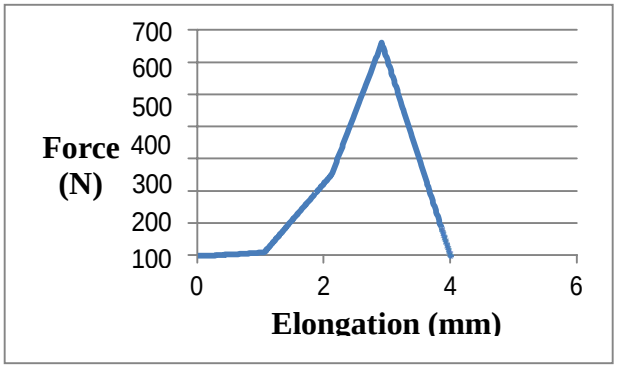


Fig. 3.1.3 Force V/s Elongation curve with 10% Silica Nanoparticles

Table-3.1: The obtained Tensile Strength of different composite samples

SPECIMEN	TENSILE STRENGTH (MPa)		
	SAMPLE A	SAMPLE B	SAMPLE C
1	2.913	4.077	6.416
2	3.737	4.625	8.781
3	3.397	5.331	7.972
AVERAGE	3.349	4.677	7.723
SAMPLE A: HDPE composite with 0% Silica nanoparticles			
SAMPLE B: HDPE composite with 5% Silica nanoparticles			
SAMPLE C: HDPE composite with 10% Silica nanoparticles			

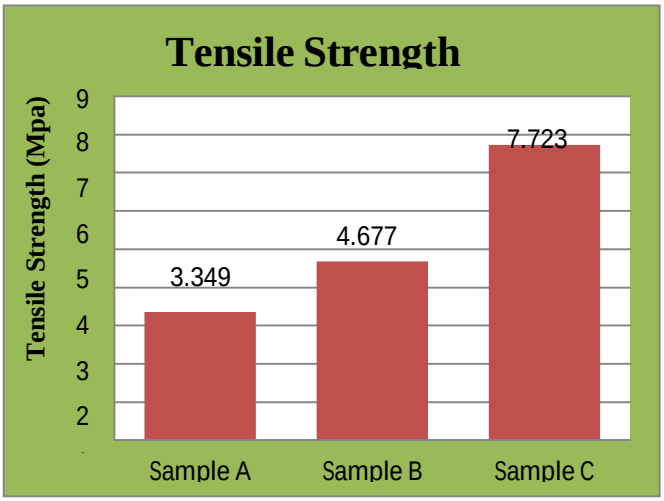


Fig. 3.1.4 Compares Tensile Strength with Silica Nanoparticle Variation

Due to the high strength of silicon carbide, the tensile strength is improved by 39.35 percent and 130.6 percent with the addition of 5 percent and 10 percent of silicon carbide, respectively, from the figures above. Impact Test: Based on tests done on the relevant samples, the impact test findings are as follows.

Table-3.2: Different composite samples' computed impact strengths.

SPECIMEN	IMPACT STRENGTH (J/m)		
	SAMPLE A (0% Silica nanoparticle s)	SAMPLE B (5%Silica nanoparticle s)	SAMPLE C (10% Silica nanoparticle s)
1	171	211.7132	251.9235
2	171	214.7136	237.4328
3	169.5689	205.8392	259.6667
AVERAGE	170.5229	210.7553	249.6743

The graph below tabulates the results' average values.

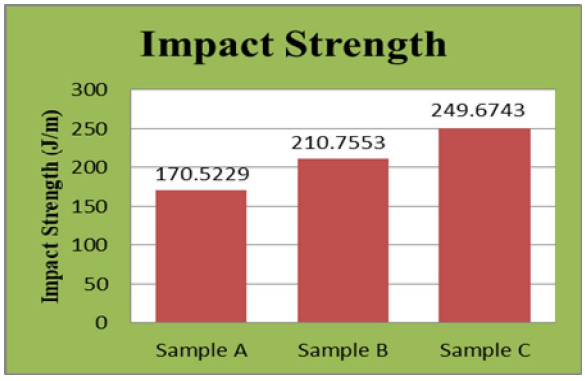


Fig. 3.2.1 Impact Strength Comparison with Silica Nanoparticle Variation

Due to silicon carbide's high strength, the aforementioned data show that adding 5 and 10% silicon carbide, respectively, increases the impact strength by 23.58 and 46.42 percent.

1) LASER Flash Thermal Conductivity Test

Composites' thermal conductivity In the graph, Samples A, B, and C are tabulated.

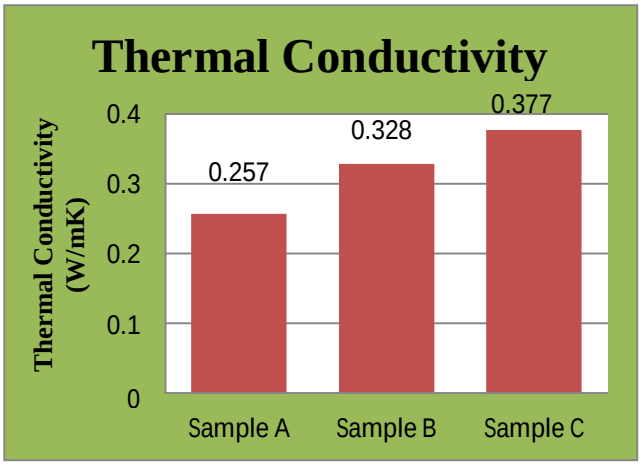


Fig. 3.3.1 Comparison of Thermal Conductivity with the variation of the Silica nanoparticles

B. STA-based DSC and TGA tests

In a thermal analyzer, a simultaneous DSC and TGA test is performed with a heating rate of 10C/min and a temperature range of 300C–1000C. Liquid nitrogen is utilised at a rate of 20ml per minute to maintain temperature variation above atmospheric conditions.

These figures demonstrate the heat flow for samples A, B, and C.

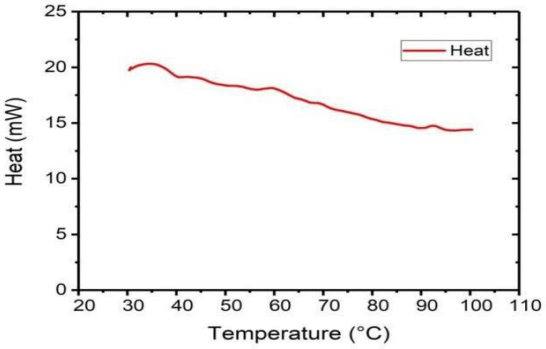


Fig. 3.4.1 Heat flow V/s temperature for Sample A

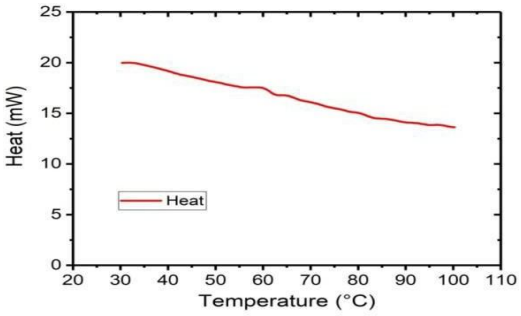


Fig. 3.4.2 Heat flow V/s temperature for Sample B

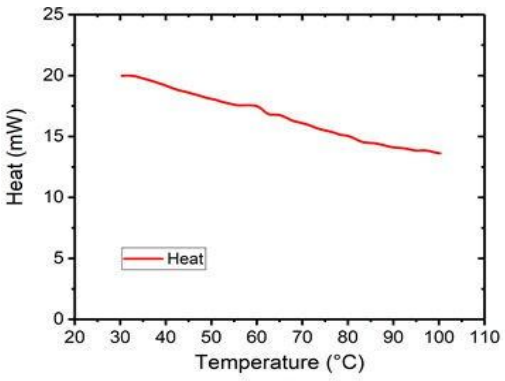


Fig. 3.4.3 Heat flow V/s temperature for Sample C

IV. CONCLUSIONS

For the purpose of creating three separate samples with a combined HDPE and Silica nanoparticle content of 10% by weight, the Silica nanoparticle content in the matrix was varied as follows: (Sample A) 0% by wt. Silica nanoparticles at two different concentrations: 10% by weight in Sample C and 5% by weight in Sample B. According to ASTM standard, three specimens of each sample were tested to determine the mechanical qualities, and one specimen of each sample was tested to determine the thermal properties. For the heat flow and thermal stability in the STA6000 apparatus, DSC and TGA measurements were performed. These are the conclusions:

1) Based on the findings of tensile testing, it can be deduced that the addition of 5 and 10% of Silica nanoparticles, respectively, increases tensile strength by 39.35 and 130.6 percent.

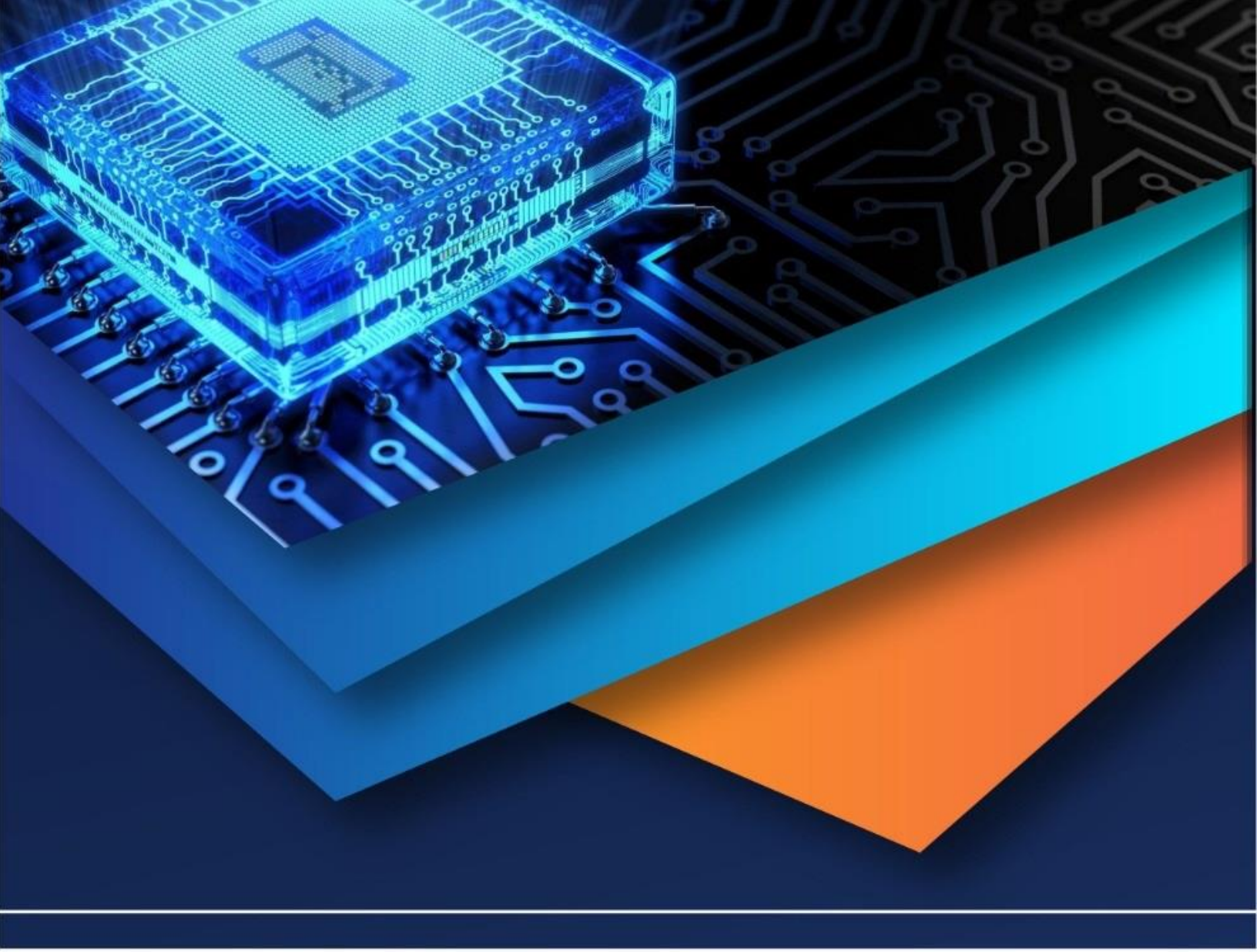
2) The impact strength is seen to rise by 23.58 percent and 46.42 percent, respectively, with the addition of 5 and 10 percent of silica nanoparticles, according to impact testing (IZOD technique).

3) According to the findings, the addition of 5 and 10% of Silica nanoparticles, respectively, enhanced heat conductivity by 27.63 and 46.69%.

4) We learned through STA that the number of Silica nanoparticles boosts heat stability.

REFERENCES

[1] Bledzki AK, Gassan, J. Composites reinforced with cellulose based fibers. J Prog Polym Sci.1999;24(2):221–274
[2] Peijs T. Composites turn green. E-Polymers. 2002;T_002:1–12
[3] Marcovich NE, Villar MA. Thermal and mechanical characterization of linear low-density polyethylene/wood flour composites. J Appl Polym Sci. 2003;90:2775–2784.
[4] Li Z, Gao H, Wang Q. Preparation of highly filled wood flour/recycled high density polyethylene composites by in situ reactive extrusion. J Appl Polym Sci. 2012;124(6):5247–5253.
[5] Fazeli, M.; Florez, J.; Simão, R. (9 November 2018). "Improvement in adhesion of cellulose fibers to the thermoplastic starch matrix by plasma treatment modification". Composites Part B: Engineering. **163**: 207–216.
[6] Smart Composites: Mechanics and Design (Composite Materials) R. Elhajjar, V La Saponara (, A. Muliana , Editors , CRC Press 2017 ISBN-10: 1138075515
[7] Tjong SC. Structure and mechanical properties of polymer Nano composites. Mater Sci Eng Rep. 2006;53(3):73–197.
[8] Mohsen Mohseni Tabar Taghi Tabarsa Mehdi Mashkour Abolghasem Khazaeian Using silicon dioxide (SiO2) nano- powder as reinforcement for walnut shell flour/HDPE composite materials. Received: 2 February 2015 / Accepted: 6 April 2015 Indian Academy of Wood Science 2015.
[9] Chrissafis K et al. Thermaldegradation mechanism of HDPE nano composites containing fumed silica nanoparticles. Thermochim Acta. 2009;485(1):65–71.
[10] Chung DDL. Continuous carbon fiber polymer-matrix composites and their joints, studied by electrical measurements. Polym Compos. 2001;22(2):251–269
[11] Deepika Shukla, Shivam Trivedi Study Of Thermal And Mechanical Properties Of High Density Polyethylene And Nanoparticle Of Silica Composite Intl. J. Engg. Sci. Adv. Research 2019 March; 5(1):35-39



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY