# THERMOPYHSICAL PROPERTIES CHARATERISATION OF WATER BASED MANGO OXIDE HYBRID NANOFLUID

JAMES LAU TZE CHEN

Master of Science

UNIVERSITI MALAYSIA PAHANG

## SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

_______________________________

(Supervisor's Signature)

Full Name : DR. AHMED NURYE OUMER

Position : SENIOR LECTURER

Date : 16/12/2020

_______________________________

(Co-supervisor's Signature)

Full Name : DR. AZIZUDDIN BIN ABD AZIZ

Position : SENIOR LECTURER

Date : 16/12/2020

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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(Student's Signature)

Full Name : JAMES LAU TZE CHEN

ID Number : MME18002

Date : 16/12/2020

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JAMES LAU TZE CHEN

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# ABSTRAK

Nanofluid boleh dijelaskan sebagai campuran nanopartikel dan bendalir. Ramai penyelidik cuba meningkatkan kekonduksian haba bendalir dengan menambahkan nanopartikel logam dan bukan logam dalam bendalir kerana kekonduksian haba nanopartikel logam dan bukan logam lebih tinggi daripada bendalir. Tetapi, ia juga meningkatkan kelikatan bendalir menyebabkan penurunan tekanan tinggi dalam aplikasi pemindahan haba. Ini menghasilkan kuasa pam yang lebih tinggi diperlukan dan seterusnya meningkatkan kos operasi sistem. Oleh itu, kombinasi nanopartikel logam atau bukan logam dengan nanopartikel bio tersebar dalam bendalir boleh menjadi satu pilihan untuk mengurangkan penurunan tekanan sambil mengekalkan aplikasi pemindahan haba. Ini adalah kerana penambahan nanopartikel bio yang bersifat serat dalam bendalir dapat menghasilkan peningkatan kekonduksian terma yang rendah dengan trend kelikatan yang berkurangan secara mendadak. Tiga objektif dalam kajian ini adalah untuk menyediakan nanofluid hibrid mango / oksida, menilai kestabilan serta sifat termofilik nanofluid hibrid mango / oksida dan menentukan keadaan untuk sifat haba yang lebih baik dan kelikatan yang berkurangan. Nanopartikel kulit mangga (MB) dan daun mangga (ML) mula-mula dihasilkan menggunakan kaedah top-down. Seterusnya, nanopartikel MB dan ML yang disediakan campur dengan nanopartikel oksida dan gantung ke dalam bendalir dengan menggunakan pengaduk dan mandi ultrasonik. Kestabilan nanofluid diukur menggunakan kaedah pemendapan dan analisis UV-Vis. Seterusnya, ketumpatan, kelikatan, kekonduksian haba dan kapasiti haba tertentu nanofluid dinilai menggunakan kaedah teori dan eksperimen. Selepas itu, keadaan untuk sifat haba yang dipertingkatkan dan kelikatan berkurang nanofluid ditentukan menggunakan Kaedah Surface Response (RSM). Dari keputusan, nanofluid mempunyai kestabilan yang sederhana dengan tanda pemendapan selepas 1 hari dan meningkat sedikit selepas 14 hari. Semua nanofluid stabil dan boleh digunakan pada panjang gelombang 300nm dengan purata serapan puncak 2.491. Nanofluid MB/$TiO_2$ dan ML/$TiO_2$ mempunyai 12.2% dan 14.7% kelikatan berkurangan berbanding dengan $TiO_2$ nanofluid. Nanofluid MB / $SiO_2$ dan ML / $SiO_2$ mempunyai 3.2% dan 4.4% kelikatan berkurang berbanding dengan $SiO_2$ nanofluid. Nanofluid MB/$TiO_2$ dan ML/$TiO_2$ telah mengekalkan peningkatan kekonduksian haba dengan 4.5% dan 5.4% lebih rendah berbanding dengan $TiO_2$ nanofluid. Nanofluida MB/$SiO_2$ dan ML/$SiO_2$ telah mengekalkan peningkatan kekonduksian haba dengan 1.1% dan 1.6% lebih rendah berbanding dengan nanofluid $SiO_2$. Kapasiti dan kapasiti haba tertentu bergantung kepada jenis bahan nanopartikel. Kelikatan menurun dengan suhu dan meningkat dengan kepekatan. Sementara itu, kekonduksian haba meningkat dengan suhu dan kepekatan. Dari hasil RSM, nanofluid MB/oksida mempunyai kekonduksian haba yang paling tinggi dan kelikatan yang paling rendah dengan jenis bahan MB/$SiO_2$ (12.92% $SiO_2$ dan 87.08% MB), suhu 70$^oC$ dan kepekatan 0.25. Sementara itu, nanofluid ML/oksida mempunyai kekonduksian haba yang paling tinggi dan kelikatan yang paling rendah dengan jenis bahan MB/$SiO_2$ (42.98% $SiO_2$ dan 57.02% ML), suhu 70$^oC$ dan kepekatan 0.25%. Kesimpulannya, nanofluid hibrid mangga/oksida mempunyai kestabilan yang sederhana dengan kelikatan yang berkurangan seterusnya mengekalkan kekonduksian haba daripada nanofluid berasaskan bukan bio. Oleh itu, nanofluid hibrid mangga/oksida boleh digunakan untuk mengurangkan penurunan tekanan sambil mengekalkan aplikasi pemindahan haba.

## ABSTRACT

Nanofluid can be described as a mixture of nanoparticles and base fluid. Many researchers attempted to enhance the thermal conductivity of base fluids by adding metallic and non-metallic nanoparticles in fluids. Although metallic and non-metallic nanoparticles can increase the thermal conductivity of base fluids, it also increases the viscosity of base fluids that causes a high pressure drop in the heat transfer application. This results that higher pumping power is needed which in turn increases the system operation cost. Therefore, an alternative solution needs to be devised. For this, hybrid nanofluid with a combination of metallic or non-metallic nanoparticles and bio nanoparticles dispersed in a base fluid can be one option to reduce the pressure drop further while maintaining the heat transfer application. This is because of the addition of bio nanoparticles that have fibre by nature in fluids resulting in low thermal conductivity enhancement with an exponentially decreasing trend of viscosity that might reduce pressure drop. Thus, the three objectives of this research are to determine the stability of mango/oxide hybrid nanofluid, to evaluate thermophysical properties of mango/oxide hybrid nanofluid and to measure the optimum parameters for enhanced thermal properties and reduced viscosity. Mango bark (MB) and mango leaf (ML) nanoparticles were first produced using the top-down method. In the second processing step, the MB and ML nanoparticles that are prepared separately mixed with oxide nanoparticles and suspended into the base fluid using stirrer and an ultrasonic bath. Stability of the nanofluids was measured using sedimentation method and UV-Vis analysis. Then, density, viscosity, thermal conductivity and specific heat capacity of the nanofluids were evaluated using theoretical and experimental method. After that, the optimum parameters for enhanced thermal properties and reduced viscosity of nanofluids were determined using Response Surface Methodology (RSM). From the results, the nanofluids have stability in moderation with the sign of sedimentation after 1 day and slightly increased after 14 days. All nanofluids are stable and applicable at 300nm wavelength with average peak absorbance of 2.491. At 30$^oC$ with 1% of volume concentration, MB/$TiO_2$ and ML/$TiO_2$ water-based nanofluids have 12.2% and 14.7% reduced viscosity than $TiO_2$ water-based nanofluid. MB/$SiO_2$ and ML/$SiO_2$ water-based nanofluids have 3.2% and 4.4% reduced viscosity than $SiO_2$ water-based nanofluid. At 30$^oC$ with 1% of volume concentration, MB/$TiO_2$ and ML/$TiO_2$ water-based nanofluids have maintained thermal conductivity enhancement with 4.5% and 5.4% lower than $TiO_2$ water-based nanofluid. MB/$SiO_2$ and ML/$SiO_2$ water-based nanofluids have maintained thermal conductivity enhancement with 1.1% and 1.6% lower than $SiO_2$ water-based nanofluid. Density and specific heat capacity are dependent on the material type. The viscosity decreased with temperature and increased with concentration. Meanwhile, the thermal conductivity increased with temperature and concentration. From the results of RSM, MB/oxide nanofluids have the most enhanced thermal conductivity and reduced viscosity with the material type of MB/$SiO_2$ (12.92% $SiO_2$ and 87.08% of mango bark), the temperature of 70$^oC$ and concentration of 0.25. Meanwhile, ML/oxide nanofluid have the most enhanced thermal conductivity and reduced viscosity with the material type of MB/$SiO_2$ (42.98% $SiO_2$ and 57.02% of mango leaf), the temperature of 70$^oC$ and concentration of 0.25%. In conclusion, mango/oxide hybrid nanofluids have stability in moderation with reduced viscosity and maintained thermal conductivity enhancement than non-bio based nanofluids that can be used to reduce the pressure drop further while maintaining the heat transfer application.

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