

Abstract

This work assesses the potential of nano-lubricants to improve air conditioning (AC) system performance, particularly in hot climates, enhancing urban resilience. The study examines the effects of production parameters on the thermophysical, tribological, and stability properties of nano-lubricants formulated from POE32 oil and carbon-based nanomaterials (short-SWCNTs, short-MWCNTs, and graphene) at concentrations ranging from 0.01 to 0.10 vol.%. A two-step mixing process was employed, and the nano-lubricants were tested at temperatures between 10°C and 100°C, implicating compressor’s operating conditions. Results showed that lubricant density remained stable across concentrations but varied with temperature. Specific heat capacity decreased with increasing nanomaterial content, with a 6.85% reduction at 0.1 vol.% short-SWCNTs at 100°C. Thermal conductivity improved minimally at low concentrations, with graphene enhancing it by 2.21% at 0.10 vol.%. Dynamic viscosity increased significantly at higher concentrations, peaking at 15.31% for short-SWCNTs. Tribological tests revealed optimal friction reduction at specific concentrations for each material. Dispersion stability was maintained for 5 days before degradation. These findings support further exploration of nano-lubricants for material compatibility with refrigerants and testing in AC compressors for high-temperature applications.

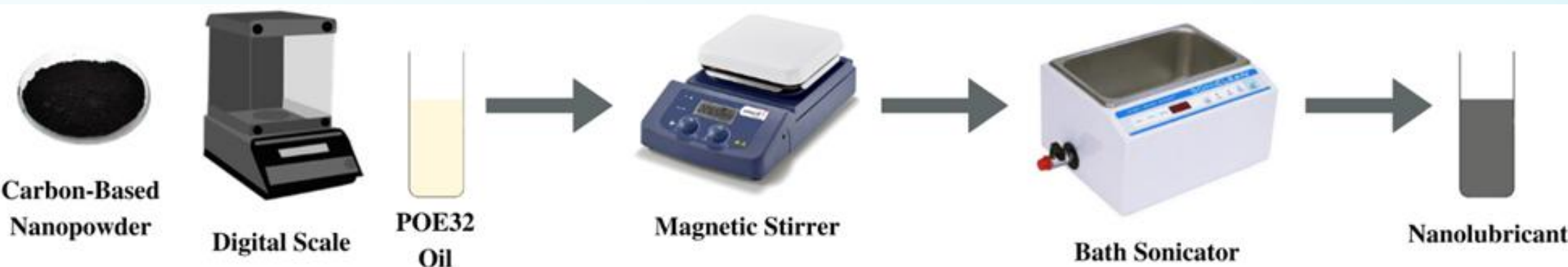
Introduction

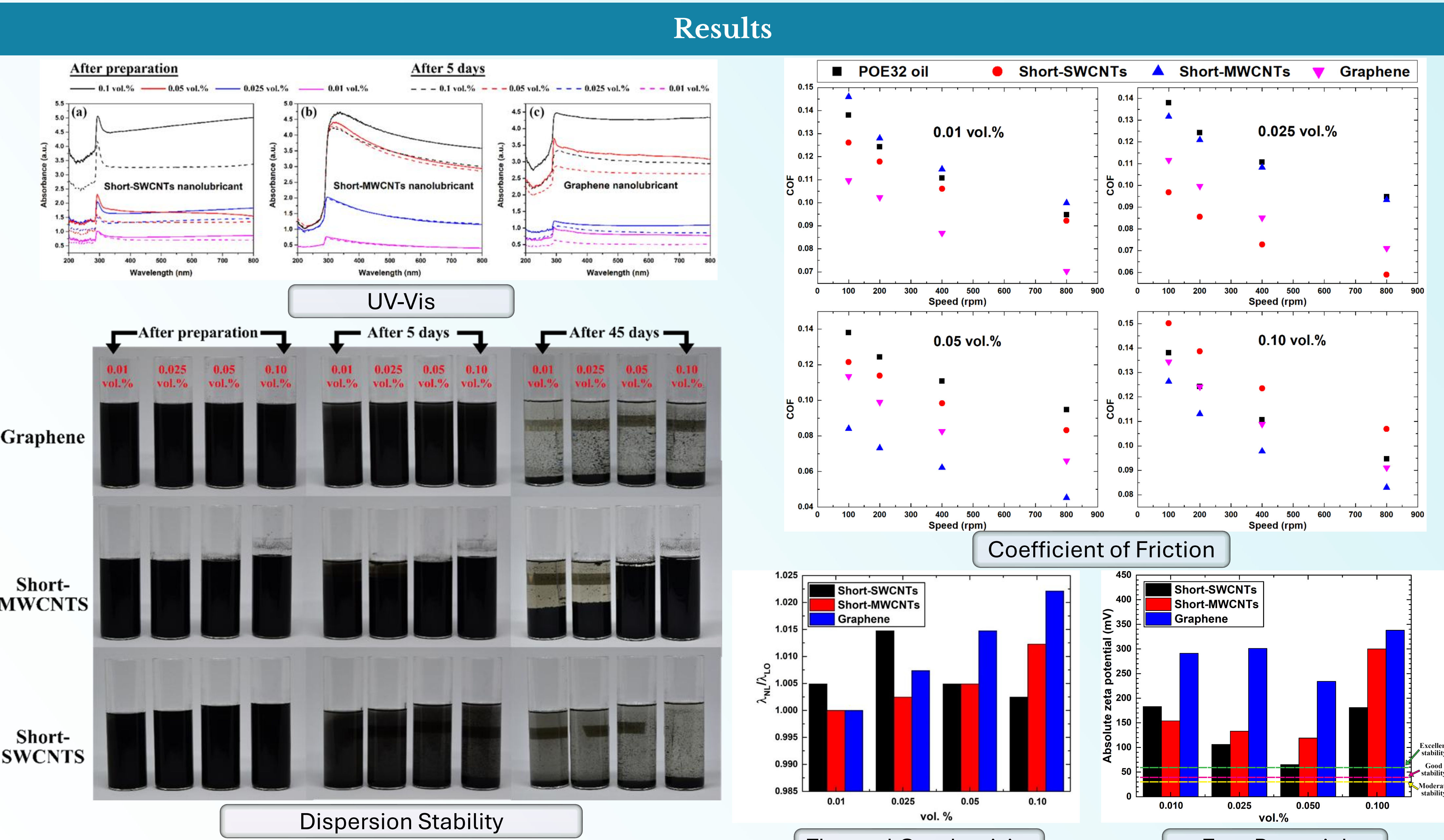
The indoor environment significantly impacts human comfort, with HVAC systems essential for maintaining optimal temperatures. In hot climates like Kuwait, AC systems consume up to 70% of electricity during peak times [1, 2]. Enhancing AC efficiency is vital, and improving compressor lubricant properties through carbon-based nanomaterials



Methodology

Category	Details
Materials and Consumables	Nanomaterials: Short multi-walled carbon nanotubes (short-MWCNTs), short single-walled carbon nanotubes (short-SWCNTs), graphene (GN) Lubricant Oil: POE32 (synthetic refrigeration oil)
Powder and Basefluid Analysis	Nanomaterial Characterization: field emission scanning electron microscope (FE-SEM) Elemental Analysis: Energy-dispersive X-ray spectroscopy (EDS) , X-Ray Diffraction (XRD) Basefluid Properties: Density , Specific heat capacity, Thermal conductivity, Dynamic viscosity Tribological Properties: Coefficient of friction (COF)
Nanolubricant Synthesis	Process: Carbon-based materials (short-MWCNTs, short-SWCNTs, GN) dispersed in 100 mL POE32 lubricant oil Volume Concentrations: 0.01, 0.025, 0.050, and 0.10 vol.% Dispersion Steps: 5 min magnetic stirring, 60 min ultrasonication
Nanolubricant Characterization	Nanofluid Properties: Density, Specific heat capacity, Thermal conductivity, and Dynamic viscosity Tribological Properties: Coefficient of friction (COF) Dispersion Stability: Image capturing method, Ultraviolet–visible (UV-Vis) spectroscopy, Zeta potential analysis





Conclusions

Since compressors are critical components of AC systems, improving their efficiency is essential to reducing energy use. Lubricants play a key role in enhancing compressor performance by reducing wear. In this study, nano-lubricants have been explored as a means to improve the performance of AC compressors. Key findings include:

- Density:** The addition of nanomaterials had minimal impact on the density of the POE32 oil.
- Specific Heat Capacity:** There was a decrease in specific heat capacity with increasing nanomaterial concentration.
- Thermal Conductivity:** At low concentrations (0.01 vol.%), thermal conductivity showed minimal improvement, except for short-SWCNTs.
- Dynamic Viscosity:** Short-MWCNTs at 0.05 vol.% increased viscosity by 15.31%, while other nano-lubricants reduced viscosity by up to 96%, indicating a negligible effect on AC compressor efficiency
- Coefficient of Friction (COF):** The optimum COF was achieved at 0.025 vol.% for short-SWCNTs, 0.05 vol.% for short-MWCNTs, and 0.01 vol.% for GN, with short-SWCNTs showing the best results while maintaining high thermal conductivity.
- Physical Stability:** All nano-lubricants exhibited good stability for up to 5 days, after which stability decreased.

Acknowledgements

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[2] N. A. Fereidani, E. Rodrigues, A. R. Gaspar, A review of the energy implications of passive building design and active measures under climate change in the middle east, Journal of Cleaner Production 305 (2021) 127152.