# Document details

‹ Back to results | ‹ Previous 2 of 2

CSV export Download Print E-mail Save to PDF Save to list More... ›

Alexandria Engineering Journal Open Access
Volume 60, Issue 5, October 2021, Pages 4537-4546

## Effect of palm-sesame biodiesel fuels with alcoholic and nanoparticle additives on tribological characteristics of lubricating oil by four ball tribo-tester (Article) (Open Access)

Mujtaba, M.A.[a,b], Kalam, M.A.[a], Masjuki, H.H.[a,c], Soudagar, M.E.M.[d], Khan, H.M.[e], Fayaz, H.[f], Farooq, M.[b], Gul, M.[a,g], Ahmed, W.[h], Ahmad, M.[i], Munir, M.[i], Yaqoob, H.[j], Samuel, O.D.[k], Razzaq, L.[b]

Save all to author list

[a]Center for Energy Science, Department of Mechanical Engineering, University of Malaya, Kuala Lumpur, 50603, Malaysia
[b]Department of Mechanical Engineering, University of Engineering and Technology, New Campus, Lahore, Pakistan
[c]Department of Mechanical Engineering, Faculty of Engineering, IIUM, Kuala Lumpur, 50728, Malaysia

View additional affiliations

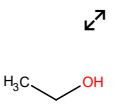
## Abstract

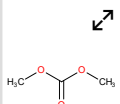
View references (61)

Dilution of engine oil with unburned fuels alters its lubricity and tribological properties. In this research paper, SAE-40 lubricating oil samples were contaminated with known percentages (5%) of fuels (diesel, palm-sesame biodiesel blend (B30), B30 + ethanol, B30 + dimethyl carbonate, B30 + carbon nanotubes and, B30 + titanium oxide). The effect of all these fuels on wear and frictional characteristics of lubricating oil was determined by using a 4-ball tribo tester and wear types on worn surfaces were analyzed by using SEM. Lubricating oil diluted with B10 (commercial diesel) showed highest COF (42.95%) with severe abrasive and adhesive wear than mineral lubricant among other fuels . Lubricating oil diluted with palm-sesame biodiesel (B30 blend) with alcoholic additives showed comparatively less COF, less wear scar diameter and polishing wear due to presence of ester molecules. Lub + B30 + Eth exhibited increment in COF value (35.81%) compared to SAE-40 mineral lubricant. While lubricating oil contaminated with B30 with nanoparticles showed least frictional characteristics with abrasive wear. Lub + B30 + $TiO_2$ showed least increment in COF value (13.78%) among all other contaminated fuels compared to SAE-40 mineral lubricant. It is concluded that nanoparticles in biodiesel blends (B30) helps in reducing degradation of lubricants than alcoholic fuel additives and commercial diesel. © 2021

## Chemistry database information

### Substances




titanium oxide

### Author keywords

Alcoholic additives | Four ball | Lubricant degradation | Nanoparticles | Palm-sesame biodiesel | Tribology

### Indexed keywords

Engineering controlled terms: Adhesives | Degradation | Friction | Minerals | Nanoparticles | Palm oil | Titanium dioxide | Tribology | Wear of materials

Engineering uncontrolled terms: Alcoholic additive | Bio-diesel blends | Bio-diesel fuel | Four-ball | Frictional characteristics | Lubricant degradation | Mineral lubricants | Nanoparticles additives | Palm-sesame biodiesel | Tribological characteristics

Engineering main heading: Biodiesel

## Funding details


| Funding sponsor | Funding number | Acronym |
|---|---|---|
| Higher Education Commission, Pakistan | 5-1/HRD/UESTPI (Batch-VI)/4954/2018/HEC | HEC |
| Universiti Malaya | FP142-2019A | UM |
| Ministry of Higher Education, Malaysia | | MOHE |

Funding text

The authors would like to thank the Faculty of Engineering at the University of Malaya, Malaysia for their support through the research grant no FP142-2019A under the Fundamental Research Grant Scheme (FRGS) from Ministry of Higher Education, Malaysia; and Higher Education Commission, Islamabad, Pakistan for financial support [Grant No. 5-1/HRD/UESTPI (Batch-VI)/4954/2018/HEC].

**ISSN:** 11100168
**Source Type:** Journal
**Original language:** English
**DOI:** 10.1016/j.aej.2021.03.017
**Document Type:** Article
**Publisher:** Elsevier B.V.


## References (61)

View in search results format >

All | CSV export | Print | E-mail | Save to PDF | Create bibliography


1 Gul, M., Zulkifli, N.W.M., Masjuki, H.H., Kalam, M.A., Mujtaba, M.A., Harith, M.H., Syahir, A.Z., (...), Bari Farooq, A.

Effect of TMP-based-cottonseed oil-biolubricant blends on tribological behavior of cylinder liner-piston ring combinations (Open Access)

(2020) *Fuel*, 278, art. no. 118242. Cited 7 times.
http://www.journals.elsevier.com/fuel/
doi: 10.1016/j.fuel.2020.118242

View at Publisher

2 International, B.
(2019)
President Jokowi launches Indonesia's B30 implementation. Bioenergy International, Kammakargatan 22, SE-111 40, Stockholm.

3 Elisha, O., Fauzi, A., Anggraini, E.
Analysis of Production and Consumption of Palm-Oil Based Biofuel using System Dynamics Model: Case of
(2019) *Indonesia.*

4 Mujtaba, M.A., Muk Cho, H., Masjuki, H.H., Kalam, M.A., Ong, H.C., Gul, M., Harith, M.H., (...), Yusoff, M.N.A.M.

Critical review on sesame seed oil and its methyl ester on cold flow and oxidation stability (Open Access)

(2020) *Energy Reports*, 6, pp. 40-54. Cited 19 times.
http://www.journals.elsevier.com/energy-reports/
doi: 10.1016/j.egyr.2019.11.160

View at Publisher

5 Latiff, R.
(2020)
Malaysia to implement B30 biodiesel mandate in transport sector before 2025. In: Sarkar H, editor. Putrajaya, Malaysia,: REUTERS;.

6 Gad, M.S., Jayaraj, S.

A comparative study on the effect of nano-additives on the performance and emissions of a diesel engine run on Jatropha biodiesel

(2020) *Fuel*, 267, art. no. 117168. Cited 33 times.
http://www.journals.elsevier.com/fuel/
doi: 10.1016/j.fuel.2020.117168

View at Publisher

7 Mujtaba, M.A., Kalam, M.A., Masjuki, H.H., Gul, M., Soudagar, M.E.M., Ong, H.C., Ahmed, W., (...), Yusoff, M.

Comparative study of nanoparticles and alcoholic fuel additives-biodiesel-diesel blend for performance and emission improvements

(2020) *Fuel*, 279, art. no. 118434. Cited 20 times.
http://www.journals.elsevier.com/fuel/
doi: 10.1016/j.fuel.2020.118434

View at Publisher

8 Saxena, V., Kumar, N., Saxena, V.K.

Multi-objective optimization of modified nanofluid fuel blends at different $TiO_2$ nanoparticle concentration in diesel engine: Experimental assessment and modeling

(2019) *Applied Energy*, 248, pp. 330-353. Cited 21 times.
https://www.journals.elsevier.com/applied-energy
doi: 10.1016/j.apenergy.2019.04.091

View at Publisher

9 Zhang, Z., Lu, Y., Wang, Y., Yu, X., Smallbone, A., Dong, C., Roskilly, A.P.

Comparative study of using multi-wall carbon nanotube and two different sizes of cerium oxide nanopowders as fuel additives under various diesel engine conditions (Open Access)

(2019) *Fuel*, 256, art. no. 115904. Cited 14 times.
http://www.journals.elsevier.com/fuel/
doi: 10.1016/j.fuel.2019.115904

View at Publisher

10 EL-Seesy, A.I., Hassan, H.

Investigation of the effect of adding graphene oxide, graphene nanoplatelet, and multiwalled carbon nanotube additives with n-butanol-Jatropha methyl ester on a diesel engine performance

(2019) *Renewable Energy*, 132, pp. 558-574. Cited 61 times.
http://www.journals.elsevier.com/renewable-and-sustainable-energy-reviews/
doi: 10.1016/j.renene.2018.08.026

View at Publisher

11 Basha, J.S., Anand, R.
Engineering. The influence of nano additive blended biodiesel fuels on the working characteristics of a diesel engine. Journal of the Brazilian Society of Mechanical Sciences and Engineering. 2013;35(3):257-64.

12 Alias, A., Thegaraju, D., Sharma, K.
, p. 3.
Effect of carbon nanotube dispersions to the palm oil diesel–biodiesel blend properties. Conference Effect of carbon nanotube dispersions to the palm oil diesel–biodiesel blend properties, vol. 1.

13 Balaji, G., Cheralathan, M.
Effect of CNT as additive with biodiesel on the performance and emission characteristics of a DI diesel engine

(2014) *International Journal of ChemTech Research*, 7 (3), pp. 1230-1236. Cited 27 times.
http://sphinxsai.com/2015/ch_vol7_no3_ICONN/12/NS49%20(1230-1236).pdf

14 Khan, H., Soudagar, M.E.M., Kumar, R.H., Safaei, M.R., Farooq, M., Khidmatgar, A.
Effect of Nano-Graphene Oxide and n-Butanol Fuel Additives Blended with Diesel—Nigella sativa Biodiesel Fuel Emulsion on Diesel Engine Characteristics. 2020;12(6):961.

15 Fayaz, H., Mujtaba, M.A., Soudagar, M.E.M., Razzaq, L., Nawaz, S., Nawaz, M.A., Farooq, M., (...), Elfasakhany, A.
Collective effect of ternary nano fuel blends on the diesel engine performance and emissions characteristics

(2021) *Fuel*, 293, art. no. 120420. Cited 3 times.
http://www.journals.elsevier.com/fuel/
doi: 10.1016/j.fuel.2021.120420

View at Publisher

16 Al-Hartomy, O.A., Mujtaba, M.A., Al-Ghamdi, A., Iqbal, J., Wageh, S.
Combined effect of Phoenix dactylifera biodiesel and multiwalled carbon nanotube–titanium dioxide nanoparticles for modified diesel engines

(2021) *International Journal of Environmental Science and Technology*
http://www.springerlink.com.ezlib.iium.edu.my/content/1735-1472
doi: 10.1007/s13762-021-03152-1

View at Publisher

17 Mujtaba, M.A., Muk Cho, H., Masjuki, H.H., Kalam, M.A., Farooq, M., Soudagar, M.E.M., Gul, M., (...), Ahmad, Z.
Effect of primary and secondary alcohols as oxygenated additives on the performance and emission characteristics of diesel engine (Open Access)

(2021) *Energy Reports*, 7, pp. 1116-1124. Cited 2 times.
http://www.journals.elsevier.com/energy-reports/
doi: 10.1016/j.egyr.2020.12.008

View at Publisher

18 Pan, M., Qian, W., Zheng, Z., Huang, R., Zhou, X., Huang, H., Li, M.
The potential of dimethyl carbonate (DMC) as an alternative fuel for compression ignition engines with different EGR rates

(2019) *Fuel*, 257, art. no. 115920. Cited 14 times.
http://www.journals.elsevier.com/fuel/
doi: 10.1016/j.fuel.2019.115920

View at Publisher

19 Liu, H., Lee, C.-F., Huo, M., Yao, M.

Comparison of ethanol and butanol as additives in soybean biodiesel using a constant volume combustion chamber

(2011) *Energy and Fuels*, 25 (4), pp. 1837-1846. Cited 114 times.
doi: 10.1021/ef200111g

View at Publisher

20 Venu, H.

An experimental assessment on the influence of fuel-borne additives on ternary fuel (diesel–biodiesel–ethanol) blends operated in a single cylinder diesel engine

(2019) *Environmental Science and Pollution Research*. Cited 16 times.
http://www.springerlink.com.ezlib.iium.edu.my/content/0944-1344
doi: 10.1007/s11356-019-04739-5

View at Publisher

21 Mujtaba, M.A., Masjuki, H.H., Kalam, M.A., Noor, F., Farooq, M., Ong, H.C., Gul, M., (...), Razzaq, L.

Effect of additivized biodiesel blends on diesel engine performance, emission, tribological characteristics, and lubricant tribology (Open Access)

(2020) *Energies*, 13 (13), art. no. 3375. Cited 17 times.
https://www.mdpi.com/1996-1073/13/13/3375
doi: 10.3390/en13133375

View at Publisher

22 Razzaq, L., Mujtaba, M.A., Soudagar, M.E.M., Ahmed, W., Fayaz, H., Bashir, S., Fattah, I.M.R., (...), EL-Seesy, A.I.

Engine performance and emission characteristics of palm biodiesel blends with graphene oxide nanoplatelets and dimethyl carbonate additives

(2021) *Journal of Environmental Management*, 282, art. no. 111917. Cited 4 times.
http://www.elsevier.com.ezlib.iium.edu.my/inca/publications/store/6/2/2/8/7/1/index.htt
doi: 10.1016/j.jenvman.2020.111917

View at Publisher

23 Taha-Tijerina, J., Shaji, S., Kanakkillam, S.S., Palma, M.I.M., Aviña, K.

Tribological and thermal transport of Ag-vegetable nanofluids prepared by laser ablation (Open Access)

(2020) *Applied Sciences (Switzerland)*, 10 (5), art. no. 1779. Cited 3 times.
https://res.mdpi.com/d_attachment/applsci/applsci-10-01779/article_deploy/applsci-10-01779-v2.pdf
doi: 10.3390/app10051779

View at Publisher

24 Taha-Tijerina, J., Aviña, K., Diabb, J.M.

Tribological and thermal transport performance of $SiO_2$-based natural lubricants (Open Access)

(2019) *Lubricants*, 7 (8), art. no. 71. Cited 10 times.
https://res.mdpi.com/d_attachment/lubricants/lubricants-07-00071/article_deploy/lubricants-07-00071.pdf
doi: 10.3390/lubricants7080071

View at Publisher

25 Gul, M., Masjuki, H.H., Kalam, M.A., Zulkifli, N.W.M., Mujtaba, M.A.

A Review: Role of Fatty Acids Composition in Characterizing Potential Feedstock for Sustainable Green Lubricants by Advance Transesterification Process and its Global as Well as Pakistani Prospective (Open Access)

(2020) *Bioenergy Research*, 13 (1). Cited 14 times.
http://www.springer.com.ezlib.iium.edu.my/life+sci/plant+sciences/journal/12155
doi: 10.1007/s12155-019-10040-7

View at Publisher

26 Agarwal, A.K.
Lubricating oil tribology of a biodiesel-fuelled compression ignition engine

(2003) *Proceedings of the Spring Technical Conference of the ASME Internal Combustion Engine Division*, pp. 751-765. Cited 5 times.
ISBN: 0791836789; 978-079183678-1
doi: 10.1115/ICES2003-0609

View at Publisher

27 Arumugam, S., Sriram, G.
Effect of Bio-Lubricant and Biodiesel-Contaminated Lubricant on Tribological Behavior of Cylinder Liner-Piston Ring Combination

(2012) *Tribology Transactions*, 55 (4), pp. 438-445. Cited 65 times.
doi: 10.1080/10402004.2012.667517

View at Publisher

28 Dhar, A., Agarwal, A.K.
Experimental investigations of effect of Karanja biodiesel on tribological properties of lubricating oil in a compression ignition engine

(2014) *Fuel*, 130, pp. 112-119. Cited 29 times.
http://www.journals.elsevier.com/fuel/
doi: 10.1016/j.fuel.2014.03.066

View at Publisher

29 Agarwal, A.K.
, pp. 751-65.
Lubricating Oil Tribology of a Biodiesel-Fuelled Compression Ignition Engine. Conference Lubricating Oil Tribology of a Biodiesel-Fuelled Compression Ignition Engine, vol. Design, Application, Performance and Emissions of Modern Internal Combustion Engine Systems and Components.

30 Singh, Y., Singla, A., Upadhyay, A., Singh, A.K.
Sustainability of Moringa-oil–based biodiesel blended lubricant

(2017) *Energy Sources, Part A: Recovery, Utilization and Environmental Effects*, 39 (3), pp. 313-319. Cited 14 times.
http://www.tandf.co.uk/journals/titles/15567036.asp
doi: 10.1080/15567036.2016.1179360

View at Publisher

31 Maleque, M.A., Masjuki, H.H., Haseeb, A.S.M.A.
Effect of mechanical factors on tribological properties of palm oil methyl ester blended lubricant

(2000) *Wear*, 239 (1), pp. 117-125. Cited 131 times.
doi: 10.1016/S0043-1648(00)00319-7

View at Publisher

32 Sulek, M.W., Kulczycki, A., Malysa, A.
Assessment of lubricity of compositions of fuel oil with biocomponents derived from rape-seed

(2010) *Wear*, 268 (1), pp. 104-108. Cited 64 times.
doi: 10.1016/j.wear.2009.07.004

View at Publisher

33 Arumugam, S., Sriram, G.

Synthesis and characterisation of rapeseed oil bio-lubricant - Its effect on wear and frictional behaviour of piston ring-cylinder liner combination

(2013) *Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology*, 227 (1), pp. 3-15. Cited 35 times.
doi: 10.1177/1350650112458398

View at Publisher

34 Soudagar, M.E.M., Banapurmath, N.R., Afzal, A., Hossain, N., Abbas, M.M., Haniffa, M.A.C.M., Naik, B., (...), Mubarak, N.M.

Study of diesel engine characteristics by adding nanosized zinc oxide and diethyl ether additives in Mahua biodiesel–diesel fuel blend (Open Access)

(2020) *Scientific Reports*, 10 (1), art. no. 15326. Cited 13 times.
www.nature.com/srep/index.html
doi: 10.1038/s41598-020-72150-z

View at Publisher

35 Soudagar, M.E.M., Mujtaba, M.A., Safaei, M.R., Afzal, A., V, D.R., Ahmed, W., Banapurmath, N.R., (...), Taqui, S.N.

Effect of Sr@ZnO nanoparticles and Ricinus communis biodiesel-diesel fuel blends on modified CRDI diesel engine characteristics

(2021) *Energy*, Part A 215, art. no. 119094. Cited 13 times.
https://www.journals.elsevier.com/energy
doi: 10.1016/j.energy.2020.119094

View at Publisher

36 Luo, T., Wei, X., Huang, X., Huang, L., Yang, F.

Tribological properties of $Al_2O_3$ nanoparticles as lubricating oil additives

(2014) *Ceramics International*, 40 (5), pp. 7143-7149. Cited 130 times.
doi: 10.1016/j.ceramint.2013.12.050

View at Publisher

37 Wu, Y.Y., Tsui, W.C., Liu, T.C.

Experimental analysis of tribological properties of lubricating oils with nanoparticle additives

(2007) *Wear*, 262 (7-8), pp. 819-825. Cited 545 times.
doi: 10.1016/j.wear.2006.08.021

View at Publisher

38 Zin, V., Agresti, F., Barison, S., Colla, L., Fabrizio, M.

Influence of Cu, $TiO_2$ nanoparticles and carbon nano-horns on tribological properties of engine oil

(2015) *Journal of Nanoscience and Nanotechnology*, 15 (5), pp. 3590-3598. Cited 25 times.
http://docserver.ingentaconnect.com/deliver/connect/asp/15334880/v15n5/s35.pdf?expires=1421019380&id=80424004&titleid=4286&accname=Elsevier+BV&checksum=ED02283A7B2F5D0688ECAC11676E27FE
doi: 10.1166/jnn.2015.9839

View at Publisher

39 Mujtaba, M.A., Masjuki, H.H., Kalam, M.A., Ong, H.C., Gul, M., Farooq, M., Soudagar, M.E.M., (...), Yusoff, M.N.A.M.

Ultrasound-assisted process optimization and tribological characteristics of biodiesel from palm-sesame oil via response surface methodology and extreme learning machine - Cuckoo search

(2020) *Renewable Energy*, 158, pp. 202-214. Cited 23 times.
http://www.journals.elsevier.com/renewable-and-sustainable-energy-reviews/
doi: 10.1016/j.renene.2020.05.158

View at Publisher

40 Al-Hartomy, O.A., Mujtaba, M.A., Al-Ghamdi, A., Iqbal, J., Wageh, S.

Combined effect of Phoenix dactylifera biodiesel and multiwalled carbon nanotube–titanium dioxide nanoparticles for modified diesel engines

(2021) *International Journal of Environmental Science and Technology*
http://www.springerlink.com.ezlib.iium.edu.my/content/1735-1472
doi: 10.1007/s13762-021-03152-1

View at Publisher

41 Habibullah, M., Masjuki, H.H., Kalam, M.A., Zulkifli, N.W.M., Masum, B.M., Arslan, A., Gulzar, M.

Friction and wear characteristics of Calophyllum inophyllum biodiesel

(2015) *Industrial Crops and Products*, 76, pp. 188-197. Cited 47 times.
www.elsevier.com/inca/publications/store/5/2/2/8/2/5
doi: 10.1016/j.indcrop.2015.05.042

View at Publisher

42 Singh, Y., Singla, A., Kumar, A., Kumar, D.

Friction and wear characteristics of jatropha oil-based biodiesel blended lubricant at different loads

(2016) *Energy Sources, Part A: Recovery, Utilization and Environmental Effects*, 38 (18), pp. 2749-2755. Cited 9 times.
http://www.tandf.co.uk/journals/titles/15567036.asp
doi: 10.1080/15567036.2015.1107924

View at Publisher

43 Mujtaba, M.A., Muk Cho, H., Masjuki, H.H., Kalam, M.A., Farooq, M., Soudagar, M.E.M.
Effect of alcoholic and nano-particles additives on tribological properties of diesel–palm–sesame–biodiesel blends
(2020) *Energy Rep.*. Cited 2 times.

44 Fazal, M.A., Haseeb, A.S.M.A., Masjuki, H.H.

Investigation of friction and wear characteristics of palm biodiesel

(2013) *Energy Conversion and Management*, 67, pp. 251-256. Cited 89 times.
doi: 10.1016/j.enconman.2012.12.002

View at Publisher

45 Arumugam, S., Sriram, G.

Preliminary Study of Nano- and Microscale $TiO_2$ Additives on Tribological Behavior of Chemically Modified Rapeseed Oil

(2013) *Tribology Transactions*, 56 (5), pp. 797-805. Cited 43 times.
doi: 10.1080/10402004.2013.792977

View at Publisher

46 Ingole, S., Charanpahari, A., Kakade, A., Umare, S.S., Bhatt, D.V., Menghani, J.
Tribological behavior of nano $TiO_2$ as an additive in base oil

(2013) *Wear*, 301 (1-2), pp. 776-785. Cited 104 times.
doi: 10.1016/j.wear.2013.01.037

View at Publisher

47 Lapuerta, M., García-Contreras, R., Agudelo, J.R.
Lubricity of ethanol-biodiesel-diesel fuel blends

(2010) *Energy and Fuels*, 24 (2), pp. 1374-1379. Cited 43 times.
doi: 10.1021/ef901082k

View at Publisher

48 Kuszewski, H., Jaworski, A., Ustrzycki, A.
Lubricity of ethanol–diesel blends – Study with the HFRR method

(2017) *Fuel*, 208, pp. 491-498. Cited 20 times.
http://www.journals.elsevier.com/fuel/
doi: 10.1016/j.fuel.2017.07.046

View at Publisher

49 De Farias, A.C.M., De Medeiros, J.T.N., Alves, S.M.
Micro and nanometric wear evaluation of metal discs used on determination of biodiesel fuel lubricity (Open Access)

(2014) *Materials Research*, 17, pp. 89-99. Cited 14 times.
http://www.scielo.br/pdf/mr/v17s1/aop_222513.pdf
doi: 10.1590/S1516-14392014005000101

View at Publisher

50 Knothe, G., Steidley, K.R.
Lubricity of components of biodiesel and petrodiesel. The origin of biodiesel lubricity

(2005) *Energy and Fuels*, 19 (3), pp. 1192-1200. Cited 324 times.
doi: 10.1021/ef049684c

View at Publisher

51 Gulzar, M.
Tribological Study of Nanoparticles Enriched Bio-based Lubricants for Piston Ring-Cylinder Interaction
(2018) . Cited 4 times.
Springer

52 Chacartegui, C., Lopez, J., Alfonso, F., Aakko, P., Hamelinck, C., Vossen, G.
Blending ethanol in diesel. Final report for Lot 3b of the Biodiesel Improvement On Standards
(2007) *Coordination Producers Ethanol Studies project*. Cited 2 times.

53 Corkwell, K.C., Jackson, M.M.
Lubricity and injector pump wear issues with e diesel fuel blends

(2002) *SAE Technical Papers*. Cited 8 times.
http://papers.sae.org/
doi: 10.4271/2002-01-2849

View at Publisher

54 Shahnazar, S., Bagheri, S., Abd Hamid, S.B.
Enhancing lubricant properties by nanoparticle additives

(2016) *International Journal of Hydrogen Energy*, 41 (4), pp. 3153-3170. Cited 189 times.
http://www.journals.elsevier.com/international-journal-of-hydrogen-energy/
doi: 10.1016/j.ijhydene.2015.12.040

View at Publisher

55 Sperring, T.P., Nowell, T.J.
SYCLOPS - A qualitative debris classification system developed for RAF early failure detection centres

(2005) *Tribology International*, 38 (10), pp. 898-903. Cited 30 times.
doi: 10.1016/j.triboint.2005.03.009

View at Publisher

56 Geller, D.P., Goodrum, J.W.
Effects of specific fatty acid methyl esters on diesel fuel lubricity

(2004) *Fuel*, 83 (17-18), pp. 2351-2356. Cited 205 times.
http://www.journals.elsevier.com/fuel/
doi: 10.1016/j.fuel.2004.06.004

View at Publisher

57 Chou, R., Battez, A.H., Cabello, J.J., Viesca, J.L., Osorio, A., Sagastume, A.
Tribological behavior of polyalphaolefin with the addition of nickel nanoparticles

(2010) *Tribology International*, 43 (12), pp. 2327-2332. Cited 110 times.
doi: 10.1016/j.triboint.2010.08.006

View at Publisher

58 Viesca, J.L., Hernández Battez, A., González, R., Chou, R., Cabello, J.J.
Antiwear properties of carbon-coated copper nanoparticles used as an additive to a polyalphaolefin

(2011) *Tribology International*, 44 (7-8), pp. 829-833. Cited 77 times.
doi: 10.1016/j.triboint.2011.02.006

View at Publisher

59 Mubashir, G.
Tribological study of nanoparticles enrichedbio-based lubricants for engine piston ring–cylinder interaction (2017)
University of Malaya Malaysia

60 Hu, K.H., Huang, F., Hu, X.G., Xu, Y.F., Zhou, Y.Q.
Synergistic effect of nano-$MoS_2$ and anatase nano-$TiO_2$ on the lubrication properties of $MoS_2$/$TiO_2$ nano-clusters

(2011) *Tribology Letters*, 43 (1), pp. 77-87. Cited 43 times.
doi: 10.1007/s11249-011-9789-3

View at Publisher

61 Laad, M., Jatti, V.K.S.
Titanium oxide nanoparticles as additives in engine oil (Open Access)

(2018) *Journal of King Saud University - Engineering Sciences*, 30 (2), pp. 116-122. Cited 53 times.
www.journals.elsevier.com/journal-of-king-saud-university-engineering-sciences/
doi: 10.1016/j.jksues.2016.01.008

View at Publisher

Mujtaba, M.A.; Center for Energy Science, Department of Mechanical Engineering, University of Malaya, Kuala Lumpur, Malaysia; email:m.mujtaba@uet.edu.pk