Sustainable Development Proceedings, Volume 1, 2023 doi: 10.5281/zenodo.8398422

Preparation and characterization of green synthesis nanofluid using mangosteen peel extract

Chaiwat Jumpholkul[1*], Nares Chimres[2], and Jatuporn Kaew-on[3]

[1] Energy Engineering Program, Faculty of Engineering, Thaksin University, Phatthalung, 93210, Thailand; chaiwat.j@tsu.ac.th

[2] Mechanical Engineering Program, Faculty of Engineering, Thaksin University, Phatthalung, 93210, Thailand; nares_ch@yahoo.com

[3] Mechanical Engineering Program, Faculty of Engineering, Thaksin University, Phatthalung, 93210, Thailand; kaew_on@yahoo.com

* Correspondence: chaiwat.j@tsu.ac.th

Abstract

In the past decade, nanofluids as working fluids have been prevalent due to better heat transfer efficiency than conventional working fluids. However, the problem with using nanofluids is the precipitation and hazardousness of nanoparticles. Therefore, plant extracts-based synthesis procedures have drawn consideration over traditional methods like physical and chemical to synthesize nanofluid. This research synthesized silver nanoparticles (AgNPs) suspended in fluid at various conditions by extracts from mangosteen peels as reducing and capping agents. Nanoparticle formation was confirmed by observing the color change of the mixture of silver nitrate from yellow to a brown colloidal suspension after adding the plant extract. In addition, UV-Vis spectroscopy, SEM, and EDX were used to analyze the synthesized nanoparticles. The prepared nanofluid shows a characteristic absorption peak band between 440 and 460 nm wavelengths. The particle size was obtained by SEM, which is spherical with an average diameter of less than 10 nm and is very well dispersed in the fluid. Furthermore, the EDX mapping images confirmed that the silver nanoparticles were distributed throughout the liquid.

Keywords: nanofluid; green synthesis; silver nanoparticle; peel extract

Peer-review under responsibility of the organizing committee 1st International Conference on ASEAN Sustainable Development (ICASD 2023).

1. Introduction

Using nanofluids as working fluids for heat transfer in various thermal systems has attracted significant interest from researchers. For example, Choudhary et al. [1] experimented with studying the stability of the MGO-EG/water nanofluid and its effect on the thermal efficiency of the flat-plate solar collector (FPSC). Cetyltrimethylammonium bromide (CTAB) was sonicated to the mixture to stabilize the suspension. Stability analysis by zeta potential showed that the nanofluids were stable for more than 15 days with a maximum nanofluid concentration of 0.2 vol.% that could be maintained. The maximum thermal efficiency of the solar collector is 69.1% at a concentration of 0.2 vol% and a flow rate of 1.5 LPM, which is 16.7% greater than the base fluid.

Hussein et al. [2] mixed a fluid nano-hybrid comprising CF-MWCNTs and CF-GNPs with hexagonal boron nitride (h-BN) into distilled water to be used as a working fluid flow through the flat-plate solar collector (FPSC) at various concentrations, and Tween-80 (Tw-80) was used as a surfactant. Stability and thermodynamic properties were tested using different measuring instruments. The structural and morphological properties were verified using FTIR, XRD, UV–vis spectrometry, HRTEM, FESEM, and EDX. The thermal efficiency of FPSCs was tested under 2, 3, and 4 LPM of inlet volumetric flow rates. The thermal efficiency of the solar collector was tested according to ASHRAE 93-2010. The results showed that the collector efficiency was increased by 85% when using a flow rate of 4 LPM as the energy absorption medium. In addition, increasing the concentration of nanoparticles increases the thermal energy absorption and consequently increases the temperature of the working fluid at the collector output.

As mentioned above, using nanofluids as working fluids can increase the thermal performance of heat exchangers. However, the stability of nanoparticles suspended in the liquid is the most crucial obstacle in applying nanofluids. The nanofluid preparation process is an essential first step. Therefore, various techniques have been proposed. It is possible (both physical and chemical) to enhance the stability of nanoparticles in aqueous media (Akram et al. [3], Alawi et al. [4]).

Akram et al. [3] investigated the effects of graphene nanoplatelets-water nanofluids. The impact of three different mass concentrations and mass flow rates on FPSC performance was found in the study. The thermal efficiency of FPSC increases with increasing mass concentration and flow rate. At a concentration of 0.1 wt.% and a flow rate of 0.0260 kg/m2s, the thermal efficiency of the FPSC was as high as 78%, which is 18.2% greater than that of water under the same flow rate condition. To investigate the stability of graphene nanoplatelets–water nanofluid and found it was highly stable for 45 days.

Alawi et al. [4] studied the effects of using a thermally treated graphene nanofluid mixed in pentamethylene glycol base fluid as the working fluid in solar collectors. Flat sheet with 0.025, 0.05, 0.075, and 0.1 wt.%, respectively. The precipitation was analyzed by scanning electron microscopy (SEM). K The mass flow rate of the fluid was 0.00833, 0.01667, and 0.025 kg/s, and the solar radiation intensity was 500, 750, and 1,000 W/m^2. The test results showed that the thermal efficiency increased with the fluid's mass flow rate and Increased solar radiation's intensity. By comparison, the thermal efficiency decreases as the inlet temperature rises. The thermal efficiency of the solar collector when using fluid is increased to 10.6%, 11%, and 13.1% compared to using water at the same flow rate.

In addition, Harish Kumar et al. [5] collected and synthesized data on the nanofluid preparation process by green synthesis. These nanofluids have unique thermal and heat transfer properties, making them attractive for electronics cooling, solar energy harvesting, and heat exchanger applications. It can be concluded that the green synthesis process using plant extracts as a reducing agent and support agent for the preparation of nanofluids increased the holding time of the

Peer-review under responsibility of the organizing committee 1st International Conference on ASEAN Sustainable Development (ICASD 2023).

Sustainable Development Proceedings, Volume 1, 2023 doi: 10.5281/zenodo.8398422

nanoparticles in the working fluid. However, there is a great need for more research data, particularly on the thermal properties of the nanofluids.

Therefore, this research aims to develop an environmentally friendly nanofluid synthesis method that reduces toxicity and production costs. As a result, biosynthetic methods, especially the synthesis of nanofluids with plant extracts, are currently desirable alternatives. There is an increasing number of research studies and publications on synthesizing nanoparticles with plant extracts.

2. Materials and Methods

2.1 Preparation of plant extracts for synthesizing nanofluid

Collect samples of ripe mangosteen. Take the mangosteen peel from the ripe fruit, whose skin is smooth and dark purple, and cut off the pole. Then wash thoroughly, cut into small pieces, and then import into a blender into powder. The powder was dried in a hot air oven at 50°C for two hours. 2.5 g of dried mangosteen peel was weighed and extracted with 100 ml of deionized water in a beaker. Heated in a hot water bath at 60°C for 30 minutes, then cooled to room temperature. Filter the extract through filter paper No. 1. The extract obtained from the filtration can be used to synthesize silver nanoparticles by adding silver nitrate solution ($AgNO_3$) with three different concentrations, 10, 20, and 40 mM, to study the effect of concentration on the thermal properties of the nanofluids. After that, it was heated on a stirrer at a speed of 500 rpm for 20 hours to obtain the nanofluid extracted from the green process from the mangosteen peel.

2.2 Characterization of nanofluids

The nanofluids used in this study were derived from a biological method in which a plant extract was mixed with a metal salt through a reduction reaction. In the synthesis process, the solvent used is water. Most reduction reactions occur at room temperature, and it does not take long for the response to complete, which can be observed from the color of the solution that has changed. Ultraviolet-visible spectroscopy (UV-Vis) characterized the synthesized nanofluids to confirm the presence of nanoparticles in the extraction process, which can be observed from the absorbance reading. The light absorption intensity increases as the atoms combine to form particles. It is commonly used to analyze silver, gold, and copper nanoparticles. It can also track nanoparticle formation from surface plasmon resonance spectra. The absorbance of silver nanoparticles, which is the desired particle from this research, is 420 nm. The shape and size of nanoparticles are also checked. The morphology of the nanoparticles suspended in the fluid was obtained by scanning electron microscopy (SEM); the images obtained from this SEM are like the 3D images and, therefore, are used to study the morphology and details of the surface characteristics of the samples. Examine the surface appearance of the sample and include the structure. The arrangement of nanoparticles and stabilizing agents in the nanofluid can also be analyzed for various elements in the extract by Energy Dispersive Spectrometry (EDS) for further analysis of the obtained results.

3. Results and Discussion

The extraction of the nanofluid by the green synthesis method was performed from the mangosteen peel. The proportion 0.5 g. of ground mangosteen peel was mixed with 20 ml. of DI water, heated on a hotplate at 60°C for 30 minutes, and then mixed with silver nitrate solution at concentrations of 10, 20, and 40. mM, then centrifuged at 500 rpm

Peer-review under responsibility of the organizing committee 1st International Conference on ASEAN Sustainable Development (ICASD 2023).

 doi: 10.5281/zenodo.8398422

and set at 45ºC for 20 hours, then left at room temperature and filtered with No. 1 filter paper. Nanofluid-containing nanoparticles were obtained. The appearance of the nanofluid is dark purple. It is a solution with a small amount of impurities at a high concentration (40 mM), as shown in Figure 1.

Figure 1. Nanofluid extracted from the green synthesis process from mangosteen peel.

After the extraction, the nanofluid was analyzed for particle formation by Ultraviolet-Visible spectroscopy (UV-Vis). Theoretically, if silver nanoparticles are present in the solution, the absorbance will reach a maximum between 420 and 450 nm wavelengths. Theoretically, As shown in Figure 2, it can be concluded that silver nanoparticles are formed in the nanofluid extraction. However, from the experimental results, it can be seen that the nanofluid concentration of 40 mM has less absorbance than that at a concentration of 2 0 mM. Due to the colliding and larger silver particles, some residue corresponds to the photograph in Figure 1.

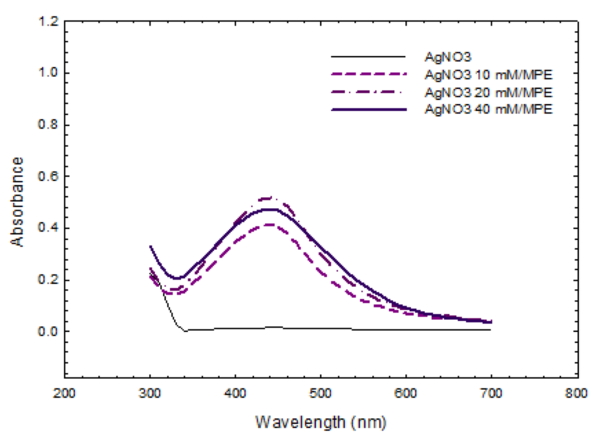


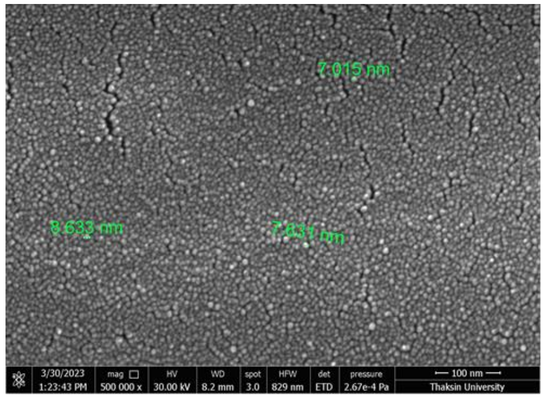
Figure 2. The UV-visible spectrum of AgNPs at different concentrations.

For the morphological analysis of the nanofluids, the nanofluids were photographed using a scanning electron microscope (SEM). The resulting images showed the position and size of the silver nanoparticles dispersed in the solution. The photos obtained have shown that the resulting silver nanoparticles were less than 10 nm in diameter, not clumped together, and well distributed. As shown in Figure 3, EDX techniques are also used to analyze elements and their presence

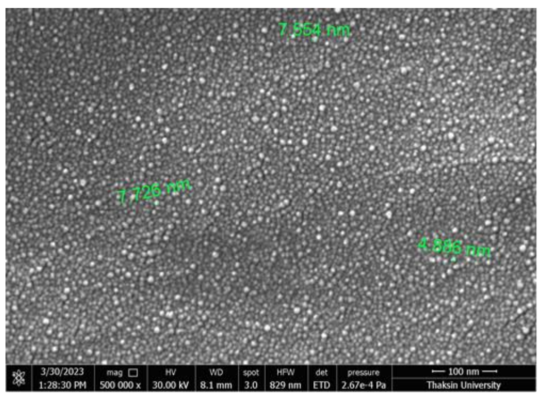
Peer-review under responsibility of the organizing committee 1st International Conference on ASEAN Sustainable Development (ICASD 2023).

Sustainable Development Proceedings, Volume 1, 2023 doi: 10.5281/zenodo.8398422

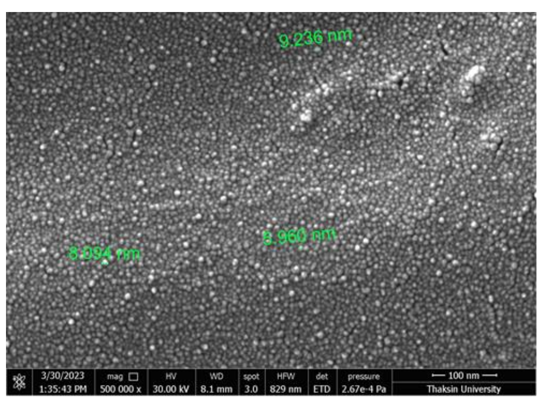
in the solution. Only carbon (C) and oxygen (O) are components of mangosteen peel extracts. As shown in Fig. 4, silver (Ag) is also present in the nanofluid element in the solution. Figure 5 shows that the silver nanoparticles are formed in the nanofluid. The dispersion of silver nanoparticles in the solution is shown in Figure. 6, not agglutinated, following the SEM images.



(a) Nanofluid with $AgNO_3$ solution concentration of 10 mM.



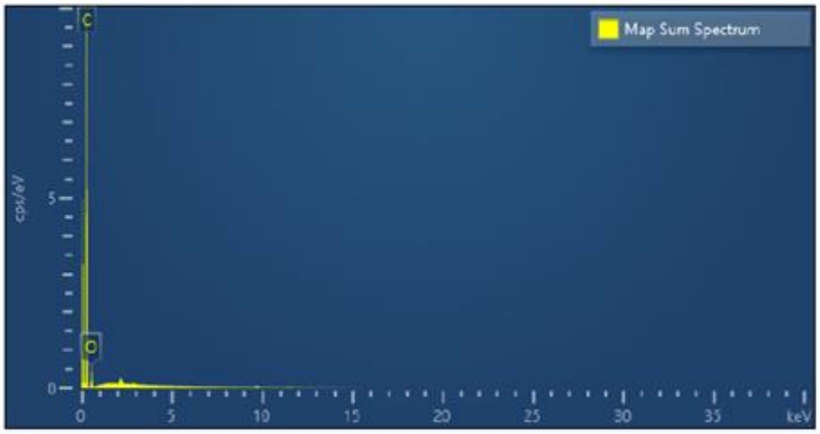
(b) Nanofluid with $AgNO_3$ solution concentration of 20 mM.



(c) Nanofluid with $AgNO_3$ solution concentration of 40 mM.

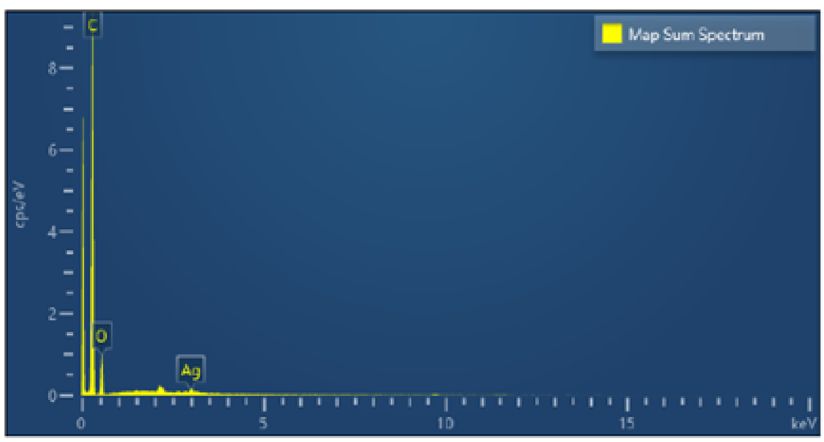
Figure 3. SEM images show silver nanoparticles' morphology and size in nanofluids at various concentrations.

Sustainable Development Proceedings, Volume 1, 2023 doi: 10.5281/zenodo.8398422



Element	Line Type	Apparent Concentration	k Ratio	Wt%	Wt% Sigma	Atomic %	Standard Label
C	K series	23.06	0.23058	85.09	0.31	88.37	C Vit
O	K series	1.47	0.00493	14.91	0.31	11.63	SiO2
Total:				100		100	

Figure 4. The results of elemental analysis of mangosteen peel extract by EDX technique.



Element	Line Type	Apparent Concentration	k Ratio	Wt%	Wt% Sigma	Atomic %	Standard Label
C	K series	6.44	0.0644	76.8	0.55	82.02	C Vit
O	K series	1.14	0.00383	22.3	0.55	17.88	SiO2
Ag	L series	0.14	0.00138	0.9	0.11	0.11	Ag
Total:				100		100	

Figure 5. The results of elemental analysis of green synthesis nanofluid by EDX technique.

 doi: 10.5281/zenodo.8398422

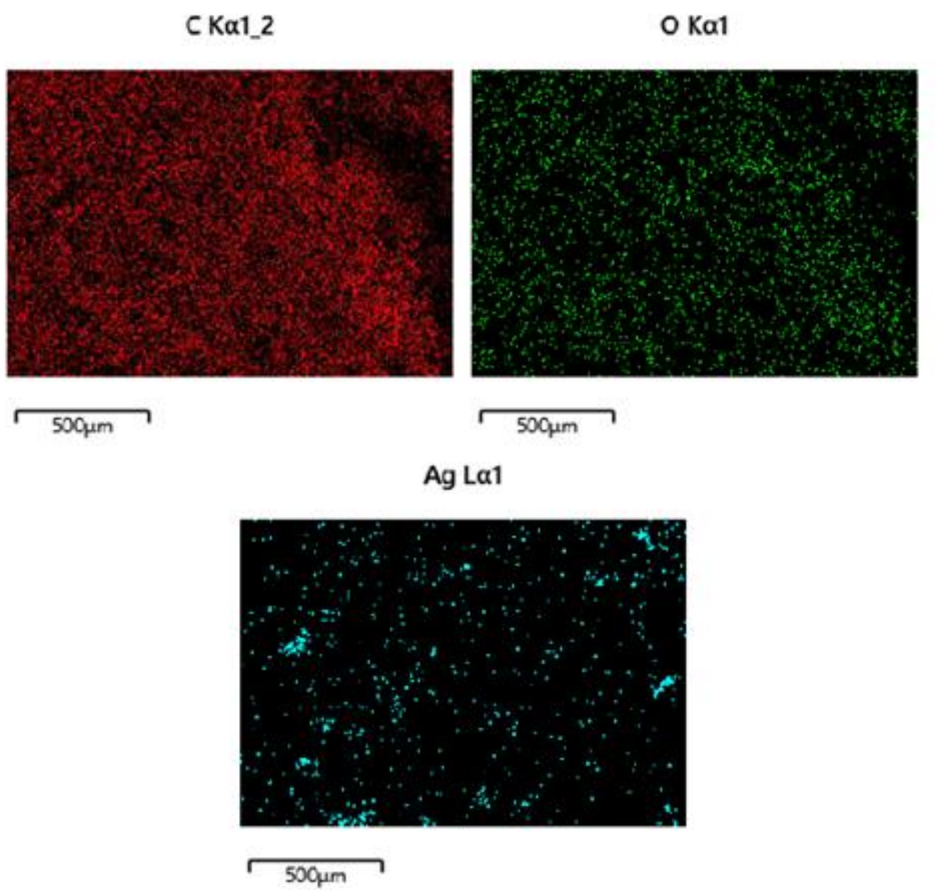


Figure 6. The results of elemental analysis of nanofluids and elemental distribution by EDX technique.

4. Conclusions

The green synthesis of nanofluids using mangosteen peel extract offers a promising approach for producing nanofluids with potential environmental and health benefits. Continued research and development in this area could lead to the utilization of mangosteen peel extract in the production of nanofluids with the improved thermal performance of working fluid and reduced environmental impact.

5. Acknowledgements

Thaksin University Research Fund supported this work.

References

[1] Choudhary, S., Sachdeva, A., & Kumar, P. (2020). Investigation of the stability of MgO nanofluid and its effect on the thermal performance of flat plate solar collector. *Renewable Energy*, (147), 1801-1814. https://doi.org/10.1016/j.renene.2019.09.126

[2] Hussein, O.A., Habib, K., Muhsan, A.S., Saidur, R., Alawi, O.A., & Ibrahim, T.K. (2020). Thermal performance enhancement of a flat plate solar collector using hybrid nanofluid. *Solar Energy*, (204), 208-222. https://doi.org/10.1016/j.solener.2020.04.034

Sustainable Development Proceedings, Volume 1, 2023 doi: 10.5281/zenodo.8398422

[3] Akram, N., Sadri, R., Kazi, S.N., Ahmed, S.M., Zubir, M.N.M., Ridha, M., Soudagar, M., Ahmed, W., Arzpeyma, M., & Goh, B.T. (2019). An experimental investigation on the performance of a flat-plate solar collector using eco-friendly treated graphene nanoplatelets-water nanofluids. *Journal of Thermal Analysis and Calorimetry*, (138), 609-621. https://doi.org/10.1007/s10973-019-08153-4

[4] Alawi, O.A., Kumar, H.M., Mohammed, H.A., Mallah, A.R., & Hussein, O.A. (2020). Energy efficiency of a flat-plate solar collector using thermally treated graphene-based nanofluids: Experimental study. *Nanomaterial and Nanotechnology*, (10), 1-13. https://doi.org/10.1177/1847980420964

[5] Harish Kumar, L., Kazi, S.N., Masjuki, H.H., & Zubir, M.N.M. (2022). A review of recent advances in green nanofluids and their application in thermal systems. *Chemical Engineering Journal*, (429), 132321. https://doi.org/10.1016/j.cej.2021.132321