

Thermal Diffusivity Nanocomposites of (UPE/Nanomagnesium Oxide)

Aws Abbas Hussein

Department of Medical Physics, Al-Karkh University of Science.

Fadhil K. Farhan

Department of Medical Physics, Al-Karkh University of Science.

Ali Q. Tuama

Department of Medical Physics, Al-Karkh University of Science.

Abstract - In this work, the nanoparticles of magnesium oxide will be prepared by chemical deposition and will be reinforced into poly aster unsaturation UPE resin, a transparent liquid with an upward starting from (1%,3%,5%,7%) percent. The thermal diffusion coefficient will be tested using the thermal conductivity device as well as the thermal insulation and peeling lab will be tested at high temperatures. We will expect a significant improvement in the heat diffusion coefficient when the addition of magnesium oxide nanoparticles is increased, as well as a decrease in the values of the thermal flux coefficient by increasing the added weight percentage of the magnesium oxide nanoparticles. The results will be interpreted based on process density and structural tests.

Keyword - Diffusivity, n-Mg O, Poly aster unsaturation resin, Therlimal coefficient.

INTRODUCTION

Material/ filler particles composites are widely used in contemporary industrial application because of high formability, good execution and good mechanical properties compared with ferrous and non-ferrous alloys. Polymer composites such as epoxy matrix composites, which is possible to transform from liquid to solid state by adding hardener, have unique thermal, electrical, chemical and mechanical properties. One of the most important things which influence on properties of UPE/ filler material composites is the adhesive and reaction between matrix and filler material interface [1]. The main reason of nano filler addition, to reinforce neat epoxy, is due to unsatisfactory properties of traditional EP that limit its uses in the engineering and industrial fields. [2]. In some industrial application, thermal properties of the materials play a main role in semiconductors and electrical chips operation more than other properties, when the thermal management considers as a serious challenge [3]. polymers matrix and nano filler materials, when mixed to produce composites materials, consider as thermal interface materials (TIMs) with vital thermal transport properties which are widely used in microelectronics and thermal interface applications due to its ability to spread out the heat generated inside electronic parts. The choice of polymer and filler material are depending on the application in which the composites will serve [4]. Conductive materials possess free electrons responsible for heat transport, in addition to having a relatively stable lattice. On the contrary, polymers depend on the vibration of their lattice, which are responsible for thermal conductivity. The amount of energy generated by vibration of polymers lattice is called phonon [5]. Low thermal conductivity of neat polymers (about $0.1 - 0.5 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$) is duo to their complex morphology which consists of long randomly linked chains. These factors cause phonon scattering and impede phonon transfer. Nano filler ceramics such as MgO, Si₃N₄, Sic, ZnO, SiO₂, Al₂O₃ have relatively high thermal conductivity which can improve λ of polymers when used as filler materials, e.g., λ of Al₂O₃ is (30–42 W/ m.K) and of Si₃N₄ is (29–600 W/ m.K) [6], [7], [8]. Adding graphene and h-BN fillers to neat epoxy enhances the thermal conductivity by 5100% and 2400% for EP/ Graphene and EP/ h- BN respectively. Whereas, the thermal conductivity of EP reinforced with single wall carbon nanotubes (SWNT) was increased by 125% at room temperature compared with neat EP [9], [10]. In current research, different wt. % of nano MgO were added and mixed with neat epoxy resin. The influence of different nano MgO loading on thermal properties was studied.

THEORETICAL PART

Heat transport at the nana scale is a very interesting and technologically important area. With the reduction of object size, phonon modes and phonon densities of states change drastically, resulting in unusual thermal transport phenomena in

microscopic systems. The thermal conductivity of the Nan belts is significantly suppressed in comparison to that in the bulk due to increased phonon–boundary scattering a modified phonon dispersion [11]. This size effect can lead to localized heating in Nan electronics [12], the thermal conductivity can be calculated using the equations as below [13].

$$Q = \frac{dH}{dt} = - \frac{\lambda A dT}{dx} \quad (1)$$

Where, Q is the Heat flow per time (Watt), H is Heat (J), t is time (sec), λ is thermal conductivity (W/ K.m), T is temperature (K), x is Height of test specimen (m), A is cross sectional area of test sample (m²).

The effusivity equation by ($\frac{W^{0.5}}{m^2 \cdot K}$) can be written as following:

$$\epsilon_{effusivity} = \sqrt{\lambda \rho C_p} \quad (2)$$

The thermal diffusion equation (m²/ s) can be expressed as:

$$\delta = \frac{\lambda}{C_p \cdot \rho} \quad (3)$$

Where, C_p is Specific heat capacity by (J/ g.k), ρ is Density of sample (g/ cm³).

The thermal resistance equation by (m². K/ W) has formula as below:

$$R_{thermal} = \frac{dx}{\lambda} \quad (4)$$

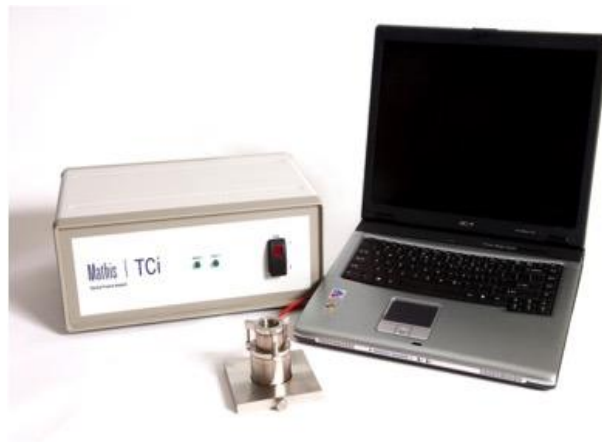


FIGURE 1
THERMAL CONDUCTIVITY ANALYZER (TCi)

RESULT AND DISCUSSION

Addition of MgO Nano particles to neat epoxy causes noticeable enhancement in the thermal conductivity of UPE/ N-MgO composites. Figure. Shows the continuous increase in λ values with increase in loading of N-MgO particles up to 7 wt. %, at which the maximum value of λ (about 0.78 w / m. k) was obtained. This development in thermal conductivity of UPE matrix composite after adding MgO Nano particle is due to high λ of Nano scale ceramics (30–390 W/m. K) compared with traditional epoxy (0.1 - 0.5 W/m. K). Figure 1 shows a picture of the electron microscope of the nanometric magnesium oxide powder used to reinforce the polymer. As it appears in the figure, the granular size limits of the powder range between 40-50 nanometers, and this indicates that it has a high surface area, which earned it the speed of adhesion and diffusion within the polymer matrix, and as a result, it showed unique properties of the prepared composites. In the field of thermal diffusion velocity and a significant improvement in thermal conductivity and thus an improvement in heat flow compared to the base material (polymer). We note through Figure 3 that the curves behavior of Nano composites with the substrate as a function of percentages. Where the curves of thermal resistance showed a clear decrease in the values of thermal resistance, which is a good indicator of the transition of materials from insulating to semi-conducting materials, and this is a very large shift in the properties of materials using nanomaterials

TABLE 1
THERMAL ANALYZER BY C- THERM SENSOR TC- I VALUES

Sample Code	λ (w / m. k)	ε (ws ^{1/2} /m ² . K)	Cp (J/kg. k)	δ (mm ² / s)	Density (ρ) (Kg/ m ³)	R (m ² .K /W)
0% n-MgO	0.22	610	1502.09	0.13	1.125	0.09
1% n-MgO	0.36	680	1060.64	0.28	1.211	0.05
3% n-MgO	0.43	780	1094.26	0.3	1.293	0.04
5% n-MgO	0.54	899	1132.98	0.36	1.321	0.03
7% n-MgO	0.78	979	889.768	0.63	1.381	0.02

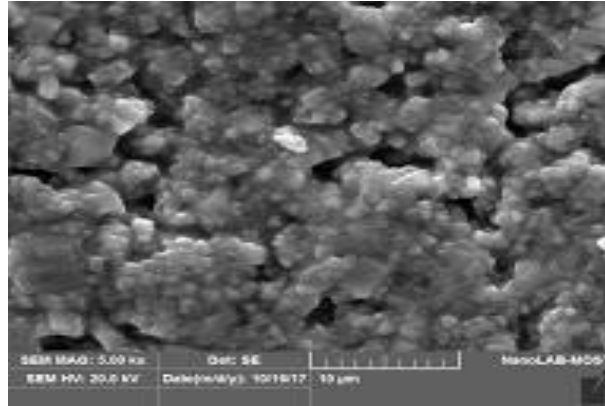
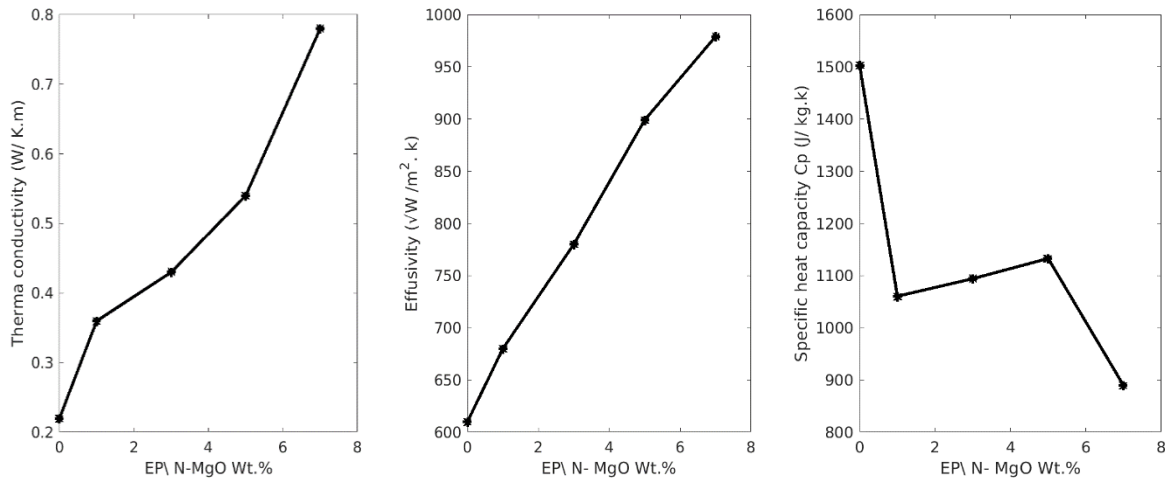


FIG. 2
SEM OF NANO- MGO



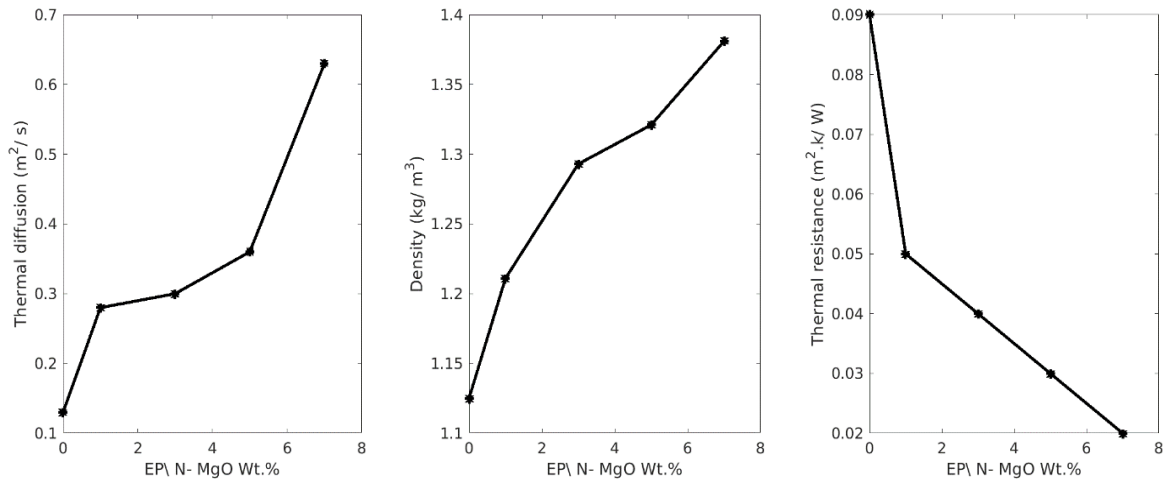


FIG. 3
EXPERIMENTAL THERMAL ANALYSIS RESULTS

CONCLUSIONS

In this work the following conclusions were obtained:

1. At less than 7% reinforcement of Nano-magnesium oxide, all thermal properties are improved
2. The heat capacity of the Nano composites increases after adding more than 7%.
3. The Nano composites within these ratios turn into materials with rapid thermal dispersion, which means that they are materials that tend to resist thermal peeling.

REFERENCES

- [1] Alam, M.S., & Chowdhury, M.A. (2020). Characterization of epoxy composites reinforced with $CaCO_3$ - Al_2O_3 - MgO - TiO_2 / CuO filler materials. *Alexandria Engineering Journal*, 59(6), 4121-4137.
- [2] Fanning, M., Zhang, Z., Peili, G., Ruiyang, K., Yash, B., Yu, J., & Liu, T. (2021). Excellent tribological properties of epoxy— Ti_3C_2 with three-dimensional nanosheets composites. *Friction*, 9(4), 734-746.
- [3] Razeeb, K.M., & Dalton, E. (2011). Nanowire-polymer nanocomposites as thermal interface material. In *Advances in Nanocomposites-Synthesis, Characterization and Industrial Applications*. *IntechOpen*, 2011, pp. 685-706.
- [4] Chiguma, J., Johnson, E., Shah, P., Gornopolskaya, N., & Jones Jr, W. E. (2013). Thermal diffusivity and thermal conductivity of epoxy-based nanocomposites by the laser flash and differential scanning calorimetry techniques, 2013, pp. 51-62.
- [5] Zhang, H., Zhang, X., Fang, Z., Huang, Y., Xu, H., Liu, Y., & Sun, J. (2020). Recent Advances in Preparation, Mechanisms, and Applications of Thermally Conductive Polymer Composites: A Review. *Journal of Composites Science*, 4(4), 180.
- [6] Huang, C., Qian, X., & Yang, R. (2018). Thermal conductivity of polymers and polymer nanocomposites. *Materials Science and Engineering: R: Reports*, 132, 1-22.
- [7] Karthikeyan, P., Babu, B. G., Sabarinathan, C., & Manikandan, J. (2015). Tribological performance of carbon nanotubes-alumina hybrid/epoxy composites. *Optoelectron Adv Mater-Rapid Commun*, 9(3-4), 455-459.
- [8] Hong, H., Kim, J. U., & Kim, T. I. (2017). Effective assembly of nano-ceramic materials for high and anisotropic thermal conductivity in a polymer composite. *Polymers*, 9(9), 413.
- [9] Kargar, F., Barani, Z., Salgado, R., Debnath, B., Lewis, J. S., Aytan, E., & Balandin, A.A. (2018). Thermal percolation threshold and thermal properties of composites with high loading of graphene and boron nitride fillers. *ACS applied materials & interfaces*, 10(43), 37555-37565.
- [10] Du, F., Guthy, C., Kashiwagi, T., Fischer, J.E., & Winey, K.I. (2006). An infiltration method for preparing single-wall nanotube/epoxy composites with improved thermal conductivity. *Journal of Polymer Science Part B: Polymer Physics*, 44(10), 1513-1519.
- [11] Marcus S.M., RL. Blaine, Thermal Conductivity of polymer glass ceramic by Modulated TA086, 2003.
- [12] Bose S, Mahan war P. A, Effect of fly ash on the mechanical, thermal, electrical, and rheological properties of filled nylon 6, *Min Mat. Char and Engg*, Vol. 3, PP. 23- 31, 2004.
- [13] Bose, S., & Mahanwar, P.A. (2004). Effect of flyash on the mechanical, thermal, dielectric, rheological and morphological properties of filled nylon 6. *Journal of Minerals & Materials Characterization & Engineering*, 3(2), 65-89.

- [14] Mateusz, B. (2007). *Carbon Nan tube Networks in Epoxy Composites and Aero gels* (Doctoral dissertation, PhD. Thesis. United State: University of Pennsylvania).