International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

March 2023 | Issue 54 | Volume 15 | Number 1 | Pages 241-247

EFFECT OF USING NANO-SILICA WITH CARBON/KEVLAR FIBER REINFORCED EPOXY ON ENERGY OBSERVATION OR TOUGHNESS

A.K. Ahmed [1] M.A. Alwan [1] A.J. Farhan [2]

1. Mechanical Department, Anbar Institute, Middle Technical University, Baghdad, Iraq
ahmedkhalil@mtu.edu.iq, alfahd443@gmail.com
2. Mechanical Engineering Department, Faculty of Engineering, Gaziantep University, Gaziantep, Turkey
arkan4872@gmail.com

Abstract- Material failure takes high consideration in a research field; this consideration came from the results of this failure may be cost lives in addition to economic losses. One of the most important types of material failure is a material fracture. Material fracture differs from one material to another depending on the material structure, type and whether the material is pure or composite. When material fractures, it needs to absorb energy and the amount of absorbed energy deferent from one material to another. Also, when the material fracture there is more than one form of energy that is absorbed, the absorber energy is called material toughness. If the material needs more energy to initiate, prorogate crack and then fracture this material called tougher material. This paper illustrates the effect of using nano-silica with carbon/Kevlar fiber reinforced epoxy composite on energy observation and how to calculate the amount of energy (material toughness) before and after using nano-silica with it. Moreover, the enhancement of using a different percentage of nano-silica with the composite on material fracture toughness of the composite.

Keywords: Fracture Toughness, Absorbed Energy, Nano Silica.

1. INTRODUCTION

1.1. Composite Material

The applications of composite material have been extended enormously recently, composite material application interferes everywhere such as aerospace, automotive, wind turbine, military application, marine structures and industrial parts. Interesting in Composite materials among other materials such as aluminum, steel, copper and iron came from their excellent properties compared with their weight, cost and manufacturing procedure. So, for this extended of using composite material safe design of the structure have been very important to ensure people's life and to reduce economic losses [1]. Composite polymers can be considered one of the most popular composites that use in industrial applications, the interest in polymer composites came from their superior properties that came out from incorporating brittle matrix to high strength fibers [2]. The structure of composite polymer provides high toughness, load fatigue resistance, stiffness, easy manufacturing, lightweight and low cost compared with other materials such as aluminum and steel [3]. All mentioned properties for fiber reinforced composite laminates make it perfect to use in many applications such as fishing roads, sports shoes, tennis rackets, airplane winks parts and shafts that are used for a golf club.

This article focusses on the famous composite polymer Carbon/Kevlar fiber (50-50%) reinforced epoxy which offers high strength, toughness to weight and design flexibility. Recently there was high interest in a hyper composite material that contains two or more of fiber in a matrix material. Hyper composite supplies a wide range of properties compared with non-hyper composite, these properties came from the combination of fibers or/and matrix materials, also architecture, uniform adjustments of fiber loading, matrix–fiber interface and so on. Usually, Carbone fiber is used as reinforcement for ceramic, polymeric and metallic matrices because of its low cost and excellent properties. However, Carbone fibers have disadvantages such as impact resistance and low elongation at break, these disadvantages can be improved by hybridization. Hybridization is a very effective way to improve composite characteristics by adding tough fiber. Kevlar fiber can be used as fiber with carbon due to its high break elongation and their composite possesses excellent impact performance. Cochran, et al. [4] where biocompatibility support Kevlar fiber hybridize with Carbone. In conclusion, the hybridization of Kevlar and Carbon can be considered an effective way to create a hybrid composite containing the advantages of Carbon and Kevlar. Light, strong, highly crashworthy composites suitable for osteosynthesis devices and tough all these properties can be considered offered from hybridization of carbon and Kevlar fiber [5].

Usually, Epoxy has used a thermosetting polymer matrix which covers alone some of the required properties. However, because of the high mechanical and tribological loading the polymer matrix exposed it is usually reinforced with fillers, Chosen fillers usually fibers such as (aramid, glass, Kevlar and carbon) [6-8]. Fillers can be practical such as nano-silica or ceramic powders. Nano silica can be used with Carbon/Kevlar fiber reinforced epoxy (CKFRE). The mechanical behavior of composite material can be increased by adding a variety of nano- and micro-fillers in addition to the usual polymeric matrix [9-19]. Enhancing damping and vibration characteristics in composites polymers by using nano-silica, nanoclay and carbon nanotube became popular and it's taken high attention [20]. Gupta, et al. [21] carried out vibration tests to determine the dynamic properties of the nanoclay-containing viny1 ester composites, loss modulus, storage modulus, flake graphite nan platelets at weights of 2.5 and 1.25, and loss factor. The results of the tests conducted by Gupta, et al, demonstrated that the incorporation of nanoclay particles had a significant impact on the dynamic properties of loss and storage modulus. Chandradass, et al. [22] worked on adding nano-clay particles to a glass fiber/vinyl ester composite at varying percentages (1%, 3%, and 5%), with the goal of determining how these additions affected the composite's vibration behavior. The new composite's results revealed that the addition of nanoclay resulted an increase in the natural frequency due to an increase in the elastic modulus. Additionally, the damping ratio was improved to its best value at a weight content of 3% of the composite. Alva and Raja [23] reinforced epoxy composite containing 0.5 and 1.0 weight percent multiwall CNTs and nano alumina to examine the impact of nanoparticles on the hyper composite's dynamic properties. The results showed that in hybrid reinforcements, storage modulus (0.5 wt%) observation was increased, whereas a 1.0 weight percent decrease in loss modulus is observed in comparison to CNT-reinforced nanocomposite.

1.2. Failure of Composite Material

Composite material offers good fatigue durability and high mechanical performance compared with traditional material used in the same applications. However, mechanical damages from composite material are more complex compared to mechanical damage from the material. Understanding the micro-mechanism of damage is crucial when designing composite parts. Typically, when the material is subjected to load, it will develop a crack that begins at a specific location and continues to grow until it results in failure. The failure process in composite materials, on the other hand, is completely different; a large number of microscopic events will develop gradually over a large volume of the material. This behavior of composite materials comes from the material's heterogeneity on a microscopic scale, as the matrix and reinforcement have different mechanical behaviors. In general, there are three damage initiation modes in a laminated composite fiber fracture, delamination and matrix cracking. Delamination and matrix cracking modes depend on the properties of the matrix. When the matrix crack initiates in plies the tensile stress is applied perpendicular to the fiber [24].

2. EXPERIMENTAL WORK AND MATHEMATICAL PROCEDURE

The toughness of the material is a very important property that indicates the sudden fracture or catastrophic failure that may happen in structure materials or machines. How to calculate toughness based on mechanical properties take a big tension in this field because mechanical properties of the material can be easily calculated from handbooks and industrial standards rather than the toughness. Stress-strain curves for pure carbon/Kevlar fiber reinforced epoxy (CKFRE) and nano-silica at various percentages were calculated using previous research [25]. A carbon/Kevlar hybrid fabric with a 2×2 twill weave (3K Carbon and 158 Tex Aramid in the warp and weft) of 210 g/m^2 and a thickness of 0.23 mm was made. The fibers were cut to the dimensions of 300 mm 260 mm using an EC fiber cutter, as shown in Figure 1. Before adding hardener at a ratio of 0.285 by mass of epoxy, epoxy resin and particles were mixed in a bowl for 20 minutes at a constant speed (800 rev/min). The mixer continued to mix for five minutes after the hardener was added until the mixture was homogeneous. The process of hand-laying up composite laminates took place at room temperature (25 °C). Using a brush, a mixture of epoxy and nano-silica was applied layer by layer to the fabric. As can be seen in Figure 2, a plastic plate was used for each layer to prevent the composite from having voids and air bubbles. This was done again until all eight layers were placed. As can be seen in Figure 3, the wetted composite laminate was then moved to the production unit.

Figure 1. Cutting carbon/Kevlar fibers with EC [25]

At 80 °C and 0.16 MPa, respectively, the wetted composite laminate was cured in the production unit for one hour. The composite laminate was then pressure-cooled for three hours to room temperature. The cured laminate was then taken out of the mold. All of the hybrid composite laminates with nano-silica were subjected to a second round of this procedure.

The thickness of the composite plates was on average 2.5 mm. Tests and specimens were taken in accordance with ASTM guidelines [26]. The specimens used in the tensile test, which was performed using a CNC machine, are depicted in Figure 4. Six composite laminates were made using the nano-silica with particle contents of 0, 0.5, 1, 1.5, 2.5, and 3 weight percent. With an average particle size of 15 nm, a specific surface area of 300 m^2/gr, and a bulk density of 0.05 gr/cm^3, nano-silica was provided with a purity of 99.5%.

Figure 2. Composite production resin application [25]

Figure 3. Composite production unit [25]

Figure 4. Tensile test specimens [25]

Toughness will calculate for these curves and compare with each other. By applying Equation (1) the toughness will calculate [27].

$$T_f = \int_0^{L_\varepsilon} \sigma d\varepsilon \quad (1)$$

Equation (1) can be simplified to estimate toughness as shown in Equation (2) [28].

$$T_f \approx L_\varepsilon \frac{(\sigma_\lambda + \lambda\sigma_{uts})}{(1+\lambda)} \quad (2)$$

where, L_ε the elongation, σ stress under loading, σ_y yield stress, σ_{uts} ultimate stress, ε the engineering strain, T_f modulus of toughness or toughness and λ the coefficient of stress concerning with the strain hardening. In this article Equation (2) will not be doubted. To solve Equation (1) next mathematical procedure will use.

$$\sigma = E\varepsilon \quad (3)$$

Sub Equation (3) in (2)

$$T_f = \int_0^{L_\varepsilon} E\varepsilon d\varepsilon \quad (4)$$

$$T_f = E\int_0^{L_\varepsilon} \varepsilon d\varepsilon$$

$$T_f = \frac{E}{2}[\varepsilon^2]_0^{L_\varepsilon}$$

$$T_f = \frac{E}{2}(L_\varepsilon{}^2) - 0$$

$$T_f = \frac{E}{2}(L_\varepsilon{}^2) \quad (5)$$

Equation (5) adopted in this section to estimate the toughness for the composite with nano silica (CKFRE-NS) and without nano silica (CKFRE). Properties for CKFRE-NS composite shown in Table 1 take from previous study [25].

Table 1. Properties for CKFRE-NS composite [25]

No	Specimen	Elongation at break (mm)	Max. tensile Strength (MPa)
1	Pure	0.0304	371.74
2	0.5%	0.0357	393.60
3	1%	0.0310	395.21
4	1.5%	0.0344	405.48
5	2.5%	0.0323	427.27
6	3%	0.0455	444.98

For pure (CKFRE) and with nano silica addition as illustrate in Table 1 and Figure 5 illustrate how to draw a stress-strain curve. Modulus of elasticity (*E*) can be calculated by using Equation (3) for (CKFRE) before and after nano silica addition as shown in Table 2.

Table 2. Modulus of elasticity CKFRE-NS composite

No	Specimen	E (MPa)	L_ε (mm)	σ_{max} (MPa)
1	Pure	12228.29	0.0304	371.74
2	0.5	11025.21	0.0357	393.60
3	1	12748.71	0.0310	395.21
4	1.5	11787.20	0.0344	405.48
5	2.5	13228.17	0.0323	427.27
6	3	9779.78	0.0455	444.98

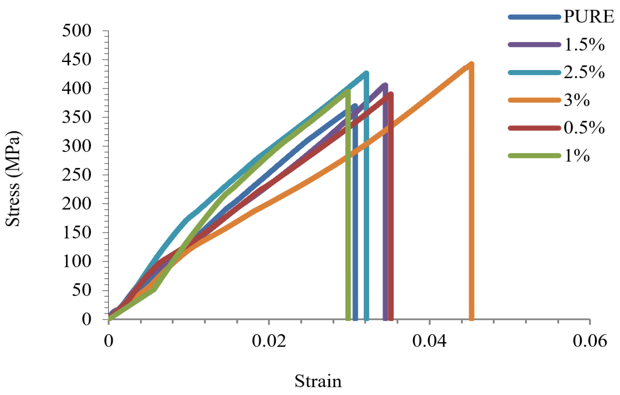

Figure 5. Stress- strain curve for CKFRE-NS composite

By using Equation (5) modulus of toughness calculates as shown in Table 3 for pure composite material and for different percentage of nano silica with composite.

No	Specimen	L_ε (mm)	σ_{max} (MPa)	T_f (MPa) Eq. (5)
1	Pure	0.0304	371.74	5.65
2	0.5	0.0357	393.60	7.03
3	1	0.0310	395.21	6.13
4	1.5	0.0344	405.48	6.90
5	2.5	0.0323	427.27	6.90
6	3	0.0455	444.98	10.12

3. RESULT AND DISCUSSION

Carbon/Kevlar fiber reinforced epoxy (CKFRE) and CKFRE-NS subjected to tensile force to investigate the impact of using nano-silica on energy observation or toughness. Elongation and maximum tensile increased after adding nano-silica to pure carbon/Kevlar fiber reinforced epoxy (CKFRE) as shown in Figure 5 and Figure 6, this Increment of elongation and maximum tensile stress will effect on toughness magnitude.

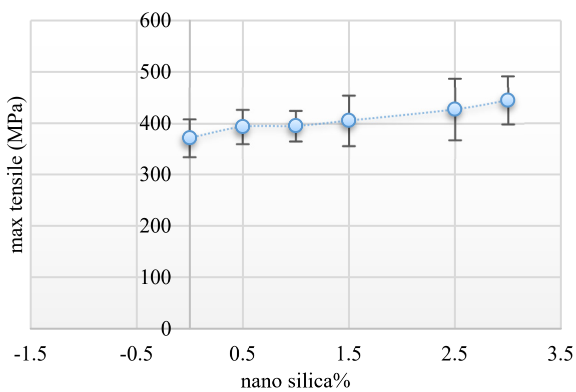

Figure 6. Effecting of using nano silica on max tensile

Maximum tensile stress starts with (371 MPa) at (0%) of nano-silica, then it increases until reaches (455 MPa) at the percentage of (3% of nano-silica). As can be seen from Figure 6 there is no fluctuation in maximum tensile stress values with nano-silica added to the composite. However, elongation values raising with nano-silica percentage increment are not gradual as shown in Figure 7, where it starts at (0.0304 mm) for pure composite and raise to (0.0357 mm) at (0.5%), then decreases to (0.0310 mm) for (1%).

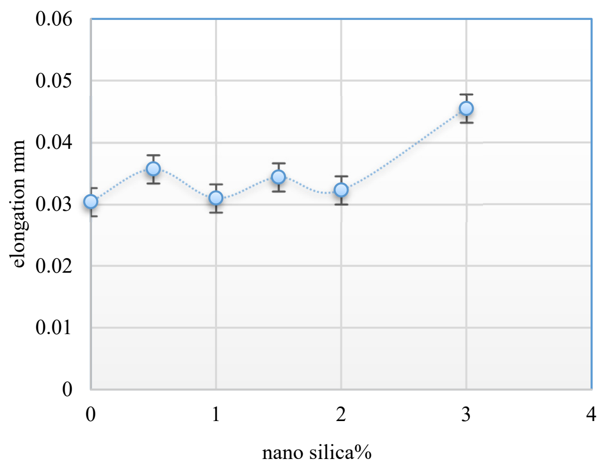

Figure 7. Effecting of using nano silica on elongation

Also, there are fluctuating strain values at (1.5%) and (2.5%) of nano-silica, but elongation reaches the maximum value at (3%) of nano-silica addition. These fluctuations in strain values will affect toughness values as can be seen below and it will be explained at the end of this section. Figure 7 and Figure 8 illustrate the type of relationship between elongation, tensile and toughness. As can be shown in Figure 8 there is a direct relation between toughness and elongation. Where strain increment will increase toughness, the strain began at (0.0304 mm) and toughness value around (5.5 MPa). The second value of strain is equal to 0.0357 mm at (7.03 MPa) toughness, and the third value of elongation decrease to 0.0310 with a toughness value (6.13). As can be seen from the previous values of elongation and toughness, there is a direct relation between them and toughness values increase with elongation increment. Maximum tensile stress and toughness contacted directly with each other as shown in Figure 8 from the first values to the final.

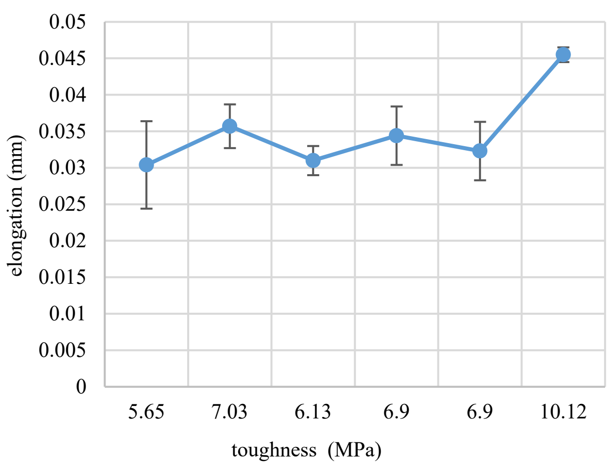

Figure 8. Relationship between elongation and toughness

As mentioned previously in this section the addition of nano-silica will enhance maximum tensile stress and elongation, this enhancement will increase the modulus of toughness for the composite.

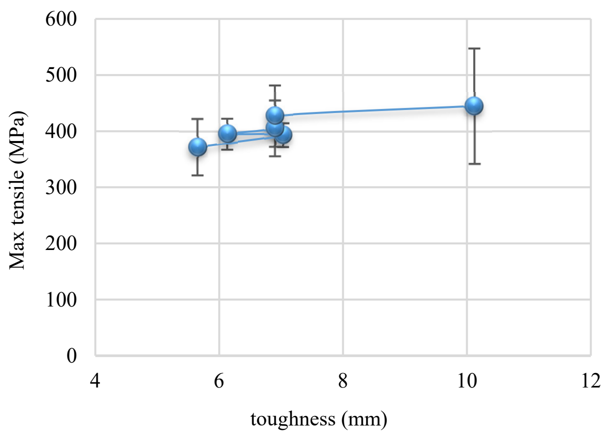

Figure 9. Maximum tensile - toughness curve

The modulus of toughness increased with nano silica addition as shown in Figure 10, where equal (to 5.65 MPa) before using nano-silica with (CKFRE) composite and then it will increase until reaches (10 MPa) at (3%) of nano silica. However, at (0.5) percentage of toughness reached (7 MPa) and then it became (6.13 MPa) at (1%) that illogical, energy observation has to increase with nano silica increasing. This unacceptable increase can be explained as an inaccurate use of machine tests or the composite's inclusion of nano-silica was inaccurate. Also, if the nano-silica addition is not homogenous will Couse this result. The perfect percentage of nano silica that enhanced the toughness was 3% as shown in Figure 10.

Also, Alsaadi [11] found that when he adds perlite particulate filler to glass fabric/epoxy composites at a perlite content of 3%, the mode I and mode II interlaminar fracture toughness increased by 39.9% and 72%, respectively. Kostagiannakopoulou [29] worked on improving the interlaminar fracture toughness of carbon fiber-reinforced polymers (CFRPs) by adding a nano-modified matrix of two distinct carbon-based nano-fillers, a few layered Graphene Nano-Platelets (GNPs), and Multi-Walled Carbon Nanotubes (MWCNTs). In the first instance, hybrid-doped CFRPs that were made by combining 0.5% weight GNPs and 0.5% weight. MWCNTs in the second by 0.5 percent weight. GDP and 1% weight. MWCNTs. The second hybrid improved Mode I fracture toughness (GIC) by up to 45 percent, in contrast to composites with 0.5 percent weight. GDP and 1% weight. The same hybrid composites were used to enhance MWCNTs and Mode II (GIC) by as much as 25%. Hong-Yuan carried out a methodical investigation into the effects of silica and rubber nanoparticles on the fracture toughness GIC behavior of epoxy [30]. Epoxy's GIC can be significantly increased by adding silica or rubber nanoparticles, according to research.

4. CONCLUSION

As mentioned previously in this section the addition of nano-silica will enhance maximum tensile stress and elongation, this enhancement will increase the modulus of toughness for the composite. Modulus of toughness increase with nano-silica addition as shown in Figure 10, where it's equal (5.65 MPa) before using nano-silica with (CKFRE) composite and then increases until reaches (10 MPa) at (3%) of nano-silica. However, at (0.5) percentage of toughness it reaches (7 MPa) and then becomes (6.13 MPa) at (1%) that's illogical, energy observation has to increase with nano-silica increasing. The incorrect application of machine tests or the incorrect addition of nano-silica to the composite can account for this unacceptable increase. Also, if the nano-silica addition is not homogenous will cause this same unacceptable result.

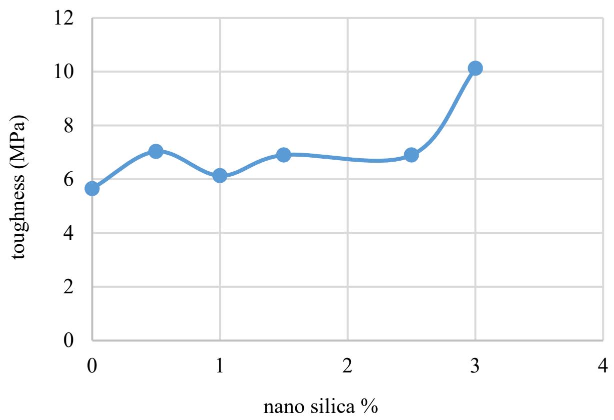

Figure 10. Toughness - specimen curve

REFERENCES

[1] K. Naumenko, M. Abmus, "Advanced Methods of Continuum Mechanics for Materials and Structures", Springer, Vol. 60, 2016.

[2] M.A. Guliyev, A.R. Sadigova, A.A. Hadiyeva, P.B. Asilbeyli, N.C. Mamedov, E.S. Safiev, "Changes Occurring in Structure of Polyethylene + Nanoclay Nanocomposites after Influence of an Electric Field", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 49, Vol. 13, No. 4, pp. 40-44, December 2021.

[3] Q. Qin, J. Ye, "Toughening Mechanisms in Composite Materials", Elsevier Science, Edition 1, pp. 263-294, June 2015.

[4] Y. Wan, J. Lian, Y. Huang, F. He, Y. Wang, H. Jiang, et al., "Preparation and Characterization of Three-Dimensional Braided Carbon/Kevlar/Epoxy Hybrid Composites", Journal of Materials Science, Vol. 42, pp. 1343-1350, 2007.

[5] J. Ferreira, L. Borrego, J. Costa, C. Capela, "Fatigue Behavior of Nanoclay Reinforced Epoxy Resin Composites", Composites Part B: Engineering, Vol. 52, pp. 286-291, 2013.

[6] H. Pihtili, N. Tosun, "Effect of Load and Speed on the Wear Behavior of Woven Glass Fabrics and Aramid Fiber-Reinforced Composites", Wear, Vol. 252, pp. 979-984, 2002.

[7] B. Wetzel, F. Haupert, M.Q. Zhang, "Epoxy Nanocomposites with High Mechanical and Tribological Performance", Composites Science and Technology, Vol. 63, pp. 2055-2067, 2003.

[8] N. Dadkar, B.S. Tomar, B.K. Satapathy, A. Patnaik, "Performance Assessment of Hybrid Composite Friction

Materials Based on Flyash-Rock Fiber Combination", Materials and Design, Vol. 31, pp. 723-731, 2010.
[9] A. Usuki, N. Hasegawa, M. Kato, S. Kobayashi, "Polymer-Clay Nanocomposites", Inorganic Polymeric Nanocomposites and Membranes, pp. 135-195, 2005.
[10] J. Donnet, "Nano and Micro Composites of Polymers Elastomers and their Reinforcement", Composites Science and Technology, Vol. 63, pp. 1085-1088, 2003.
[11] M. Alsaadi, A. Erklig, "Effect of Perlite Particle Contents on Delamination Toughness of S-Glass Fiber Reinforced Epoxy Matrix Composites", Composites Part B: Engineering, Vol. 141, pp. 182-190, 2018.
[12] O. Zabihi, M. Ahmadi, S. Nikafshar, K.C. Preyeswary, M. Naebe, "A Technical Review on Epoxy-Clay Nanocomposites: Structure, Properties, and Their Applications in Fiber Reinforced Composites", Composites Part B: Engineering, Vol. 135, pp. 1-24, 2018.
[13] A. Kumar, S. Roy, "Characterization of Mixed Mode Fracture Properties of Nanographene Reinforced Epoxy and Mode I Delamination of its Carbon Fiber Composite", Composites Part B: Engineering, Vol. 134, pp. 98-105, 2018.
[14] A. El Moumen, M. Tarfaoui, K. Lafdi, H. Benyahia, "Dynamic Properties of Carbon Nanotubes Reinforced Carbon Fibers/Epoxy Textile Composites under Low Velocity Impact", Composites Part B: Engineering, Vol. 125, pp. 1-8, 2017.
[15] Z. Wang, X. Huang, L. Bai, R. Du, Y. Liu, Y. Zhang, et al., "Effect of Micro-Al2O3 Contents on Mechanical Property of Carbon Fiber Reinforced Epoxy Matrix Composites", Composites Part B: Engineering, Vol. 91, pp. 392-398, 2016.
[16] Q. Jiang, X. Wang, Y. Zhu, D. Hui, Y. Qiu, "Mechanical, Electrical and Thermal Properties of Aligned Carbon Nanotube/Polyimide Composites", Composites Part B: Eng., Vol. 56, pp. 408-412, 2014.
[17] S. Chhetri, N.C. Adak, P. Samanta, N.C. Murmu, D. Hui, T. Kuila, J.H. Lee, "Investigation of the Mechanical and Thermal Properties of l-Glutathione Modified Graphene/Epoxy Composites", Composites Part B: Engineering, Vol. 143, pp. 105-112, June 2018.
[18] N. Podymova, A. Karabutov, "Combined Effects of Reinforcement Fraction and Porosity on Ultrasonic Velocity in SiC Particulate Aluminum Alloy Matrix Composites", Composites Part B: Engineering, Vol. 113, pp. 138-143, 2017.
[19] M. Bulut, "Mechanical Characterization of Basalt/Epoxy Composite Laminates Containing Graphene Nano Pellets", Composites Part B: Engineering, Vol. 122, pp. 71-78, 2017.
[20] R.N. Agayev, "Vibrations of an Inhomogeneous Cylindrical Shell Dynamically Interacting with Motive Fluid and Stiffened with Rings", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 42, Vol. 12, No. 1, pp. 31-34, March 2020.
[21] S. Gupta, P. Raju Mantena, A. Al Ostaz, "Dynamic Mechanical and Impact Property Correlation of Nanoclay and Graphite Platelet Reinforced Vinyl Ester Nanocomposites", Journal of Reinforced Plastics and Composites, Vol. 29, pp. 2037-2047, 2010.
[22] J. Chandradass, M.R. Kumar, R. Velmurugan, "Effect of Nanoclay Addition on Vibration Properties of Glass Fiber Reinforced Vinyl Ester Composites", Materials Letters, Vol. 61, pp. 4385-4388, 2007.
[23] A. Alva, S. Raja, "Dynamic Characteristics of Epoxy Hybrid Nanocomposites", Journal of Reinforced Plastics and Composites, Vol. 30, pp. 1857-1867, 2011.
[24] A.C. Garg, Y.W. Mai, "Failure Mechanisms in Toughened Epoxy Resins - A Review", Composites Science and Technology, Vol. 31, pp. 179-223, 1988.
[25] A.J. Farhan, "Vibration, Damping Property, Tensile and Flexural Behavior of Kevlar-Carbon/Epoxy/Nano Silica Composites", M.Sc. Thesis, Mechanical Engineering, Gaziantep University, Institute of Science, Turkey, 2017.
[26] M. Kelsey, J. Foreman, "Temperature Measurements in TGA, Limitations of Test Methods for Plastics", ASTM STP 1369, J.S. Peraro (Ed.), West Conshohocken, American Society for Testing and Materials, Philadelphia, USA 2000.
[27] S.G. Nunes, W.F. de Amorim Jr, A. Manes, S.C. Amico, "The Effect of Thickness on Vacuum Infusion Processing of Aramid/Epoxy Composites for Ballistic Application", Journal of Composite Materials, Vol. 53, pp. 383-391, 2019.
[28] G. Oh, "A Simplified Toughness Estimation Based on Standard Tensile Data", Research and Experiment Department, Roki Co. Ltd., Tokyo, Japan, 2020.
[29] C. Kostagiannakopoulou, X. Tsilimigkra, G. Sotiriadis, V. Kostopoulos, "Synergy Effect of Carbon Nano-Fillers on the Fracture Toughness of Structural Composites", Composites Part B: Engineering, Vol. 129, pp. 18-25, November 2017.
[30] H.Y. Liu, G.T. Wang, Y.W. Mai, Y. Zeng, "On Fracture Toughness of Nano-Particle Modified Epoxy", Engineering, Composites Part B, Vol. 42, No. 8, pp. 2170-2175, December 2011.

BIOGRAPHIES

Name: **Ahmed**
Middle Name: **Khaleel**
Surname: **Ahmed**
Birthday: 21.09.1991
Birth Place: Ramadi, Iraq
Bachelor: Mechanical Engineering, Anbar University, Ramadi, Iraq, 2013
Master: Mechanical Engineering, Bradford University, Bradford, United Kingdom, 2017
The Last Scientific Position: Assist. Lecturer, Mechanical Engineering, Middle Technical University, Baghdad, Iraq, 2017
Research Interests: Composite Materials, Polymers and Structure Integrity
Scientific Publications: 1 Paper

Name: **Majeed**
Middle Name: **Abbas**
Surname: **Alwan**
Birthday: 22.07.1966
Birth Place: Ramadi, Iraq
Bachelor: Mechanical Engineering, Anbar University, Ramadi, Iraq, 2005
Master: Mechanical Engineering, Gaziantep University, Gaziantep, Turkey, 2017
The Last Scientific Position: Assist. Lecturer, Mechanical Engineering, Middle Technical University, Bagdad, Iraq, 2007
Research Interests: Composite Materials and Polymers
Scientific Publications: 1 Paper

Name: **Arkan**
Middle Name: **Jabbar**
Surname: **Farhan**
Birthday: 7.01.1970
Birth Place: Baghdad, Iraq
Bachelor: Engineering, Mechanical, engineering, Baghdad University, Baghdad, Iraq, 2009
Master: Mechanical Engineering, Gaziantep University, Gaziantep, Turkey, 2017
Research Interests: Composite Materials and Polymers