A Comprehensive Review on Graphene Oxide Nanofluids for Enhanced Heat Transfer Performance in Automotive Radiator Systems

[1]Zahid Anwar, [2]Amit Kumar Asthana
[1]Research Scholar, Department of Mechanical Engineering, Truba Institute of Engineering & Information Technology Bhopal (M.P.) India
[2]Assistant Professor, Department of Mechanical Engineering, Truba Institute of Engineering & Information Technology Bhopal (M.P.) India
zahid.krazy4u@gmail.com, asthana603@gmail.com

* Corresponding Author: Zahid Anwar

Abstract:

In the current era, thermal management is one of the primary requirements for the modern automotive and industrial systems because of the increasing density of engine power and design space constraints. The conventional heat transfer fluids-water and ethylene glycol-are deficient in thermal conductivity and offer little operating temperature range, on top of having some corrosion-related problems, all of which adversely affect the performance of the radiator. Nanofluids are now considered a potential class of fluids in order to overcome these shortcoming effects by enhancing the thermophysical properties of the base fluid by introducing nanoparticles into the fluids. Among the various nanoparticle materials, graphene oxide (GO) is considered particularly interesting owing to its superior thermal conductivity, high surface area, chemical stability, and good dispersibility in polar base fluids. The thrust of this article is to critically evaluate the subject of graphene oxide nanofluids placed within the context of automotive radiator thermal management and in respect to recent investigations. The review provides an overview of adoptive coolants, issues related to production methods of GO nanofluids, retention and sedimentation challenges, and engineering aspects such as the enhancement of the thermal conductivity and kinetic dynamism viscosity. Enhancement mechanisms in heat transfer-inspected via Brownian motion, micro-convection, and fluid flow-are discussed. Furthermore, it looks at how the performance of the radiator can be influenced through various aspects, including nanoparticle concentration, base fluid composition (such as ethylene glycol-water mixtures), temperature, and flow conditions. Areas around critical heat transfer mechanisms; like long-term stability, pumping power penalties, and lack of standards for experiments, need much further investigation. The paper concludes by providing evidence that the optimal use and handling of GO nanofluids could easily enhance the radiator operational paradigm, reduce the coolant temperature, and promote the overall thermal conditions required for the climate, and they are perfect representatives of future cooling systems.

Keywords: *Graphene oxide nanofluids, Automotive radiator, Heat transfer enhancement, Ethylene glycol–water mixture, Thermal conductivity, Nanofluid stability, Thermal management*

I. INTRODUCTION

In present-day automotive systems, efficient thermal management is required for significant reasons. The performance improvement in engine technology, the increase of power density, and the stringent emission regulations are the overlying reasons for this requirement. Automotive radiators ensure that the engine is not subject to overheating, which could prove damaging if left unattended. It dissipates the heat generated during the combustion and mechanical processes to maintaining the temperature within the required parameters. The cooling works mainly on the thermophysical properties of the coolant, which regulate heat absorption, transfer, and ultimately heat dissipation. Furthermore, the application of conventional heat transfer fluids such as water and ethylene glycol or their mixtures is very extensive because they are within reach and possess an efficient heat capacity. Beyond the heat capacity, inadequately low thermal conductivities of most standard lubricants limit the heat transfer rate at the radiator system [1].

To counteract limitations with traditional coolants, nanofluids have come in handy as upstream thermal-heavy applications. Nanofluids bear improved thermal conductivity, convective heat transfer coefficient, and overall improved thermal performance as comparably to conventional heat exchanges with coolants. More importantly, when considering widely available nanoparticles, use of graphene oxide is quite popular because it comes with an exclusive 2D setup, supporting large surface area, high thermal conductivity, and strong chemical stability. Graphene oxide is high in dispersion in polar base fluids such as water and water-ethanol while sharing oxygen-functionalized groups; this is because it finds its place as an excellent dispersion within the coolant, thereby enhancing the coolant stability and increasing the accuracy of distribution. Figure 1 represents Scheme showing factors influencing heat exchanger performance [2]

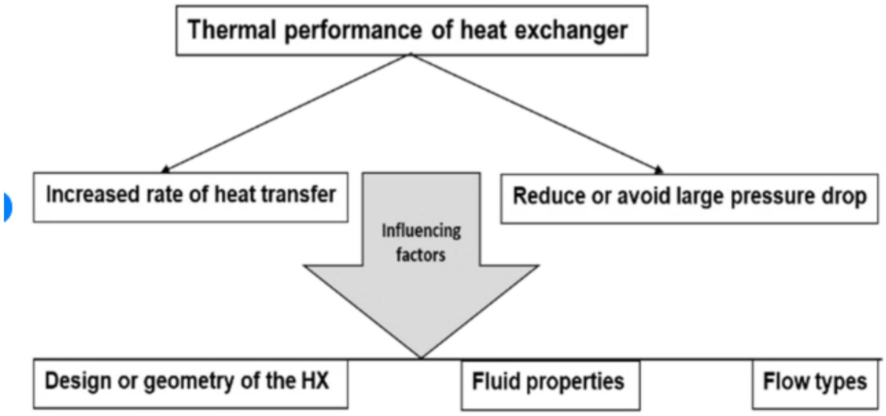


FIGURE 1: SCHEME SHOWING FACTORS INFLUENCING HEAT EXCHANGER PERFORMANCE.

Some recent studies have shown that the addition of graphene oxide nanoparticles, even in very dilute proportions, results in a significant enhancement in condenser exchanger thermal operation owing to different heat transfer augmentation mechanisms such as Brownian motion, micro-counterflow in nano convection, interface heat transfer, and base fluid thermal networks. But, the increase in viscosity, increased pressure loss, increase in pumping power requirement, stability problems, etc. hinder more real-life applications in automotive condenser heat exchangers [3].

Even though a detailed comparative review of like studies, the majority of experimental and numerical studies were conducted on metallic and metal oxide nanoparticles with only a few explanatory and surveying reviews thus extended to graphene oxide nanofluids, specifically for automotive-motor radiator applications. The review is proposed to an inventory of the preparation methods, stability characteristics, thermophysical properties, mechanisms of heat transfer, and the performance of the radiator using graphene oxide nanofluids. Through discussion of the latest trends, challenges, and gaps, one is hopeful that the article helps to draw the line on the potential of graphene oxide nanofluids as coolants in future generations for high-performance automotive thermal management systems [4].

II. EVOLUTION OF NANOFLUIDS IN THERMAL MANAGEMENT

Increased demands for heat dissipation have led to the development of finer high-performance thermal systems typically occurring in the automotive, electronic, and industrial sectors, for which fleet of modern advanced heat-transfer fluids are adequately required. Traditional products used as coolants, such as pure water, ethylene glycol, or their mixture, were used in most applications, thanks to their availability and reasonable heat capacities. However, due to their low thermal conductivity giving but a limited heat transfer rate, these solutions did not energetically satisfy dense, high heat flux thermal systems. These limitations of conventional working fluids inspired the prospects of some new coolant-enhancing ideas, whilst buying neither the initial operational system designs nor their major modifications [5].

The idea of nanofluids came about in the middle of the 1990s as a possible means of enhancing heat transfer mechanisms by dispersing solid nanoparticles measuring less than 100 nm in diameter in conventional base fluids. Early research was particularly centered on metal nanoparticles. The most notable of these are copper and aluminum which have much higher innate thermal conductivities. However, although substantial thermal improvements were noted, the attractiveness of using these nanoparticles in real applications was spoiled by problems with agglomeration and oxidation, huge costs, and metal corrosion [6]. Therein begin the metal oxide nanoparticles, such as Al_2O_3, CuO, TiO_2, and ZnO, in ascending order of thermal stability thus reduced cost and tendency toward the enhanced presence of corrosion for long-term thermal applications. The development of the field of nanotechnologies has made the carbon-based nanomaterials a potential and most preferred choice of nanoparticles for the purposes of developing specific nano-fluids [7].

At very low concentrations, these materials show extra thermal conductivity, and therefore, a significant influence on this property through the addition of carbon-containing nanomaterials. Among these, GO displays particular interest due to its hydrophilic nature and, of course, stability concerning the dispersion in water-based and ethylene glycol-based fluids. Meanwhile, strong interfacial interactions can be developed between GO sheets and the base fluid due to the presence of oxygen-containing functional groups, making the heat conduction and convective heat transfer improved [8].

In present times, with the growing research on nanofluids, from simply enhancing thermal conductivity to optimizing enhancements, focusing on that balance among heat transfer enhancement, viscosity control, stability, and parameters affecting pumping, belongs to a whole new game. This tendency signals a broader capacity of nanofluids, specifically graphene oxide nanofluids, to serve as advanced working fluids in the thermal Management of the Next-Gen systems which may include automobile radiators and cooling for electrical vehicles [9]. Figure 2: evolution of nanofluids in thermal management.

FIGURE 2: EVOLUTION OF NANOFLUIDS IN THERMAL MANAGEMENT

III. GRAPHENE OXIDE: STRUCTURE, PROPERTIES, AND ADVANTAGES

Graphene oxide (GO) is a two-dimensional carbon-based nanomaterial derived from graphene through the oxidation of graphite. Structurally, graphene oxide consists of a single or few layers of carbon atoms arranged in a hexagonal lattice, similar to pristine graphene, but decorated with various oxygen-containing functional groups such as hydroxyl, epoxy, carbonyl, and carboxyl groups. These functional groups are distributed across the basal plane and edges of the graphene sheets, resulting in a mixed sp^2–sp^3 hybridized structure. The presence of these oxygen functionalities increases the interlayer spacing and introduces structural defects, which significantly influence the physicochemical behavior of graphene oxide [10].

From a property standpoint, graphene oxide exhibits several characteristics that make it attractive for thermal management applications. Although its intrinsic thermal conductivity is lower than that of pristine graphene due to structural defects, graphene oxide still demonstrates superior thermal conductivity compared to conventional nanoparticles when well-dispersed in base fluids [11]. The large specific surface area of GO enhances interfacial heat transfer between the nanoparticle and the surrounding fluid, facilitating efficient energy transport. Additionally, graphene oxide shows excellent mechanical strength, flexibility, and chemical stability, enabling it to withstand harsh thermal and chemical environments typically encountered in automotive cooling systems [12].

Table 1: Advantages of Graphene Oxide Nanofluids in Automotive Radiator Systems [13]

Advantage	Description	Impact on Radiator Performance
Hydrophilic nature	Presence of oxygen-containing functional groups (hydroxyl, epoxy, carboxyl) enhances affinity with polar base fluids	Ensures uniform dispersion in water and ethylene glycol–water mixtures
Improved dispersion stability	Strong interfacial interaction between GO sheets and base fluid reduces particle agglomeration	Maintains consistent thermophysical properties over long operating periods
Reduced need for surfactants	Natural surface functionalization of GO eliminates or minimizes surfactant usage	Prevents degradation of thermal conductivity and viscosity
High aspect ratio	Two-dimensional sheet-like morphology provides large contact area with base fluid	Enhances interfacial heat transfer efficiency
Formation of thermal networks	GO sheets form interconnected conductive pathways within the fluid	Significantly improves effective thermal conductivity at low concentrations
Low nanoparticle concentration requirement	Effective heat transfer enhancement achieved at small volume fractions	Minimizes viscosity increase and pumping power penalties

Superior thermal properties	High thermal conductivity compared to metal and metal oxide nanoparticles	Increases heat transfer coefficient of radiator systems
Mechanical and chemical stability	Strong carbon framework and functional groups withstand thermal and chemical stresses	Ensures durability and reliability in automotive cooling environments
Advantage over metal/metal oxide nanoparticles	Lower corrosion risk, better stability, and higher efficiency	Suitable for long-term, high-performance radiator applications

The present day automotive and industrial systems perform at increased power density and compactness and thus there has been intense requirement for efficient thermal management solutions. Traditional coolants, including water and ethylene glycol, ensure limited thermal conductivity despite being used in highest numbers. As a result, they are ineffective when high heat flux requirements have to be fulfilled. The cooler's performance and hydraulic limitation under high loading situations were observed by developing and experimenting on known heat transfer fluids on automotive radiators. The performance limitations have encouraged researchers to explore the nanofluid as an advanced heat transfer medium. The introduction of a fluid, i.e., nanofluid, which may be defined as a nanoparticle–suspended base fluid, in a variety of heat transfer systems, has a profound improvement in their thermal and hydraulic behavior. Previous experimental results of convection-enhancing-enhanced heat transfer rates in metal and metal oxide nanofluids in vehicle radiators where significant heat transfer enhancement was observed; however, agglomeration behavior and the issue of pressure loss were observed simultaneously [1]. Even some of these findings led to the probable used of ethylene glycol-based nanofluids in the cooling operation of an engine, which would be under a different set of operating conditions [7]. Nevertheless, the limitation due to increased viscosity remained; notably, at increasing loading of nanofluids, viscosity increases much more rapidly. In the recent past, eminent researchers have focused on graphene oxide-based nanofluids for their pronounced thermophysical properties and dispersion stability. Comparison of experimental evidence indicates that use of Grandio nanofluids can cause a synergistic increase in heat transfer enhancement in an advanced heat transfer configuration, outperforming conventional metal oxide nanofluids at low particle loadings [10]. Moreover, the studies on pool boiling and forced convective heat transfer convincingly testify to the beneficial enhancement of heat transfer under steady flow conditions with time [14,15]. Stability and thermophysical properties of graphene oxide nanofluids are very much observed. A little comparative study suggested the presence of hydrophilic functional groups on the graphene oxide surface, which promoted the dispersion in polar base fluids, thus preventing sedimentation and agglomeration without the need for excess surfactants [18,20]. Nano-fluid studies using surfactant-free functionalized graphene oxide have also shown their potential in improving thermal conduction with viscosity control for field applications [21]. Similarly, thermal stability tests under flow conditions also accord with the stability to see the commercial application of graphene oxide for a long term life [22]. Graphene oxide nanofluids beyond car radiators were tested in many other thermal systems such as microchannel heat sinks, solar thermal collectors, and spacecraft cooling loops, all of which appeared to show enhanced heat dissipation in microchannel systems due to improved nanoparticle–fluid interactions and micro-convection effects [23]. Graphene oxide nanofluids showed high solar absorption efficiencies and improved energy conversion in solar thermal and photothermal applications [16]. These findings have further strengthened the versatility of these nanofluids in thermal management. Despite their advantages, graphene oxide nanofluids are not completely free from challenges. In particular, the increase in viscosity and thus pump power requirements become critical, mostly at high nanoparticle concentrations [24]. In brief, the environmental, economic, and safety issues related to large-scale production and disposal of graphene-based nanomaterials have been reported as barriers to widespread commercialization [25]. In aqueous graphene oxide suspension reviews, the necessity for common preparation protocols and efficient arrangements for dependable long-term operations was highlighted as the gap. Recent reviews suggest that the necessity of minimizing the overall system costs (nanofluid cost and energy loss) due to inefficiency in systems is the main challenge in widespread commercial development of nanofluid application in industrial or automotive systems. The two-dimensional nanomaterial enhanced nanofluids give a ray of hope to the researchers and the fields providing nanofluid in an appropriate thermal short term trade-off between the hydraulic performances of the system and sustainability . Overall, literature portrays GO nanofluids as highly promising in terms of heat transfer enhancement for automotive cooling systems, provided that some impediments, e.g., stability, high viscosity, and environmental concerns, are up to the mark.

Table 2: Summary of Literature on Nanofluids and Graphene Oxide for Thermal Applications

Ref. No.	Technique Used	Key Contribution	Limitations
[1]	Experimental radiator testing	Demonstrated enhanced thermal and hydraulic performance of metal oxide nanofluids in passenger-car radiators	Increased pressure drop and stability concerns
[2]	Review and analytical study	Comprehensive assessment of mono and hybrid nanofluids in heat pipes	Limited experimental validation
[3]	Experimental performance evaluation	Compared water and commercial coolant mixtures in automotive-scale heat exchangers	No nanoparticle enhancement considered

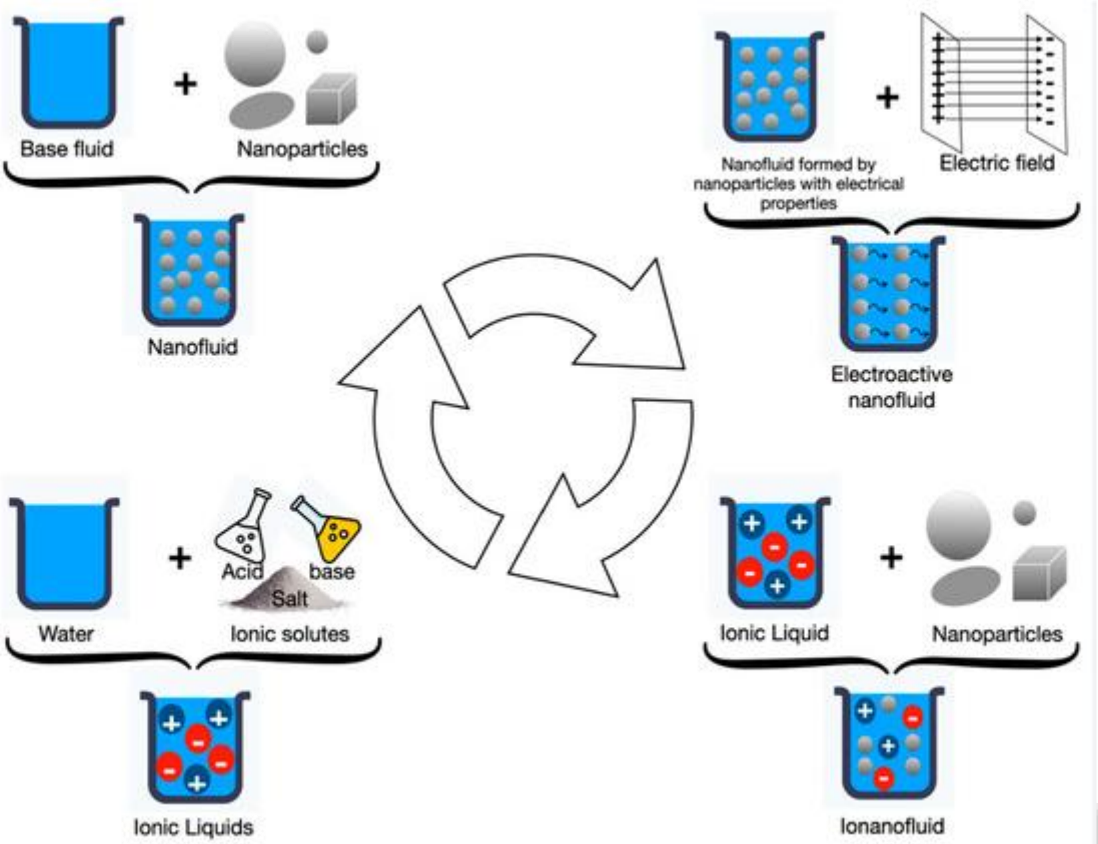
[4]	Experimental and correlation development	Showed synergistic heat transfer enhancement using GO and Al_2O_3 nanofluids	Complexity in preparation and higher viscosity
[5]	Experimental synthesis and testing	Evaluated heat transfer improvement using iron oxide nanofluids	Agglomeration at higher concentrations
[6]	Design and performance review	Highlighted advancements in microchannel heat exchangers using nanofluids	Manufacturing complexity and cost
[7]	Experimental engine cooling analysis	Improved engine cooling capacity using EG-based nanofluids	Increased pumping power requirement
[8]	Review study	Summarized evolution and future directions of nanofluids in automotive applications	Lack of long-term performance data
[9]	Experimental and numerical analysis	Enhanced thermal performance in microchannel heat sinks using nanofluids	Fouling and clogging risks
[10]	Experimental material characterization	Studied solvent and reduction effects on GO performance	Application limited to energy storage
[11]	Experimental material development	Demonstrated anticorrosion benefits of GO-based nanocomposites	Not directly focused on heat transfer
[12]	Experimental material optimization	Improved stability of doped GO materials	Thermal application not explored
[13]	One-step synthesis technique	Enhanced electrochemical performance of graphene-based composites	Limited relevance to fluid thermal systems
[14]	Pool boiling experiments	Compared boiling heat transfer of graphene-based nanofluids	Stability under prolonged boiling conditions
[15]	Experimental stability analysis	Verified long-term thermal stability of GO nanofluids under flow	High-cost experimental setup
[16]	Experimental photothermal study	Demonstrated superior solar absorption of GO nanofluids	Limited automotive relevance
[17]	Experimental thermophysical analysis	Compared surfactant-free and functionalized GO nanofluids	Viscosity increase at higher loadings
[18]	Experimental thermophysical analysis	Validated enhanced thermal conductivity of GO nanofluids	Same limitations as Ref. [17]
[19]	Experimental thermophysical evaluation	Showed synergistic effects of hybrid graphene–oil nanofluids	High viscosity and pumping losses
[20]	Review overview	Summarized aqueous GO suspensions for thermal heating systems	Lack of system-level experimental data

IV. BASE FLUIDS FOR GRAPHENE OXIDE NANOFLUIDS

Base fluid selection plays a significant role in determining the thermophysical properties, stability, and applicability of graphene oxide nanofluids. Base fluid impacts certain properties, with respect to thermal conductivity, viscosity, corrosion behavior, and the temperature operating range. Based on many considerations, water and ethylene glycol–water mixtures are widely used in commercial applications where their compatibility, availability, and stability with graphene oxide nanoparticles had been assessed suitable for the solar- or battery-controlled cooling system (car radiator) [14].

Water-Based Fluids :- Graphene oxide nanofluids exhibit remarkable properties concerning heat absorption and thermal conductance as a result of water's high specific heat. The hydrophilicity of graphene oxide ensures the stability of dispersion. Nevertheless, the direct application of the dispersion falls short, due mainly to the freezing nature, corrosion tendencies, and limited possibilities in the temperature-operating window which make the indirect use of nanofluids in automobile radiators the only option [15].

Ethylene Glycol–Water Mixtures: - Ethylene glycol–water combination has largely been used as a base solution for preparing automotive radiators with graphene oxide nanofluids, as the system presents up to the 100° C range of operation. Antifreeze protection, enhanced corrosion resistance, and stable dispersion of graphene oxide are the main features of the mixtures; however, higher pumping power requirements may arise as the viscosity is increased [16]. figure 3: fluids for graphene oxide nanofluids.



FIUGRE 3: FLUIDS FOR GRAPHENE OXIDE NANOFLUIDS

Table 3: Selection Criteria for Automotive Radiator Applications [17]

Selection Parameter	Water-Based Fluids	Ethylene Glycol–Water Mixtures
Thermal conductivity	High	Moderate
Specific heat capacity	Very high	Lower than water
Operating temperature range	Limited	Wide
Freezing protection	Poor	Excellent
Boiling point	Lower	Higher
Corrosion resistance	Moderate	High
Viscosity	Low	Higher
Nanofluid stability with GO	Good	Very good
Pumping power requirement	Low	Moderate to high
Suitability for automotive radiators	Limited	Highly suitable

V. THERMOPHYSICAL PROPERTIES OF GRAPHENE OXIDE NANOFLUIDS

The thermophysical properties of nanofluids based on graphene oxide are likely to significantly affect their heat transfer performance in automobile radiators. Key properties, including thermal conductivity, viscosity, and density, are directly proportional to the concentration of graphene oxide, sterically controlled by all the types of particles. The dispersion quality of these particles then becomes of great concern in the thermal conductivity and hence the overall efficiency and hydraulic behavior of the system[18] .

Thermal Conductivity Enhancement: - Graphene oxide nanofluids are noted for their increased thermal conductivity primarily attributed to the Brownian motion, interfacial heat transfer, and the formation of conductive networks, all permitted due to the high aspect ratio and large surface area of the GO nanosheets [19].
Viscosity and Density Variations: - As the nanoparticle concentration increases, the introduction of graphene oxide enhances the viscosity and density of nanofluids. Increased viscosity may lead to flow resistance and pumping power requirements, necessitating optimum operations for the radiator to function efficiently.
Effect of Temperature and Nanoparticle Concentration: - Higher temperatures normally reduce viscosity and enhance conductivity, while larger amounts of nanoparticles enhance heat transfer but also impose the risk of agglomeration, instability, and excessive pressure drops [20].

VI. APPLICATION OF GRAPHENE OXIDE NANOFLUIDS IN AUTOMOTIVE RADIATORS

Table 4: Application of Graphene Oxide Nanofluids in Automotive Radiators [21]-[22]

Aspect	Graphene Oxide Nanofluids	Impact on Radiator Performance
Heat transfer performance	Significant enhancement in heat transfer coefficient and Nusselt number at low GO concentrations	Improves radiator effectiveness and reduces coolant outlet temperature
Thermal conductivity improvement	Formation of conductive networks due to sheet-like GO structure	Accelerates heat dissipation from radiator tubes
Temperature uniformity	Improved heat distribution within radiator core	Reduces thermal hotspots and enhances system reliability
Pressure drop	Moderate increase due to higher viscosity compared to base fluid	Requires optimization to avoid excessive hydraulic losses
Pumping power requirement	Slightly higher than conventional coolants	Acceptable when GO concentration is optimized
Stability under flow conditions	High stability due to hydrophilic nature of GO	Maintains consistent performance during long-term operation
Comparison with metal nanofluids	Lower corrosion risk and better dispersion stability	More suitable for long-term automotive use
Comparison with metal oxide nanofluids	Higher thermal enhancement at lower volume fraction	Reduces viscosity penalty and pumping energy
Comparison with CNT-based nanofluids	Better dispersion and lower agglomeration tendency	Easier preparation and improved reliability
Overall suitability	Highly suitable for advanced radiator applications	Enables compact radiator design and energy-efficient cooling

VII. CHALLENGES AND LIMITATIONS

Although-highly performing, stable, hydraulic, and safe, only a little is known about graphene-based nanofluids.

Stability and Agglomeration Issues: - While solvent-dispersible GO generally means good in terms of dispersibility, it also has a tendency to have little stable moves or some sort of residue due to the effects of van der Waals interactions and particle frictions at higher concentrations. It will probably agglomerate and sediment thereby adversely affecting the thermal conductivity and running characteristics, with particular concern being the chronic thermal cycling and flow conditions in heat exchanger systems [23].
Increased Viscosity and Flow Resistance :- With the incorporation of the virtually incompatible GO nanoparticles, the solution, at least especially at higher concentrations, has led to an increased viscosity for nanofluids, which in turn has caused greater pressure drop and flow resistance across the radiator channels. Such an increase would require even more energy for further pumping that could offset the benefits of heat transfer unless both the nanofluid formulation and its operating conditions are reasonably optimized [24].
Environmental, Economic, and Safety Concerns: - The major issue in large-scale usage of graphene oxide nanofluid is related to the cost of materials, the effect on the environment, and how to deal with them. Like I have just said, health hazards from nanoparticle exposure might arise and make it imperative that comprehensive life-cycle assessment and safety evaluation be placed in position before wide application in the automotive world [25].

VIII. CONCLUSION AND FUTURE WORK

This review critically evaluated the potential of graphene oxide (GO) nanofluids for use as advanced heat transfer fluids in the automotive radiator and thermal management systems. Past development and performance were discussed in relation to the traditional coolants like water and ethylene glycol. The need for alternative solutions arises from the inefficiency of conventional coolants: low specific heat, poor thermal conductivity, high cost, toxicity, and corrosiveness. Nanofluids in general have presented a very promising alternative solution in this regard, while GO has been an avenue where so much promise has been seen among promising nanoparticles for heat transfer. Many reviewed studies offer deep insight into how very minute amounts of graphene oxide in a water-ethylene glycol solvent can improve the thermal conductivity and heat-transfer coefficients involved in heat-flux radiation and engine cooling. Mechanisms of heat flux, including Brownian motion, micro convection, and the formation of conductive paths, increase performance. However, viscosity problems correlate with higher nanoparticle concentrations, providing more flow resistance and apparent pumping power requirements at the same time, soliciting fluid optimization. On the whole, graphene oxide nanofluids display enormous potential for future-generation radiator applications by enhancing heat transfer performance and thermal efficiency. The future head should be on long-term stability assessment, the optimization of nanoparticle volume, standardization of testing procedures, and an exhaustive techno-economic assessment to propel the large-scale industrial and automotive uptake.

REFERENCES

1. Taşkesen, Edip. "Experimental thermal and hydrolic behavior of CuO/water and Cr/water nanofluids in a production passenger-car radiator." *Environmental Progress & Sustainable Energy* (2026): e70296.
2. Syam Sundar, L. "An Enhanced Thermal Resistance of Heat Pipe Working with Mono and Hybrid Nanofluids: A Comprehensive Review." *International Journal of Nanoscience* (2026).
3. Rao, B. Nageswara, and Sanjay Kumar Gupta. "Experimental performance assessment of automotive-scale compact heat exchangers using water and commercial coolant mixtures." *Journal of Thermal Analysis and Calorimetry* (2026): 1-23.
4. Rai, Niranjana, Ramakrishna N. Hegde, and H. M. Murthy. "Experimental comparison and correlation development for synergistic heat transfer enhancement using GO and Al2O3 nanofluids with fin turbulator in coil-in-shell heat exchangers." *Journal of Thermal Analysis and Calorimetry* (2026): 1-28.
5. AMIRI, Mehdi, Rasoul KARIMI, and Iman ABBASPOUR. "Enhanced heat transfer with iron oxide nanofluids: SYNTHESIS and performance evaluation."
6. Kasi, Lakshmanan, et al. "Advancements in microchannel heat exchangers: Design, performance, and applications." *Smart Heat Transfer and Thermal Management*. Woodhead Publishing, 2026. 327-361.
7. Satpute, Jitendra, et al. "Analysis of ethylene glycol (EG) based nanofluid coolant for enhancing cooling capacity of engine." *Discover Applied Sciences* 8.1 (2026): 1.
8. Iqbal, Muhammad Ahmad, and Anum Shafiq. "The Evolution of Nanofluids in Automotive Applications: Current State and Future Directions." *Materials Engineering and Technologies* 2.1 (2026): 1-18.
9. Ayyappan, N., et al. "Nanofluid Dynamics in Microchannel Heat Sinks: Enhancing Thermal Performance for High-Power Density Applications."
10. Udayantha, U. L. I., et al. "Influence of graphene oxide reduction and solvent effect on the performance of graphene oxide based supercapacitor." *Next Materials* 10 (2026): 101388.
11. Khan, Nadia, et al. "Nanocomposite of eugenol/polysiloxane/graphene oxide as an efficient anticorrosion and anti-biofouling additive for marine epoxy coatings." *Materials Advances* 7.1 (2026): 214-227.
12. Deng, Haoyue, et al. "Optimizing doped graphene oxide in Mg-MOF-74 to enhance its stability and CO2 adsorption and separation performance." *Materials Science and Engineering: B* 323 (2026): 118788.
13. Kim, Byeong Guk, et al. "One-Step Core-Shell Structuring of Silicon Graphene Composite Anode Materials by Aqueous Reduced Graphene Oxide: Toward Practical Use of High-Performance Lithium-Ion Battery." *Energy & Environmental Materials* 9.1 (2026): e70086.
14. Singh, Sudhir Kumar, and Deepak Sharma. "Pool boiling experiments in graphene, graphene oxide and reduced graphene oxide nanofluid." *Heat Transfer Engineering* (2025): 1-20.
15. Bai, Mingjie, et al. "Thermal stability of graphene-oxide nanofluids during enhanced convective heat transfer in a spacecraft fluid loop." *Diamond and Related Materials* 154 (2025): 112142.
16. Sattar, Abdul, et al. "Photothermal performance of nanofluids: An experimental study on direct absorption solar energy conversion using graphene oxide and its binary composites for water purification." *Energy Conversion and Management: X* 26 (2025): 100898.
17. Sharma, Gourav, Vikrant Khullar, and Sanjeev Soni. "Thermophysical & photothermal characteristics of surfactant free graphene oxide, functionalized graphene oxide and reduced graphene oxide nanofluids." *Materials Science and Technology* 41.14 (2025): 1032-1044.
18. Sharma, Gourav, Vikrant Khullar, and Sanjeev Soni. "Thermophysical & photothermal characteristics of surfactant free graphene oxide, functionalized graphene oxide and reduced graphene oxide nanofluids." *Materials Science and Technology* 41.14 (2025): 1032-1044.
19. Ilyas, Suhaib Umer, et al. "Thermophysical Profile and Synergistic Effects of Graphene-Thermal Oil Nanofluids with Hybrid Additives of MWCNTs and CNFs." *International Journal of Thermophysics* 46.10 (2025): 150.
20. Canazas Rodriguez, Jose Carlos, Rosendo Diomedes Velez Mamani, and Yuri Lester Silva Vidal. "A Short Overview on Aqueous Graphene Oxide Suspensions for Application in Thermal Heating Systems." *Journal of Engineering Science & Technology Review* 18.4 (2025).
21. Heidarshenas, Behzad, Yanjie Yuan, and A. S. El-Shafay. "Advancements in 2D nanomaterial-enhanced nanofluids: Stability, thermophysical properties, and industrial applications." *Powder Technology* (2025): 120687.

22. Awais, Muhammad, et al. "An exhaustive examination of the thermal and mechanical properties of nanofluids containing graphene oxide nanoparticles through the utilization of artificial neural network." *Neural Computing and Applications* (2025): 1-28.
23. Garg, Ashish, et al. "Emerging perspectives in non-Newtonian fluid dynamics: Research gaps, evolving methods, and conceptual limitations." *Physics of Fluids* 37.7 (2025): 071401.
24. Rabani, Reza, and Kamyar Hosseinian Naeini. "Molten Salt Nanofluids for High-Temperature Thermal Energy Storage: Advances, Mechanisms, and Challenges." *Intelligence* 1.3 (2025): 165-181.
25. Bocanegra, Johan Augusto, Annalisa Marchitto, and Mario Misale. "Nanofluids in solar collectors: a comprehensive review focused on its sedimentation." *Clean Technologies and Environmental Policy* 27.4 (2025): 1753-1784.