THERMOPHYSICAL PROPERTIES OF STABILIZED COPPER OXIDE-POLYANILINE-PALM OIL BASED NANOFLUIDS

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Doctor of Philosophy

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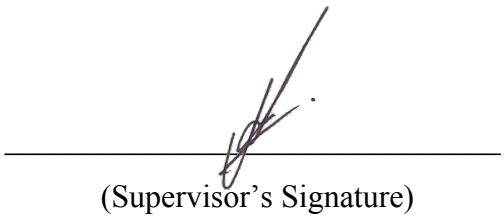

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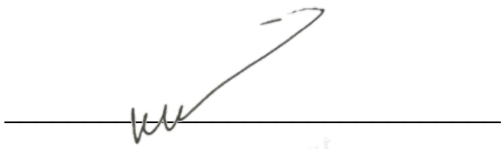

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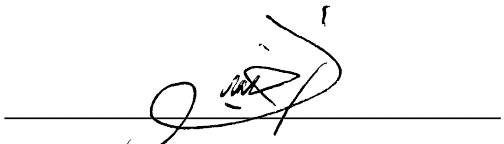

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ABSTRAK

Bendalir nano telah menarik minat dikalangan saintis kerana telah dibuktikan mempunyai sifat konduktif terma yang baik untuk digunakan dalam pelbagai bidang applikasi. Walaubagaimanapun, kebanyakan bahan nano yang digunakan adalah mahal dan mempunyai potensi yang tinggi untuk mengakibatkan pencemaran alam berikutan bahan nano yang biasa digunakan kini mempunyai nilai toxic yang tinggi. Kemajuan teknologi telah menggalakkan pencarian untuk bendalir haba yang lebih maju untuk menggantikan minyak mineral konvensional. Oleh itu, dengan mencadangkan bahan nano yang lebih mesra alam dan murah, kemampuan polimer konduktif sebagai bahan tambahan nano dalam bendalir asas telah dikaji. Minyak sawit dicadangkan untuk menggantikan minyak mineral telah digunakan dalam kajian ini. Dalam kajian ini, polianilin (PANI) yang murah dan mesra alam telah dihasilkan dan dikajuk bersama kuprum teroksida (CuO) untuk dijadikan bahan tambahan nano didalam bendalir nano yang berasakan minyak sawit olein (RBDL). Kestabililan sistem bendalir nano telah dikaji kerana ia memainkan peranan penting untuk memastikan sistem terma berfungsi. Sifat terma fizik juga dikaji memandangkan sifat ini sangat dititik beratkan oleh para saintis. Model persamaan matematik dibina melalui kaedah RSM bagi tujuan ramalan. Bendalir nano yang diformulasi diberi nama CuO-RBDL, PANI-RBDL dan CuO-PANI-RBDL dengan kepekatan bahan nano yang berbeza dalam julat 0.01-0.5% kepekatan isipadu telah diformulasi dengan kaedah dua-langkah. Morfologi dan struktur bahan nano yang dibina telah dianalisis dengan kaedah TEM, EDX, XRD, FT-IR, dan TGA. Penelitian pemendapan, DLS, UV-vis, FTIR dan TGA dijalankan untuk kajian terhadap kestabilan. Sifat terma fizik seperti ketumpatan, kelikatan dan sifat konduktif terma masing-masing telah diuji dengan meter ketumpatan, meter kelikatan dan penguji haba. Model persamaan matematik dibina melalui kaedah RSM dan disahkan dengan kaedah perbandingan dengan data experimen. Kajian ini membongkarkan PANI dan komposit PANI-CuO Berjaya dibina dibuktikan melalui kaedah analisis TEM, EDX, XRD, FTIR dan TGA. Pemerhatian pemendapan mendapati bendalir nano CuO-RBDL mencapai kestabilan selama satu minggu manakala bendalir nano PANI-RBDL dan CuO-PANI-RBDL mencapai kestabilan selama hamper satu bulan. Pemerhatian kestabilan ini telah disokong dan lebih dipastikan dengan kaedah DLS dan UV-vis. Daripada analisis UV-vis, semua sampel bendalir nano PANI-RBDL dan CuO-PANI / RBDL mencapai penurunan penyerapan dalam julat 4 hingga 12% selepas 30 hari penilaian. Graf FTIR dan TGA masing-masing menunjukkan semua bendalir nano mempunyai kestabilan kimia dan thermal. Ketumpatan semua nanofluid didapati meningkat dengan jumlah aditif nano sebaliknya menurun dengan pertambahan suhu. Sifat reologi bendalir nano didapati mempunyai sifat ideal Newtonion dan menunjukkan peningkatan kelikatan dengan pertambahan jumlah aditif nano tetapi menurun dengan kenaikan suhu. Ciri konduktif terma yang paling baik dicapai oleh bendalir nano dengan komposit CuO-PANI 10wt% dengan peningkatan sebanyak 31.34% manakala kekonduksian terma yang diperolehi untuk CuO /RBDL adalah paling sedikit dengan peningkatan 17.8%. Data experimen telah dibandingkan dengan data ramalan. Kesemua data yang diplot mempunyai persetujuan yang baik dengan data experimen menunjukkan model matematik yang dibina mempunyai kebolehpercayaan untuk ramalan respon. Minyak sawit RBD yang ditambah nano seharusnya menjadi bendalir alternative untuk industri berikutan kewujudan kualiti yang hebat yang ada padanya. Tambahan lagi, dengan penggunaan sepenuhnya minyak sawit sebagai bendalir alternatf, akan membawa keuntungan kepada Malaysia dan dapat menyumbang kepada persekitaran yang lebih hijau.

ABSTRACT

Nanofluids have attracted boundless attention among researchers due to their excellent heat transfer properties and have been proposed for various advanced heat transfer applications. However, the use of excessive nanoadditives could be costly and pose a threat to the environment due to the high toxicity of recent used nanoparticles. The advancement in technology has forced the search for advanced heat transfer fluid to replace the non-renewable conventional mineral oil base fluids. Therefore, to propose more ecologically and cost-effective nanofluids, the possibility of conducting polymer as nanoadditives in vegetable-based heat transfer fluids is proposed and investigated. Palm oil (a vegetable-based oil) has been the preferred fluid to substitute the centuries-old oil in the present work. In this research, the inexpensive and environmentally friendly polymers, PANI nanofibers, were synthesized and hybridized with CuO nanoparticles to serve as nanoadditives in RBDL for nanofluid formulation. The stability of formulated nanofluids was evaluated as stability plays a vital role in ensuring the behavior of the thermal system at a designed parameter. The formulated nanofluids' thermophysical properties were investigated in greater depth to reveal the possibility as advanced heat transfer fluid. Mathematical equations were developed at the final stage of the research for future properties prediction. The two-step approach was espoused to formulate CuO-RBDL, PANI-RBDL, and CuO-PANI-RBDL nanofluid with different volume concentrations ranging from 0.01-0.5%. The morphology and structure of the synthesized nanoadditives were analyzed using TEM, EDX, XRD, FT-IR, and TGA. Meanwhile, sedimentation observation, DLS, UV-Vis, FTIR, TGA are performed for stability evaluation. Thermophysical properties of formulated nanofluids such as density, rheology, and thermal conductivity were measured using density meter, rheometer, and thermal analyzer instruments. The mathematical model was developed using RSM for future prediction and validation via comparison study with the present data. Morphological and structural analysis performed using TEM, EDX, XRD, FTIR, and TGA analysis revealed that the PANI nanofibers had been successfully hybridized with CuO nanoparticles. Sedimentation observation noticed that the CuO-RBDL achieved stability only for a week, while PANI-RBDL and CuO-PANI-RBDL samples maintain their dispersion stability near a month. The stability observation findings were supported and further inveterate by DLS and UV-vis analysis. All PANI-RBDL and CuO-PANI-RBDL nanofluids samples achieved an absorbance drop in the range of 4 to 12% in 30 days from the UV-Vis analysis. The FTIR spectrum and TGA curve for all the nanofluids indicate that the prepared nanofluids are chemically and thermally stable. The density of all nanofluids was found to increase with the volume concentration of nanoadditives but decrease with temperature. All nanofluids' rheology properties were found to have Newtonian flow behavior, and the viscosity increases with nanoparticle volume concentrations, but their properties diminish with temperature increment. The most outstanding thermal conductivity properties achieved by nanofluid were the 10wt% CuO-PANI nanocomposites with 31.34% enhancement, while the least thermal conductivity acquired is for CuO-RBDL with 17.8% enhancement. The experimental results were compared with the predicted result obtained from the mathematical model. All the plotted data were found to have good agreement with the experimental data indicating the developed mathematical model's reliability for response estimation. In summary, the formulated nano-enhanced RBDL nanofluid evaluated properties expose the possibility of alternative advanced heat transfer fluid for industrial application due to their superior inherent qualities.

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