Document type
Article

Source type
Journal

ISSN
13858947

DOI
10.1016/j.cej.2021.132321

View more

Chemical Engineering Journal • Volume 429 • 1 February 2022 • Article number 132321

A review of recent advances in green nanofluids and their application in thermal systems

Kumar L.H.[a] , Kazi S.N.[a] , Masjuki H.H.[a, b], Zubir M.N.M.[a]

Save all to author list

[a] Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur, Malaysia

[b] Department of Mechanical Engineering, Faculty of Engineering, International Islamic University Malaysia, Kuala Lumpur, Malaysia

Abstract

Author keywords

SciVal Topics

Funding details

Abstract

An increase in energy demand is leading to the continuous rise in global temperature above pre-industrial levels with the discharges of toxic gases and radiations leading to severe climatical circumstances. Thus, it is mandatory to develop ever-lasting, highly efficient thermal systems to overcome this issue. Scientific works on different nanofluids for enhancing performance in thermal applications have gained attention significantly over the last few years owing to their superior qualities. However, it increases safety and health concerns as they are generally more reactive in solvents. Also, other undesired effects such as corrosion of the equipment, non-biodegradable byproducts occur due to the presence of strong chemicals. Therefore, developing cost-effective, and eco-friendly nanofluids has emerged as an alternate research area that is rapidly growing with a great deal of interest. The current review gives a comprehensive view of the different techniques utilized in the preparation of green nanofluids using several natural extracts. Unique morphology, optical properties, stability, high surface area, less toxicity, and enhanced thermo-physical properties of green nanoparticles makes them a favorable candidate in enhancing the performance of thermal systems. Further, various factors affecting the preparation of green nanofluids are highlighted in addition to the evaluation and enhancement techniques concerning the stability and thermophysical properties. Recent experimental and numerical works on the effect of green nanofluids in thermal systems are critically analyzed and provide an overview from economic and environmental perspectives. The challenges and future developments are highlighted to ensure safer health and environment using nanofluids. © 2021 Elsevier B.V.

Author keywords

Environmental assessment; Green nanofluids; Nanoparticles; Natural extracts; Safety; Thermal systems

SciVal Topics

Funding details

References (157)

View in search results format >

All | Export | Print | E-mail | Save to PDF | Create bibliography

1 Economic, U.N.
(2020)
Social Council, Progress towards the Sustainable Development Goals.

2 (2020)
The Carbon Brief, Analysis: Coronavirus set to cause largest ever annual fall in CO2 emissions, Carbon Br.
https://www.carbonbrief.org/analysis-coronavirus-set-to-cause-largest-ever-annual-fall-in-co2-emissions

3 IPCC Summary for Policymakers - Global warming of 1.5oC, an IPCC special report IPCC Spec. Rep. 2018 32
www.ipcc.ch/publications_and_data/ar4/wg2/en/spm.html

4 Murdock Duncan Gibb Thomas André, H.E.
(2019) *Renewables 2019 Global Status Report*. Cited 440 times.

5 Johnsson, F., Kjärstad, J., Rootzén, J.
The threat to climate change mitigation posed by the abundance of fossil fuels (Open Access)

(2019) *Climate Policy*, 19 (2), pp. 258-274. Cited 79 times.
http://www.tandfonline.com/loi/tcpo20
doi: 10.1080/14693062.2018.1483885

View at Publisher

6 Vinet, L., Zhedanov, A.
A 'missing' family of classical orthogonal polynomials (Open Access)

(2011) *Journal of Physics A: Mathematical and Theoretical*, 44 (8), art. no. 085201. Cited 190 times.
http://iopscience.iop.org/1751-8121/44/8/085201/pdf/1751-8121_44_8_085201.pdf
doi: 10.1088/1751-8113/44/8/085201

View at Publisher

7 Bakthavatchalam, B., Habib, K., Saidur, R., Saha, B.B., Irshad, K.
Comprehensive study on nanofluid and ionanofluid for heat transfer enhancement: A review on current and future perspective

(2020) *Journal of Molecular Liquids*, 305, art. no. 112787. Cited 62 times.
https://www.journals.elsevier.com/journal-of-molecular-liquids
doi: 10.1016/j.molliq.2020.112787

View at Publisher

8 Choi, Stephen U.S.
Enhancing thermal conductivity of fluids with nanoparticles

(1995) *American Society of Mechanical Engineers, Fluids Engineering Division (Publication) FED*, 231, pp. 99-105. Cited 6595 times.

9 Ali, M.K.A., Xianjun, H.
Colloidal stability mechanism of copper nanomaterials modified by ionic liquid dispersed in polyalphaolefin oil as green nanolubricants

(2020) *Journal of Colloid and Interface Science*, 578, pp. 24-36. Cited 7 times.
http://www.elsevier.com/inca/publications/store/6/2/2/8/6/1/index.htt
doi: 10.1016/j.jcis.2020.05.092

View at Publisher

10 Sarsam, W.S., Kazi, S.N., Badarudin, A.

Thermal performance of a flat-plate solar collector using aqueous colloidal dispersions of graphene nanoplatelets with different specific surface areas

(2020) *Applied Thermal Engineering*, 172, art. no. 115142. Cited 12 times.
http://www.journals.elsevier.com/applied-thermal-engineering/
doi: 10.1016/j.applthermaleng.2020.115142

View at Publisher

11 Sadri, R., Hosseini, M., Kazi, S.N., Bagheri, S., Abdelrazek, A.H., Ahmadi, G., Zubir, N., (...), Abidin, N.I.Z.

A facile, bio-based, novel approach for synthesis of covalently functionalized graphene nanoplatelet nano-coolants toward improved thermo-physical and heat transfer properties

(2018) *Journal of Colloid and Interface Science*, 509, pp. 140-152. Cited 46 times.
http://www.elsevier.com/inca/publications/store/6/2/2/8/6/1/index.htt
doi: 10.1016/j.jcis.2017.07.052

View at Publisher

12 Moravej, M., Bozorg, M.V., Guan, Y., Li, L.K.B., Doranehgard, M.H., Hong, K., Xiong, Q.

Enhancing the efficiency of a symmetric flat-plate solar collector via the use of rutile TiO_2-water nanofluids

(2020) *Sustainable Energy Technologies and Assessments*, 40, art. no. 100783. Cited 34 times.
http://www.journals.elsevier.com/sustainable-energy-technologies-and-assessments
doi: 10.1016/j.seta.2020.100783

View at Publisher

13 Kumar, L.H., Kazi, S.N., Masjuki, H.H., Zubir, M.N.M., Jahan, A., Bhinitha, C.

Energy, exergy and economic analysis of liquid flat-plate solar collector using green covalent functionalized graphene nanoplatelets (Open Access)

(2021) *Applied Thermal Engineering*, 192, art. no. 116916. Cited 2 times.
http://www.journals.elsevier.com/applied-thermal-engineering/
doi: 10.1016/j.applthermaleng.2021.116916

View at Publisher

14 Kumar, L.H., Kazi, S.N., Masjuki, H.H., Zubir, M.N.M., Jahan, A., Sean, O.C.

Experimental study on the effect of bio-functionalized graphene nanoplatelets on the thermal performance of liquid flat plate solar collector

(2021) *Journal of Thermal Analysis and Calorimetry*. Cited 3 times.
http://www.springer.com/sgw/cda/frontpage/0,11855,1-40109-70-35752391-0,00.html
doi: 10.1007/s10973-020-10527-y

View at Publisher

15 Mahian, O., Bellos, E., Markides, C.N., Taylor, R.A., Alagumalai, A., Yang, L., Qin, C., (...), Wongwises, S.

Recent advances in using nanofluids in renewable energy systems and the environmental implications of their uptake

(2021) *Nano Energy*, 86, art. no. 106069. Cited 11 times.
http://www.journals.elsevier.com/nano-energy/
doi: 10.1016/j.nanoen.2021.106069

View at Publisher

16 Khanafer, K., Vafai, K.

Analysis of turbulent two-phase flow and heat transfer using nanofluid

(2021) *International Communications in Heat and Mass Transfer*, 124, art. no. 105219. Cited 3 times.
https://www.journals.elsevier.com/international-communications-in-heat-and-mass-transfer
doi: 10.1016/j.icheatmasstransfer.2021.105219

View at Publisher

17 Chen, G., Wang, Y., Zou, Y., Jia, D., Zhou, Y.

A fractal-patterned coating on titanium alloy for stable passive heat dissipation and robust superhydrophobicity

(2019) *Chemical Engineering Journal*, 374, pp. 231-241. Cited 16 times.
www.elsevier.com/inca/publications/store/6/0/1/2/7/3/index.htt
doi: 10.1016/j.cej.2019.05.106

View at Publisher

18 Alizad, K., Vafai, K., Shafahi, M.

Thermal performance and operational attributes of the startup characteristics of flat-shaped heat pipes using nanofluids

(2012) *International Journal of Heat and Mass Transfer*, 55 (1-3), pp. 140-155. Cited 67 times.
doi: 10.1016/j.ijheatmasstransfer.2011.08.050

View at Publisher

19 Shafahi, M., Bianco, V., Vafai, K., Manca, O.

Thermal performance of flat-shaped heat pipes using nanofluids

(2010) *International Journal of Heat and Mass Transfer*, 53 (7-8), pp. 1438-1445. Cited 134 times.
doi: 10.1016/j.ijheatmasstransfer.2009.12.007

View at Publisher

20 Shafahi, M., Bianco, V., Vafai, K., Manca, O.

An investigation of the thermal performance of cylindrical heat pipes using nanofluids

(2010) *International Journal of Heat and Mass Transfer*, 53 (1-3), pp. 376-383. Cited 188 times.
doi: 10.1016/j.ijheatmasstransfer.2009.09.019

View at Publisher

21 Wickramasinghe, K.C., Sasahara, H., Rahim, E.A., Perera, G.I.P.

Green Metalworking Fluids for sustainable machining applications: A review

(2020) *Journal of Cleaner Production*, 257, art. no. 120552. Cited 24 times.
https://www.journals.elsevier.com/journal-of-cleaner-production
doi: 10.1016/j.jclepro.2020.120552

View at Publisher

22 Khalil, M., Jan, B.M., Tong, C.W., Berawi, M.A.

Advanced nanomaterials in oil and gas industry: Design, application and challenges

(2017) *Applied Energy*, 191, pp. 287-310. Cited 104 times.
http://www.elsevier.com/inca/publications/store/4/0/5/8/9/1/index.htt
doi: 10.1016/j.apenergy.2017.01.074

View at Publisher

23 Maria Joseph Raj, N.P., Alluri, N.R., Vivekananthan, V., Chandrasekhar, A., Khandelwal, G., Kim, S.-J.

Sustainable yarn type-piezoelectric energy harvester as an eco-friendly, cost-effective battery-free breath sensor

(2018) *Applied Energy*, 228, pp. 1767-1776. Cited 21 times.
http://www.elsevier.com/inca/publications/store/4/0/5/8/9/1/index.htt
doi: 10.1016/j.apenergy.2018.07.016

View at Publisher

24 He, J., Yang, X., Zhang, G.
A phase change material with enhanced thermal conductivity and secondary heat dissipation capability by introducing a binary thermal conductive skeleton for battery thermal management

(2019) *Applied Thermal Engineering*, 148, pp. 984-991. Cited 64 times.
http://www.journals.elsevier.com/applied-thermal-engineering/
doi: 10.1016/j.applthermaleng.2018.11.100

View at Publisher

25 Yang, X., Yu, I.K.M., Tsang, D.C.W., Budarin, V.L., Clark, J.H., Wu, K.C.-W., Yip, A.C.K., (...), Ok, Y.S.
Ball-milled, solvent-free Sn-functionalisation of wood waste biochar for sugar conversion in food waste valorisation

(2020) *Journal of Cleaner Production*, 268, art. no. 122300. Cited 6 times.
https://www.journals.elsevier.com/journal-of-cleaner-production
doi: 10.1016/j.jclepro.2020.122300

View at Publisher

26 Xian, H.W., Sidik, N.A.C., Najafi, G.
Recent state of nanofluid in automobile cooling systems

(2019) *Journal of Thermal Analysis and Calorimetry*, 135 (2), pp. 981-1008. Cited 36 times.
http://www.springer.com/sgw/cda/frontpage/0,11855,1-40109-70-35752391-0,00.html
doi: 10.1007/s10973-018-7477-3

View at Publisher

27 Bioucas, F.E.B., Vieira, S.I.C., Lourenço, M.J.V., Santos, F.J.V., Nieto de Castro, C.A.
Performance of heat transfer fluids with nanographene in a pilot solar collector

(2018) *Solar Energy*, Part 2 172, pp. 171-176. Cited 14 times.
www.elsevier.com/inca/publications/store/3/2/9/index.htt
doi: 10.1016/j.solener.2018.05.040

View at Publisher

28 Arshad, A., Jabbal, M., Yan, Y., Reay, D.
A review on graphene based nanofluids: Preparation, characterization and applications (Open Access)

(2019) *Journal of Molecular Liquids*, 279, pp. 444-484. Cited 72 times.
doi: 10.1016/j.molliq.2019.01.153

View at Publisher

29 Verma, S.K., Tiwari, A.K., Chauhan, D.S.
Experimental evaluation of flat plate solar collector using nanofluids

(2017) *Energy Conversion and Management*, 134, pp. 103-115. Cited 123 times.
doi: 10.1016/j.enconman.2016.12.037

View at Publisher

30 F. Trotta A. Mele Nanomaterials: Classification and Properties, in 2019 Nanosponges 10.1002/9783527341009.ch1 1 26.

31 Rai, M., Ingle, A.
Role of nanotechnology in agriculture with special reference to management of insect pests

(2012) *Applied Microbiology and Biotechnology*, 94 (2), pp. 287-293. Cited 279 times.
doi: 10.1007/s00253-012-3969-4

View at Publisher

32 Saratale, R.G., Saratale, G.D., Shin, H.S., Jacob, J.M., Pugazhendhi, A., Bhaisare, M., Kumar, G.

New insights on the green synthesis of metallic nanoparticles using plant and waste biomaterials: current knowledge, their agricultural and environmental applications

(2018) *Environmental Science and Pollution Research*, 25 (11), pp. 10164-10183. Cited 99 times.
http://www.springerlink.com/content/0944-1344
doi: 10.1007/s11356-017-9912-6

View at Publisher

33 Kharissova, O.V., Dias, H.V.R., Kharisov, B.I., Pérez, B.O., Pérez, V.M.J.

The greener synthesis of nanoparticles

(2013) *Trends in Biotechnology*, 31 (4), pp. 240-248. Cited 561 times.
doi: 10.1016/j.tibtech.2013.01.003

View at Publisher

34 Debnath, S., Reddy, M.M., Yi, Q.S.

Environmental friendly cutting fluids and cooling techniques in machining: A review

(2014) *Journal of Cleaner Production*, 83, pp. 33-47. Cited 360 times.
doi: 10.1016/j.jclepro.2014.07.071

View at Publisher

35 Ismail, Z.

Green reduction of graphene oxide by plant extracts: A short review

(2019) *Ceramics International*, Part A 45 (18), pp. 23857-23868. Cited 24 times.
https://www.journals.elsevier.com/ceramics-international
doi: 10.1016/j.ceramint.2019.08.114

View at Publisher

36 Saratale, R.G., Karuppusamy, I., Saratale, G.D., Pugazhendhi, A., Kumar, G., Park, Y., Ghodake, G.S., (...), Shin, H.S.

A comprehensive review on green nanomaterials using biological systems: Recent perception and their future applications

(2018) *Colloids and Surfaces B: Biointerfaces*, 170, pp. 20-35. Cited 113 times.
www.elsevier.com/locate/colsurfb
doi: 10.1016/j.colsurfb.2018.05.045

View at Publisher

37 Albojamal, A., Vafai, K.

Analysis of particle deposition of nanofluid flow through porous media

(2020) *International Journal of Heat and Mass Transfer*, 161, art. no. 120227. Cited 11 times.
http://www.journals.elsevier.com/international-journal-of-heat-and-mass-transfer/
doi: 10.1016/j.ijheatmasstransfer.2020.120227

View at Publisher

38 Hatami, M., Kheirkhah, A., Ghanbari-Rad, H., Jing, D.

Numerical heat transfer enhancement using different nanofluids flow through venturi and wavy tubes (Open Access)

(2019) *Case Studies in Thermal Engineering*, 13, art. no. 100368. Cited 16 times.
http://www.journals.elsevier.com/case-studies-in-thermal-engineering/
doi: 10.1016/j.csite.2018.100368

View at Publisher

39 Kole, M., Dey, T.K.

Thermal performance of screen mesh wick heat pipes using water-based copper nanofluids

(2013) *Applied Thermal Engineering*, 50 (1), pp. 763-770. Cited 110 times.
doi: 10.1016/j.applthermaleng.2012.06.049

View at Publisher

40 Sarafraz, M.M., Hormozi, F., Peyghambarzadeh, S.M.
Thermal performance and efficiency of a thermosyphon heat pipe working with a biologically ecofriendly nanofluid

(2014) *International Communications in Heat and Mass Transfer*, 57, pp. 297-303. Cited 71 times.
doi: 10.1016/j.icheatmasstransfer.2014.08.020

View at Publisher

41 John, J., Thomas, L., Kurian, A., George, S.D.
Modulating fluorescence quantum yield of highly concentrated fluorescein using differently shaped green synthesized gold nanoparticles

(2016) *Journal of Luminescence*, 172, pp. 39-46. Cited 13 times.
doi: 10.1016/j.jlumin.2015.11.005

View at Publisher

42 Milanese, M., De Risi, A., Colangelo, G.
Energy simulation of a nanofluid solar cooling system in Italy

(2019) *Proceedings of the Institution of Civil Engineers: Engineering Sustainability*, 172 (1), pp. 32-39. Cited 5 times.
http://www.icevirtuallibrary.com/content/serial/ensu
doi: 10.1680/jensu.16.00027

View at Publisher

43 Karami, M., Akhavan-Bahabadi, M.A., Delfani, S., Raisee, M.
Experimental investigation of CuO nanofluid-based Direct Absorption Solar Collector for residential applications

(2015) *Renewable and Sustainable Energy Reviews*, 52, pp. 793-801. Cited 98 times.
doi: 10.1016/j.rser.2015.07.131

View at Publisher

44 Tong, Y., Chi, X., Kang, W., Cho, H.
Comparative investigation of efficiency sensitivity in a flat plate solar collector according to nanofluids

(2020) *Applied Thermal Engineering*, 174, art. no. 115346. Cited 16 times.
http://www.journals.elsevier.com/applied-thermal-engineering/
doi: 10.1016/j.applthermaleng.2020.115346

View at Publisher

45 Yang, L., Ji, W., Mao, M., Huang, J.-N.
An updated review on the properties, fabrication and application of hybrid-nanofluids along with their environmental effects

(2020) *Journal of Cleaner Production*, 257, art. no. 120408. Cited 67 times.
https://www.journals.elsevier.com/journal-of-cleaner-production
doi: 10.1016/j.jclepro.2020.120408

View at Publisher

46 Alawi, O.A., Sidik, N.A.C., Kazi, S.N., Najafi, G.
Graphene nanoplatelets and few-layer graphene studies in thermo-physical properties and particle characterization

(2019) *Journal of Thermal Analysis and Calorimetry*, 135 (2), pp. 1081-1093. Cited 18 times.
http://www.springer.com/sgw/cda/frontpage/0,11855,1-40109-70-35752391-0,00.html
doi: 10.1007/s10973-018-7585-0

View at Publisher

47 Ahangaran, F., Navarchian, A.H.
Recent advances in chemical surface modification of metal oxide nanoparticles with silane coupling agents: A review

(2020) *Advances in Colloid and Interface Science*, 286, art. no. 102298. Cited 9 times.
https://www.journals.elsevier.com/advances-in-colloid-and-interface-science
doi: 10.1016/j.cis.2020.102298

View at Publisher

48 Hemmat Esfe, M., Bahiraei, M., Mir, A.

Application of conventional and hybrid nanofluids in different machining processes: A critical review

(2020) *Advances in Colloid and Interface Science*, 282, art. no. 102199. Cited 15 times.
https://www.journals.elsevier.com/advances-in-colloid-and-interface-science
doi: 10.1016/j.cis.2020.102199

View at Publisher

49 Qiu, L., Zhu, N., Feng, Y., Michaelides, E.E., Żyła, G., Jing, D., Zhang, X., (...), Mahian, O.

A review of recent advances in thermophysical properties at the nanoscale: From solid state to colloids (Open Access)

(2020) *Physics Reports*, 843, pp. 1-81. Cited 157 times.
http://www.elsevier.com/locate/physrep
doi: 10.1016/j.physrep.2019.12.001

View at Publisher

50 Hatami, M., Zhou, J., Geng, J., Jing, D.

Variable magnetic field (VMF) effect on the heat transfer of a half-annulus cavity filled by Fe_3O_4-water nanofluid under constant heat flux

(2018) *Journal of Magnetism and Magnetic Materials*, 451, pp. 173-182. Cited 28 times.
doi: 10.1016/j.jmmm.2017.10.110

View at Publisher

51 Kong, L., Sun, J., Bao, Y.

Preparation, characterization and tribological mechanism of nanofluids (Open Access)

(2017) *RSC Advances*, 7 (21), pp. 12599-12609. Cited 79 times.
http://pubs.rsc.org/en/journals/journalissues
doi: 10.1039/c6ra28243a

View at Publisher

52 Kachi, W., Al-Shammari, A.M., Zainal, I.G.

Cobalt ferrite nanoparticles: Preparation, characterization and salinized with 3-aminopropyl triethoxysilane (Open Access)

(2019) *Energy Procedia*, 157, pp. 1353-1365. Cited 5 times.
http://www.sciencedirect.com/science/journal/18766102
doi: 10.1016/j.egypro.2018.11.300

View at Publisher

53 Suresh, S., Venkitaraj, K.P., Selvakumar, P., Chandrasekar, M.

Synthesis of Al_2O_3-Cu/water hybrid nanofluids using two step method and its thermo physical properties

(2011) *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 388 (1-3), pp. 41-48. Cited 430 times.
www.elsevier.com/locate/colsurfa
doi: 10.1016/j.colsurfa.2011.08.005

View at Publisher

54 Mohammadpoor, M., Sabbaghi, S., Zerafat, M.M., Manafi, Z.

Investigating heat transfer properties of copper nanofluid in ethylene glycol synthesized through single and two-step routes

(2019) *International Journal of Refrigeration*, 99, pp. 243-250. Cited 18 times.
doi: 10.1016/j.ijrefrig.2019.01.012

View at Publisher

55 Salari, E., Peyghambarzadeh, S.M., Sarafraz, M.M., Hormozi, F., Nikkhah, V.

Thermal behavior of aqueous iron oxide nano-fluid as a coolant on a flat disc heater under the pool boiling condition

(2017) *Heat and Mass Transfer/Waerme- und Stoffuebertragung*, 53 (1), pp. 265-275. Cited 68 times.
http://www.springer.com/sgw/cda/frontpage/0,11855,1-40109-70-1034617-0,00.html
doi: 10.1007/s00231-016-1823-4

View at Publisher

56 Sundar, L.S., Venkata Ramana, E., Graça, M.P.F., Singh, M.K., Sousa, A.C.M.

Nanodiamond-Fe_3O_4 nanofluids: Preparation and measurement of viscosity, electrical and thermal conductivities

(2016) *International Communications in Heat and Mass Transfer*, 73, pp. 62-74. Cited 88 times.
doi: 10.1016/j.icheatmasstransfer.2016.02.013

View at Publisher

57 Hosseini, M., Sadri, R., Kazi, S.N., Bagheri, S., Zubir, N., Bee Teng, C., Zaharinie, T.

Experimental Study on Heat Transfer and Thermo-Physical Properties of Covalently Functionalized Carbon Nanotubes Nanofluids in an Annular Heat Exchanger: A Green and Novel Synthesis

(2017) *Energy and Fuels*, 31 (5), pp. 5635-5644. Cited 20 times.
http://pubs.acs.org/journal/enfuem
doi: 10.1021/acs.energyfuels.6b02928

View at Publisher

58 Vijilvani, C., Bindhu, M.R., Frincy, F.C., AlSalhi, M.S., Sabitha, S., Saravanakumar, K., Devanesan, S., (...), Atif, M.

Antimicrobial and catalytic activities of biosynthesized gold, silver and palladium nanoparticles from Solanum nigurum leaves

(2020) *Journal of Photochemistry and Photobiology B: Biology*, 202, art. no. 111713. Cited 36 times.
www.elsevier.com/locate/jphotobiol
doi: 10.1016/j.jphotobiol.2019.111713

View at Publisher

59 Behravan, M., Hossein Panahi, A., Naghizadeh, A., Ziaee, M., Mahdavi, R., Mirzapour, A.

Facile green synthesis of silver nanoparticles using Berberis vulgaris leaf and root aqueous extract and its antibacterial activity (Open Access)

(2019) *International Journal of Biological Macromolecules*, 124, pp. 148-154. Cited 230 times.
www.elsevier.com/locate/ijbiomac
doi: 10.1016/j.ijbiomac.2018.11.101

View at Publisher

60 Kalpana, V.N., Devi Rajeswari, V.

A Review on Green Synthesis, Biomedical Applications, and Toxicity Studies of ZnO NPs (Open Access)

(2018) *Bioinorganic Chemistry and Applications*, 2018, art. no. 3569758. Cited 77 times.
http://www.hindawi.com/journals/bca/
doi: 10.1155/2018/3569758

View at Publisher

61 Mohanpuria, P., Rana, N.K., Yadav, S.K.

Biosynthesis of nanoparticles: Technological concepts and future applications

(2008) *Journal of Nanoparticle Research*, 10 (3), pp. 507-517. Cited 1149 times.
doi: 10.1007/s11051-007-9275-x

View at Publisher

62 Sarafraz, M.M., Hormozi, F.

Intensification of forced convection heat transfer using biological nanofluid in a double-pipe heat exchanger

(2015) *Experimental Thermal and Fluid Science*, 66, pp. 279-289. Cited 69 times.
doi: 10.1016/j.expthermflusci.2015.03.028

View at Publisher

63 Kumar, R., Sharma, J., Sood, J.

Rayleigh-Bénard cell formation of green synthesized nano-particles of silver and selenium

(2020) *Materials Today: Proceedings*, Part 3 28, pp. 1781-1787. Cited 3 times.
http://www.journals.elsevier.com/materials-today-proceedings/
doi: 10.1016/j.matpr.2020.05.191

View at Publisher

64 Jameel, M.S., Aziz, A.A., Dheyab, M.A.

Comparative analysis of platinum nanoparticles synthesized using sonochemical-assisted and conventional green methods

(2020) *Nano-Structures and Nano-Objects*, 23, art. no. 100484. Cited 15 times.
http://www.journals.elsevier.com/nano-structures-and-nano-objects/
doi: 10.1016/j.nanoso.2020.100484

View at Publisher

65 Rufus, A., Sreeju, N., Vilas, V., Philip, D.

Biosynthesis of hematite (α-Fe_2O_3) nanostructures: Size effects on applications in thermal conductivity, catalysis, and antibacterial activity

(2017) *Journal of Molecular Liquids*, 242, pp. 537-549. Cited 35 times.
doi: 10.1016/j.molliq.2017.07.057

View at Publisher

66 Jegadeesan, G.B., Srimathi, K., Santosh Srinivas, N., Manishkanna, S., Vignesh, D.

Green synthesis of iron oxide nanoparticles using Terminalia bellirica and Moringa oleifera fruit and leaf extracts: Antioxidant, antibacterial and thermoacoustic properties

(2019) *Biocatalysis and Agricultural Biotechnology*, 21, art. no. 101354. Cited 9 times.
http://www.journals.elsevier.com/biocatalysis-and-agricultural-biotechnology/
doi: 10.1016/j.bcab.2019.101354

View at Publisher

67 Ranjbarzadeh, R., Moradikazerouni, A., Bakhtiari, R., Asadi, A., Afrand, M.

An experimental study on stability and thermal conductivity of water/silica nanofluid: Eco-friendly production of nanoparticles
(Open Access)

(2019) *Journal of Cleaner Production*, 206, pp. 1089-1100. Cited 110 times.
https://www.journals.elsevier.com/journal-of-cleaner-production
doi: 10.1016/j.jclepro.2018.09.205

View at Publisher

68 Okonkwo, E.C., Essien, E.A., Akhayere, E., Abid, M., Kavaz, D., Ratlamwala, T.A.H.

Thermal performance analysis of a parabolic trough collector using water-based green-synthesized nanofluids

(2018) *Solar Energy*, 170, pp. 658-670. Cited 42 times.
www.elsevier.com/inca/publications/store/3/2/9/index.htt
doi: 10.1016/j.solener.2018.06.012

View at Publisher

69 Omiddezyani, S., Gharehkhani, S., Yousefi-Asli, V., Khazaee, I., Ashjaee, M., Nayebi, R., Shemirani, F., (...), Houshfar, E.

Experimental investigation on thermo-physical properties and heat transfer characteristics of green synthesized highly stable $CoFe_2O_4$/rGO nanofluid

(2021) *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 610, art. no. 125923. Cited 3 times.
www.elsevier.com/locate/colsurfa
doi: 10.1016/j.colsurfa.2020.125923

View at Publisher

70 Sone, B.T., Diallo, A., Fuku, X.G., Gurib-Fakim, A., Maaza, M.

Biosynthesized CuO nano-platelets: Physical properties & enhanced thermal conductivity nanofluidics (Open Access)

(2020) *Arabian Journal of Chemistry*, 13 (1), pp. 160-170. Cited 40 times.
http://colleges.ksu.edu.sa/Arabic%20Colleges/CollegeOfScience/ChemicalDept/AJC/default.aspx (ScienceDirect http://www.sciencedirect.com/science/journal/18785352)
doi: 10.1016/j.arabjc.2017.03.004

View at Publisher

71 Sharmila, G., Muthukumaran, C., Sangeetha, E., Saraswathi, H., Soundarya, S., Kumar, N.M.

Green fabrication, characterization of Pisonia alba leaf extract derived MgO nanoparticles and its biological applications

(2019) *Nano-Structures and Nano-Objects*, 20, art. no. 100380. Cited 13 times.
http://www.journals.elsevier.com/nano-structures-and-nano-objects/
doi: 10.1016/j.nanoso.2019.100380

View at Publisher

72 Luna-Sánchez, J.L., Jiménez-Pérez, J.L., Carbajal-Valdez, R., Lopez-Gamboa, G., Pérez-González, M., Correa-Pacheco, Z.N.

Green synthesis of silver nanoparticles using Jalapeño Chili extract and thermal lens study of acrylic resin nanocomposites

(2019) *Thermochimica Acta*, 678, art. no. 178314. Cited 9 times.
https://www.journals.elsevier.com/thermochimica-acta
doi: 10.1016/j.tca.2019.178314

View at Publisher

73 Sadri, R., Hosseini, M., Kazi, S.N., Bagheri, S., Ahmed, S.M., Ahmadi, G., Zubir, N., (...), Dahari, M.

Study of environmentally friendly and facile functionalization of graphene nanoplatelet and its application in convective heat transfer

(2017) *Energy Conversion and Management*, 150, pp. 26-36. Cited 31 times.
doi: 10.1016/j.enconman.2017.07.036

View at Publisher

74 Sadri, R., Hosseini, M., Kazi, S.N., Bagheri, S., Zubir, N., Ahmadi, G., Dahari, M., (...), Zaharinie, T.

A novel, eco-friendly technique for covalent functionalization of graphene nanoplatelets and the potential of their nanofluids for heat transfer applications

(2017) *Chemical Physics Letters*, 675, pp. 92-97. Cited 46 times.
http://www.elsevier.com/locate/cplonline
doi: 10.1016/j.cplett.2017.02.077

View at Publisher

75 Sadri, R., Hosseini, M., Kazi, S.N., Bagheri, S., Zubir, N., Solangi, K.H., Zaharinie, T., (...), Badarudin, A.

A bio-based, facile approach for the preparation of covalently functionalized carbon nanotubes aqueous suspensions and their potential as heat transfer fluids

(2017) *Journal of Colloid and Interface Science*, 504, pp. 115-123. Cited 60 times.
http://www.elsevier.com/inca/publications/store/6/2/2/8/6/1/index.htt
doi: 10.1016/j.jcis.2017.03.051

View at Publisher

76 Wang, F., Jyothirmayee Aravind, S.S., Wu, H., Forys, J., Venkataraman, V., Ramanujachary, K., Hu, X.

Tunable green graphene-silk biomaterials: Mechanism of protein-based nanocomposites

(2017) *Materials Science and Engineering C*, 79, pp. 728-739. Cited 28 times.
doi: 10.1016/j.msec.2017.05.120

View at Publisher

77 Khdher, A.M., Sidik, N.A.C., Hamzah, W.A.W., Mamat, R.

An experimental determination of thermal conductivity and electrical conductivity of bio glycol based Al_2O_3 nanofluids and development of new correlation

(2016) *International Communications in Heat and Mass Transfer*, 73, pp. 75-83. Cited 48 times.
doi: 10.1016/j.icheatmasstransfer.2016.02.006

View at Publisher

78 Vidhu, V.K., Philip, D.

Phytosynthesis and applications of bioactive SnO_2 nanoparticles

(2015) *Materials Characterization*, 101, pp. 97-105. Cited 24 times.
doi: 10.1016/j.matchar.2014.12.027

View at Publisher

79 Seyed Shirazi, S.F., Gharehkhani, S., Yarmand, H., Badarudin, A., Cornelis Metselaar, H.S., Kazi, S.N.

Nitrogen doped activated carbon/graphene with high nitrogen level: Green synthesis and thermo-electrical properties of its nanofluid

(2015) *Materials Letters*, 152, pp. 192-195. Cited 39 times.
http://www.journals.elsevier.com/materials-letters/
doi: 10.1016/j.matlet.2015.03.110

View at Publisher

80 Meena Kumari, M., Jacob, J., Philip, D.

Green synthesis and applications of Au-Ag bimetallic nanoparticles

(2015) *Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy*, 137, pp. 185-192. Cited 162 times.
https://www.journals.elsevier.com/spectrochimica-acta-part-a-molecular-and-biomolecular-spectroscopy
doi: 10.1016/j.saa.2014.08.079

View at Publisher

Kumar, L.H.; Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur, Malaysia; email:harishsanjeetha@gmail.com