East European Journal of Physics. **1.** 185-188 (2023)
DOI:10.26565/2312-4334-2023-1-24 ISSN 2312-4334

PREPARATION OF NANOFLUIDS FROM INORGANIC NANOSTRUCTURES DOPED PEG: CHARACTERISTICS AND ENERGY STORAGE APPLICATIONS[†]

Ahmed Hashim[a]*, Farhan Lafta Rashid[b], M.H. Abbas[c], Bahaa H. Rabee[a]
[a]*Department of Physics, College of Education for Pure Sciences, University of Babylon, Babylon, Iraq*
[b]*University of Kerbala, College of Engineering, Petroleum Engineering Department, Iraq*
[c]*Department of Medical Physics, Al-Mustaqbal University College, Babylon, Iraq*
**Corresponding Author e-mail: ahmed_taay@yahoo.com*
Received December 27, 2022; revised January 24, 2023; accepted January 25, 2023

Polymeric nanocomposites have drawn a lot of interest when it comes to innovative materials because of their enhanced optical, electrical, and magnetic properties. These materials have a high rising modulus, are flame resistant, and may also halt oxidation and agglomeration. These improvements in properties are related to interactions between nanoparticles and polymers. The addition of nanoparticles to polymers prolongs their life, changes their surface via passivation defect levels, and provides low cost, simple device manufacture, as well as adjustable electrical and optical properties. This study examines the properties and potential uses of nanofluids made from inorganic nanostructures doped with PEG. The results demonstrate that when the concentration of ZrO_2/SiC NPs increased to 12wt%, the electrical conductivity of nanofluids increased by roughly 43.6%. Additionally, when the concentration of ZrO_2/SiC nanoparticles increases, the melting time reduces. Additionally, when the concentration of ZrO_2/SiC NPs increases from 3 weight percent to 12 weight percent within 15 minutes, the growth of melting time reaches 51.2%, and the absorbance increases by approximately 80.3% while transmittance decreases by about 82.5%.
Keywords: *nanocomposites; inorganic nanostructures; PEG; energy storage*
PACS: 68.03.Kn**,** 78.66.Li, 78.66.Nk, 82.35.Np.

1. INTRODUCTION

The past few years have witnessed a huge increase in interest in nanotechnology since miniaturization and nanomaterials are often predicted to be the key to a sustainable future. In this regard, a significant portion of the scientific community is currently concentrating on a very difficult and pertinent research area, which is the synthesis of novel nanostructured hybrid materials capable of absorbing the photonic energy from sunlight with the intention of converting it into electrical or chemical energy. Whereas, substantial study on the use of solar energy has been sparked by rising worries about energy and environmental issues. Among these, several methods for employing semiconductor photocatalysts to degrade organic dyes and/or produce photocatalytic hydrogen for fuel cells are investigated [1-4]. While electrical features are designed to know conveyance of the fee widespread presence in these compounds, optical qualities are intended to be anti-reflective, getting polarization characters and greater reflection. The dopant addition will customize the polymer matrix-based polymers' electrical and optical characteristics. Additionally, the outstanding qualities of inorganic compounds, such as thermal resistance, heat strength, and high strength, can be combined with the advantages of polymer fabrics, such as nice moldability, high power, and durability, to create composite materials, which require high strength and chemical resistance. The electrical, magnetic, mechanical, optical, and thermal properties of nanofillers can be enhanced by incorporating organic and inorganic materials into their structures. Nanofillers can be used in a wide range of applications, such as the production of tissue, filters, catalysis, scaffolds, wound dressing, and sensors [5–11].

Phase change materials (PCMs) based on poly(ethylene glycol) 400 gmol1 and nano-enhanced by either carbon black (CB), a raw graphite/diamond nano mixture (G/D-r), a purified graphite/diamond nano mixture (G/D-p), or nano-Diamond nano powders with purity grades of 87% or 97% were presented by Cabaleiro et al (nD87 and nD97, respectively). In order to create PEG/$MgCaCO_3$ as a ss-PCM, MgO-$CaCO_3$ matrices were first constructed and examined by Zahir et al. [13]. PEG-5$MgCaCO_3$ (P-5-MCC), PEG-10$MgCaCO_3$ (P-10-MCC), and PEG-15$MgCaCO_3$ samples were detected in the samples (P-15-MCC). A technique for the manufacture of gelatin-stabilized copper oxide nanoparticles was created by Gvozdenko et al. [14]. The process of synthesis used direct chemical precipitation. For the manufacture of copper oxide, copper sulfate, chloride, and acetate were employed as precursors. As a stabilizer, gelatin was utilized. It was discovered that only when copper acetate was utilized as a precursor would monophase copper oxide II develop. The addition of SiCto polymers has many applications in various approaches like electronics sensors and biomedical [15-21]. This study examines the properties and potential uses of nanofluids made from inorganic nanostructures doped with PEG.

2. MATERIALS AND METHODS

This study made use of polyethylene glycol (PEG), zirconium oxide nanoparticles (ZrO_2 NPs), and silicon carbide nanoparticles as its raw materials (SiC NPs). After dissolving 1 gram of PEG in 50 milliliters of distilled water, we were

[†] ***Cite as:*** A. Hashim, F.L. Rashid, M.H. Abbas, B.H. Rabee, East Eur. J. Phys. **1**, 185 (2023), https://doi.org/10.26565/2312-4334-2023-1-24

able to create the PEG-H2O fluid. The various concentrations of ZrO_2/SiC NPs that were used in the fabrication of the nanofluids are 3%, 6%, 9%, and 12%. PEG/ZrO_2/SiC-H_2O nanofluids had their optical and electrical characteristics investigated as part of this study. The double beam spectrophotometer (Shimadzu, UV-18000A) with a wavelength range of (200-1000) nm is used to analyze the optical characteristics of the PEG/ZrO_2/SiC-H_2O nanofluids. The technique of assessing the melting features of PEG/ZrO_2/SiC-H_2O nanofluids during the heating process is included in the thermal energy storage. The PEG/ZrO_2/SiC-H_2O nanofluids were used as the heat transfer fluid. The temperature of the heat transfer fluid can be varied from 35 degrees Celsius to 100 degrees Celsius using a stirrer, and a digital device was used to measure the temperature of the PEG/ZrO_2/SiC-H_2O nanofluids while they were being heated.

3.RESULTS AND DISCUSSION

For various concentrations of ZrO_2/SiC NPs, the absorbance and transmittance spectra of PEG/ZrO_2/SiC-H_2O nanofluids are shown in Figs. 1 and 2, respectively. These graphs showed that when ZrO_2/SiC NP concentrations climbed from 3 weight percent to 12 weight percent, absorbance increased by around 80.3% and transmittance reduced by about 82.5%. The PEG/ZrO_2/SiC-H_2O nanofluids exhibit increased UV absorption, making them potential nanofluids for use in a variety of renewable areas, including solar collectors, energy storage, and heating and cooling systems. The absorbance, which alludes to greater nanofluid dispersion, will grow when ZrO_2/SiC NP concentration rises [22].

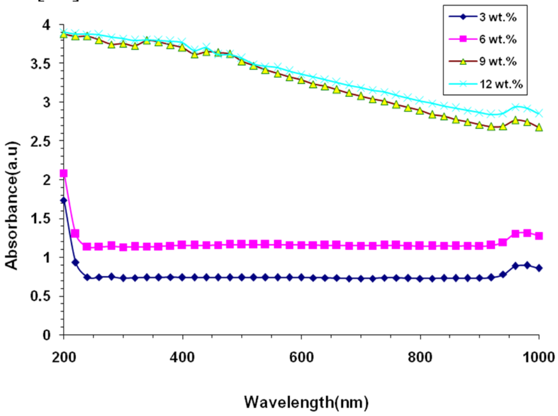

Figure 1. Absorbance and transmittance spectra of PEG/ZrO_2/SiC-H_2O nanofluids with photon wavelength for different concentrations of ZrO_2/SiC NPs

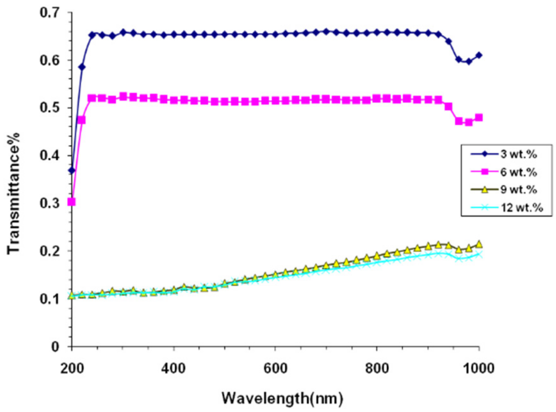

Figure 2. Transmittance spectra of PEG/ZrO_2/SiC-H_2O nanofluids with photon wavelength for different concentrations of ZrO_2/SiC NPs

The association between the concentrations of ZrO_2/SiC NPs and the electrical conductivity of PEG/ZrO_2/SiC-H_2O nanofluids is shown in Fig. 3. When ZrO_2/SiC NP concentrations approach 12 weight percent, the electrical conductivity of nanofluids increases by roughly 43.6%, which is caused by an increase in the number of charge carriers[23]. The melting curves of PEG/ZrO_2/SiC-H_2O nanofluids are shown in Fig. 4. As the concentration of ZrO_2/SiC nanoparticles increases, the melting time reduces. PEG/ZrO_2/SiC-H_2O nanofluids' reduced melting time for energy storage applications is owing to improved thermal conductivity, which increases heat transfer[24–32]. When the concentration of ZrO_2/SiC NPs increases from 3 weight percent to 12 weight percent within 15 minutes, the increment in melting time reaches 51.2%. As a result of this behavior, PEG/ZrO_2/SiC-H_2O nanofluids may be thought of as a key for heating and cooling systems.

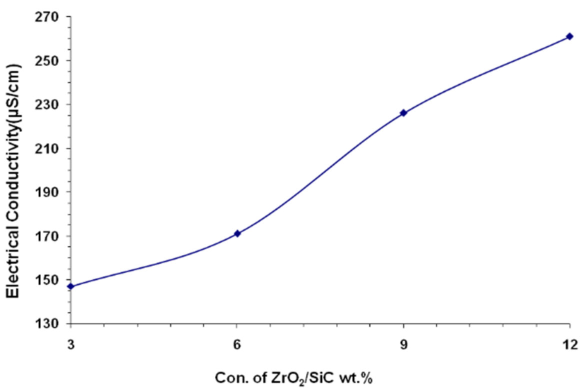

Figure 3. Variation of electrical conductivity of PEG/ZrO_2/SiC-H_2O nanofluids and concentrations of ZrO_2/SiC NPs

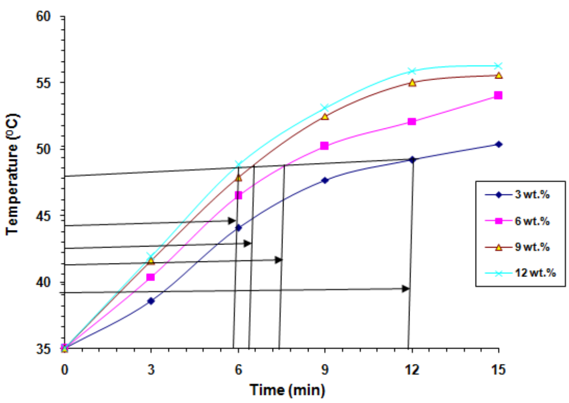

Figure 4. Melting curves of PEG/ZrO_2/SiC-H_2O nanofluids

4.CONCLUSIONS

Because of its simpler construction process and ability to easily control the properties of polymer electrolytes by altering the blended polymer composition, polymeric blends may have a more beneficial impact. The following list of potential consequences follows:

1.When the concentration of ZrO_2/SiC NPs increased to 12 weight percent, the electrical conductivity of nanofluids increased by around 43.6%.

2. As the concentration of ZrO_2/SiC nanoparticles increases, the melting time reduces.

3. When the concentration of ZrO_2/SiC NPs increases from 3 weight percent to 12 weight percent within 15 minutes, the increment in melting time reaches 51.2%.

4. As the concentration of ZrO_2/SiC NPs rose from 3 weight percent to 12 weight percent, the absorbance increased by approximately 80.3% and the transmittance dropped by about 82.5%.

5. The increase in ZrO_2/SiC NP concentration will result in a higher absorbance, which indicates improved nanofluid dispersion.

Acknowledgment

This publication was supported by the Deanship of Al-Mustaqbal University College, Babylon, Iraq.

ORCID IDs

Ahmed Hashim, https://orcid.org/0000-0002-0778-1159; **Farhan Lafta Rashid**, https://orcid.org/0000-0002-7609-6585
Bahaa H. Rabee, https://orcid.org/0000-0001-9780-1311

REFERENCES

[1] N. Hayder, M.A. Habeeb, and A. Hashim, "Structural, Optical and Dielectric Properties of (PS-In_2O_3/$ZnCoFe_2O_4$) Nanocomposites", Egypt. J. Chem. **62**(2), 577-592 (2019). https://doi.org/10.21608/ejchem.2019.14646.1887

[2] A. Babapoor, A.R. Haghighi, S.M. Jokar, and M.A. Mezjin, "The Performance Enhancement of Paraffin as a PCM During the Solidification Process: Utilization of Graphene and Metal Oxide Nanoparticles", Iran. J. Chem. Chem. Eng. 41(1), (2022). https://doi.org/10.30492/ijcce.2020.127799.4135

[3] A.M. Hashim, F.L. Rashid, and I.K. Fayyadh, "Preparation of Nanofluid (Al2O3-water) for Energy Storage", IOSR Journal of Applied Chemistry, **5**(3), 48-49 (2013). https://www.slideshare.net/IOSR/preparation-of-nanofluid-al2o3water-for-energy-storage

[4] Z.H. Obaid, F.L. Rashid, M.A. Habeeb, A. Hashim, and A. Hadi, "Synthesis of New Biomaterial Composite for Thermal Energy Storage and Release", Journal of Chemical and Pharmaceutical Sciences, **10**(3), 1125-1128 (2017).

[5] Batool Mohammed, Hind Ahmed, Ahmed Hashim, Improving the Optical Properties of PVA/PEG Blend Doped with BaTiO3 NPs, Journal of Physics: Conference Series 1963 (2021) 012005. https://doi.org/10.1088/1742-6596/1963/1/012005

[6] G.M. Nasr, A.S.A. El-Haleem, A. Klingner, A.M. Alnozahy, and M.H. Mourad, "The DC Electrical Properties of Polyvinyl Alcohol/Multi-Walled Carbon Nanotube Composites", Journal of Multidisciplinary Engineering Science and Technology, **2**(5), (2015).https://www.jmest.org/wp-content/uploads/JMESTN42350633.pdf

[7] C. Tyagi, and A. Sharma, "Linear and Nonlinear optical study of pure PVA and CdSe doped PVA nanocomposite", AIP Conference Proceedings, **1728**, 020151 (2016). https://doi.org/10.1063/1.4946202

[8] H.N. Obaid, M.A. Habeeb, F.L. Rashid, A. Hashim, "Thermal energy storage by nanofluids", Journal of Engineering and Applied Sciences, **8**(5), 143-145 (2014). https://doi.org/10.36478/jeasci.2013.143.145

[9] F.L. Rashid, A. Hadi, A.A. Abid, and A. Hashim, "Solar energy storage and release application of water - phase change material - (SnO_2-TaC) and (SnO_2–SiC) nanoparticles system", International Journal of Advances in Applied Sciences (IJAAS), **8**(2), 154-156 (2019). https://doi.org/10.11591/ijaas.v8.i2.pp154-156

[10] F.L. Rashid, and A. Hashim, "Recent Review on Nanofluid/ Nanocomposites for Solar Energy Storage", International Journal of Scientific Research and Engineering Development, **3**(4), 780-789 (2020). http://www.ijsred.com/volume3/issue4/IJSRED-V3I4P94.pdf

[11] F.L. Rashid, and A. Hashim, "Development of Phase Change Materials/Nanoparticles for Thermal Energy Storage", International Journal of Scientific Research and Engineering Development, **3**(4), 790-799 (2020). http://www.ijsred.com/volume3/issue4/IJSRED-V3I4P95.pdf

[12] D. Cabaleiro, S. Hamze, J. Fal, M.A. Marcos, P. Estellé, and G. Zyła, "Thermal and Physical Characterization of PEG Phase Change Materials Enhanced by Carbon-Based Nanoparticles", Nanomaterials, **10**, 1168 (2020). https://doi.org/10.3390/nano10061168

[13] Md.H. Zahir, M.M. Rahman, S.K.S. Basamad, K.O. Mohaisen, K. Irshad, M.M. Rahman, Md.A. Aziz, A. Ali, and M.M. Hossain, "Preparation of a Sustainable Shape-Stabilized Phase Change Material for Thermal Energy Storage Based on Mg^{2+}-Doped CaCO3/PEG Composites", Nanomaterials, **11**, 1639 (2021). https://doi.org/10.3390/nano11071639

[14] A.A. Gvozdenko, S.A. Siddiqui, A.V. Blinov, A.B. Golik, A.A. Nagdalian, D.G. Maglakelidze, E.N. Statsenko, et al., "Synthesis of CuO nanoparticles stabilized with gelatin for potential use in food packaging applications", Scientifc Reports, 12, 12843 (2022). https://doi.org/10.1038/s41598-022-16878-w

[15] Al-Aaraji, N.AH., Hashim, A., Hadi, A. *et al.* Effect of Silicon Carbide Nanoparticles Addition on Structural and Dielectric Characteristics of PVA/CuO Nanostructures for Electronics Devices. *Silicon* (2021). https://doi.org/10.1007/s12633-021-01265-3

[16] A. Hashim, H.M. Abduljalil, and H. Ahmed, "Fabrication and Characterization of $(PVA\text{-}TiO_2)_{1-x}/SiC_x$ Nanocomposites for Biomedical Applications", Egypt. J. Chem., **63**(1), (2020).https://doi.org/10.21608/EJCHEM.2019.10712.1695

[17] A. Hashim, H. Abduljalil, and H. Ahmed, "Analysis of Optical, Electronic and Spectroscopic properties of (Biopolymer-SiC) Nanocomposites for Electronics Applications", Egypt. J. Chem. **62**, (2019).https://doi.org/10.21608/EJCHEM.2019.7154.1590

[18] H. Ahmed, and A. Hashim, "Structural, Optical and Electronic Properties of Silicon Carbide Doped PVA/NiO for Low Cost Electronics Applications", Silicon, (2020).https://doi.org/10.1007/s12633-020-00543-w

[19] H. Ahmed,A. Hashim,and H.M. Abduljalil, "Determination of Optical Parameters of Films Of PVA/TiO2/SiC and PVA/MgO/SiC Nanocomposites for Optoelectronics and UV-Detectors", Ukr. J. Phys. **65**(6), (2020). https://doi.org/10.15407/ujpe65.6.533
[20] A. Hashim, "Fabrication and characteristics of flexible, lightweight, and low-cost pressure sensors based on PVA/SiO_2/SiC nanostructures", J. Mater. Sci: Mater. Electron.**32,** 2796–2804 (2021). https://doi.org/10.1007/s10854-020-05032-9
[21] H. Ahmed, and A. Hashim, "Geometry Optimization, Optical and Electronic Characteristics of Novel PVA/PEO/SiC Structure for Electronics Applications", Silicon, (2020).https://doi.org/10.1007/s12633-020-00620-0
[22] M. Mehrali, E. Sadeghinezhad, S.T. Latibari, S.N. Kazi, M. Mehrali, M.N.B.M. Zubir, H. Simon, and C. Metselaar, "Investigation of thermal conductivity andrheological properties of nanofluids containinggraphene nanoplatelets", Nanoscale Research Letters, **9**(15), (2014). https://doi.org/10.1186/1556-276X-9-15
[23] B. Bakthavatchalam, K. Habib, R. Saidur, N. Aslfattahiand, and A. Rashedi, "Investigation of Electrical Conductivity, Optical Property, and Stability of 2D MXene Nanofluid Containing Ionic Liquids", Appl. Sci., **10**, (2020). https://doi.org/10.3390/app10248943
[24] A. Hadi, A. Hashim, and D. Hassan, "Fabrication of new ceramics nanocomposites for solar energy storage and release, Bulletin of Electrical Engineering and Informatics", **9**(1), (2020), https://doi.org/10.11591/eei.v9i1.1323
[25] I.R. Agool, K.J. Kadhim, and A. Hashim, "Preparation of (polyvinyl alcohol–polyethylene glycol–polyvinyl pyrrolidinone–titanium oxide nanoparticles) nanocomposites: electrical properties for energy storage and release", International Journal of Plastics Technology, **20**(1), https://doi.org/10.1007/s12588-016-9144-5
[26] A.Hashim,and A. Hadi, "Synthesis and Characterization of Novel Piezoelectric and Energy Storage Nanocomposites: Biodegradable Materials–Magnesium Oxide Nanoparticles", Ukrainian Journal of Physics, **62**(12),1050-1056, (2017).https://doi.org/10.15407/ujpe62.12.1050
[27] I.R. Agool, K.J. Kadhim, and A. Hashim, "Synthesis of (PVA-PEG-PVP-ZrO_2) Nanocomposites For Energy Release and Gamma Shielding Applications, International Journal of Plastics Technology", **21**(2), (2017).https://doi.org/10.1007/s12588-017-9196-1
[28] N.H. Al-Garah, F.L. Rashid, A. Hadi, and A. Hashim, "Synthesis and Characterization of Novel (Organic–Inorganic) Nanofluids for Antibacterial, Antifungal and Heat Transfer Applications", Journal of Bionanoscience, **12**, 1538 (2018). https://doi.org/10.1166/jbns.2018
[29] F.L. Rashid, A. Hadi, N.H. Al-Garah, and A. Hashim, "Novel Phase Change Materials, MgO Nanoparticles, and Water Based Nanofluids for Thermal Energy Storage and Biomedical Applications", International Journal of Pharmaceutical and Phytopharmacological Research, **8**(1), (2018).https://eijppr.com/2KsaVdO
[30] F.L. Rashid, S.M. Talib, A. Hadi, and A. Hashim, "Novel of thermal energy storage and release: water/(SnO_2-TaC) and water/(SnO2–SiC) nanofluids for environmental applications", IOP Conf. Series: Materials Science and Engineering, **454**, 012113 (2018). https://doi.org/10.1088/1757-899X/454/1/012113
[31] A.S. Shareef, F.L. Rashid, A. Hadim, and A. Hashim, "Water-Polyethylene Glycol/ (SiC-WC) and (CeO_2-WC) Nanofluids For Saving Solar Energy", International Journal of Scientific & Technology Research, **8**(11), (2019).https://www.researchgate.net/profile/Farhan-Lafta/publication/337315854_Water-Polyethylene_Glycol_Sic-Wc_And_Ceo2WcNanofluids_For_Saving_Solar_Energy/links/5dd14a87299bf1b74b49250d/Water-Polyethylene-Glycol-Sic-Wc-And-Ceo2WcNanofluids-For-Saving-Solar-Energy.pdf
[32] A. Hadi, F. L. Rashid, H. Q. Hussein, A. Hashim, Novel of water with (CeO2-WC) and (SiC-WC) nanoparticles systems for energy storage and release applications, IOP Conference Series: Materials Science and Engineering, **518**(3), 5 (2019).https://doi.org/10.1088/1757-899X/518/3/032059

ПРИГОТУВАННЯ НАНОРІДИН З НЕОРГАНІЧНИХ НАНОСТРУКТУРЛЕГОВАНИХ ПЕГ: ХАРАКТЕРИСТИКИ ТА ЗАСТОСУВАННЯ ДЛЯ ЗБЕРІГАННЯ ЕНЕРГІЇ

Ахмед Хашим[a], Фархан Лафта Рашид[b], М.Х. Аббас[c], Бахаа Х. Рабі[a]
[a]Факультет фізики, Освітній коледж чистих наук, Вавилонський університет, Вавилон, Ірак
[b]Університет Кербали, інженерний коледж, факультет нафтової інженерії, Ірак
[c]Кафедра медичної фізики, коледж університету Аль-Мустакбал, Вавилон, Ірак

Полімерні нанокомпозити викликають великий інтерес, коли мова заходить про інноваційні матеріали через їхні покращені оптичні, електричні та магнітні властивості. Ці матеріали мають високий модуль зростання, вогнестійкі, а також можуть зупинити окислення та агломерацію. Ці покращення властивостей пов'язані із взаємодією між наночастинками та полімерами. Додавання наночастинок до полімерів подовжує їх життя, змінює їхню поверхню через рівні дефектів пасивації та забезпечує низьку вартість, просте виготовлення пристроїв, а також регульовані електричні та оптичні властивості. У цьому дослідженні розглядаються властивості та потенційне використання нанофлюїдів, виготовлених з неорганічних наноструктур, легованих PEG. Результати демонструють, що коли концентрація наночастинок ZrO_2/SiC зросла до 12 мас.%, електропровідність нанофлюїдів зросла приблизно на 43,6 %. Крім того, коли концентрація наночастинок ZrO2/SiC збільшується, час плавлення скорочується. Крім того, коли концентрація наночастинок ZrO_2/SiC збільшується з 3 вагових відсотків до 12 вагових відсотків протягом 15 хвилин, збільшення часу плавлення досягає 51,2 %, а поглинання збільшується приблизно на 80,3 %, тоді як пропускна здатність зменшується приблизно на 82,5 %.

Ключові слова: *нанокомпозити; неорганічні наноструктури; ПЕГ; зберігання енергії*