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Review Article

Biolubricants from Non-Edible Vegetable Oil: A Bibliometric Review

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ABSTRACT

The petroleum-based lubricants cause harmful effect on the environment because they are non-degradable and highly toxic. This study reviewed articles from Google Scholar database on the subject of development of biolubricants from non-edible vegetable oil and its modifications; chemically and/or addition of nanoparticles to improve the tribological properties of the oil. 136 articles were gotten from the search and later cut down to 30 after screening. These studies did not conclude that biolubricants obtained with the application of nanoparticles and modification has greater tribological properties together with thermal stability and oxidation stability. There is a need of production of a flexible environmental-friendly nanolubricant having excellent rheological, tribological properties and antioxidant properties which will be suitable in automotive application.

1. INTRODUCTION

Lubricants minimize friction, prevent wear, provide cooling and transport debris away from interface. Lubricants can be solids, solid/liquid thick colloid such as grease, liquids, liquid-liquid dispersions or gases. A thin layer of gas is suitable for low body to body force while solid thin layers mostly apply to low velocity bodies communication. According to Ajithkumar et al., (2009), lubricants are made up of over 9 out of 10 parts base oil and lower than 10% package of additive. The base oil used for the formulation of most lubricants is environmentally hostile mineral oil and 30% of lubricants consumed ends up in the ecosystem (Bartz, 2006; Ajithkumar et al., 2009).

However, mineral oil reserve is depleting and the environmental concern about the damaging impact of mineral oil is growing. The search for environmentally friendly substitutes to mineral oils as base oils in lubricants has become a frontier area of research in the lubricant industry. Vegetable oils are perceived to be alternatives to mineral oils for lubricant base oils due to certain inherent technical properties and their ability to be biodegradable (Woma et al., 2019)

Biolubricants are biodegradable and non-toxic to humans and have better physicochemical properties than petroleum-based lubricants. Biolubricants are more advantageous than mineral oil-based lubricants because it has a higher flash point, higher boiling point, high lubricity, high biodegradability, high viscosity index, low volatility, and less toxic(Cecilia et al., 2020). Biolubricants can be obtained from both edible and non-edible oils. The use of edible oil for the production of bio-oil is not practicable because they are in great urge for fulfilling the requirement of human food. As edible oil is used in the food chain, the use of edible oil as a lubricant can give rise to the ecological damage by using their land (Singh et al., 2019).

Besides this, petroleum reserve is depleting globally leading to increase in the cost of mineral oil available for lubricant production. These problems call for attention to search for cheap available alternatives that have no controversy for food security and non-edible vegetable oil has been identified as a viable option (Woma et al., 2019)

The employment of non-edible oil as lubricant has various advantages such as inedible plant can be cultivated in a harsh environment and does not cause ecological damage, easily obtainable, low price and biodegradable, and non-toxic (Singh et al., 2019). These biolubricants can be classified according to the chemical composition as natural and synthetic oil. Natural oils are obtained from plant or animal fat by various extraction or distillation process. Synthetic oil uses the natural oil as basic material and obtained by chemical modification of natural oils. The natural oil contains triglycerides which are obtained from glycerol and fatty acid chain. The percentage composition of fatty acid in oil affects the physicochemical properties of oils. Fatty acid is carboxyl acid with long carbon–carbon chain. Fatty acids are classified on the basis of presence of double bond in the carbon–carbon chain. Saturated fatty acid is those who do not have double bond, and unsaturated fatty acid has minimum one double bond. Synthetic oil is obtained from chemical modification of natural oil. This review was done to find research gaps in the area of finding alternative for mineral oil lubricant using non edible vegetable oil for development of biolubricants. It also highlighted and presented what has been done and the results obtained by other researchers.

2. METHODOLOGY

Google Scholar search engine was used for choosing the most significant articles for the subject of the current study. Biolubricant, non-edible oil, and nanoparticles keywords combination were used. The block diagrams for selection and identification of significant research article are as shown in Figure 1. This study is limited to articles searched on the Google scholar database with the following key words: biolubricant, non-edible oil and nanoparticles. The articles must also be published within the period under review i.e., 2010 to 2021.

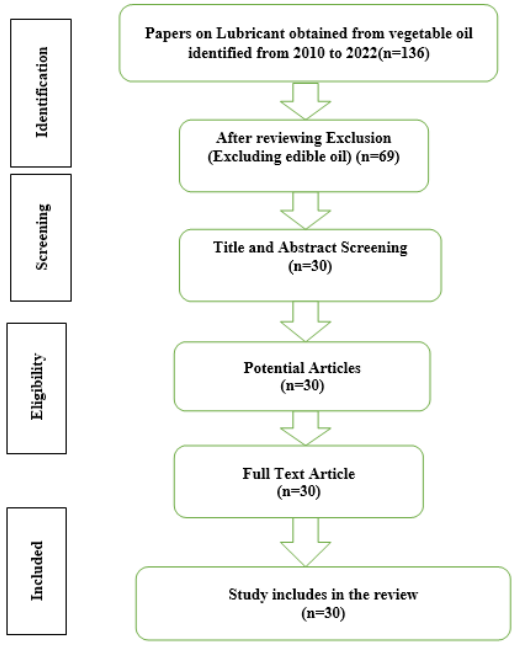

Figure 1: Block diagram for selecting and identification of relevant research articles

3. FINDINGS

The application of nanoparticles was used to conquer the disadvantages of conventional additives. Various non-edible oils were considered for the production of biolubricant by the chemical modification and addition of nanoparticles. The tribological applications of different non-edible plant were examined by various studies such as *Moringa oleifera* seed (Ozioko, 2014; Nwokocha et al., 2017; Singh et al., 2019), Thumba (*Citrullus colocynthis* L.) seed (Kamalakar et al., 2015), sandbox (*Huracrepitans*) seed oil (Popoola et al., 2021), *Balanites aegyptiaca* (Singh, et al., 2020), *Euphorbia lathyris* (Singh et al., 2021), *Michellia champaca* (Singh and Abd Rahim, 2020), *Shorea robusta* (Chaurasia et al., 2020), neem oil (Kareemullah et al., 2021), jatropha oil (Begum et al., 2019) and jojoba oil (Sadriwala et al., 2020), and (Gupta et al., 2020). These studies include the development of a biolubricant from non-edible plant by enhancing tribological properties through chemical modification and using nanoparticles.The summary of the literatures reviewed is shown in Table 1.

Selection of the relevant articles was carried out: First, the articles were identified and selected on the basis of their title and abstract. The selection was according to three main criteria such as (a) the article must be from (2010-2022) only (b) the article must be on non-edible oil only, and (c) the articles must be on the non-edible oil which were considered for production of biolubricant. These articles were selected after studying the year wise growth in the study of biolubricant for the past twelve years. The yearly publications on biolubricant and articles distributions based on where they are published, and network visualization of bibliometric analysis are shown in Figures 2 to 4. Figure 2 showed the yearly publications of articles on biolubricants using non-edible oil as the based oil. The trend clearly showed increase in the number of researchers interested and working on such topics. From the year 2010 to 2019, there was no significant change in the number of publications. From 2010 to 2012, there were no articles published, and in 2013, only one article was published. In 2014 and 2015, no articles were published, but in 2016, the number of articles published increased to 3, and then reduced to 1 article each in 2017 and 2018. It will also jump back to 2 articles in 2019. However, in 2020 and 2021 there was a significant increase in number of publications which shows that searching for alternative to mineral oil lubricant is an emerging area of research and researchers are beginning to work in that direction.

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Table 1: Summary of the literatures

Non edible oil	Author	Method	Findings
Desert date oil (*Balanites aegyptiaca)*	Singh et al., (2020)	Pin on disc machine	0.6% of SiO2 nanoparticles show better result in terms demonstrated a crucial increase in the reduction of coefficient of friction (COF), wear rate, and improved surface morphology with synthetic oil correlation
Michellia champaca oil	Singh et al., (2020)	Pin on disc machine	Improvement in terms of reducing friction, less wear and damage to surface was seen by using 0.6% of cerium nanoparticles with chemically modified champaca oil.
Sal (*Shorea robusta*) oil	Chaurasia et al., (2020)	Pin on disc tirbometer	Improvement in terms of reducing friction, less wear, and damage to the surface was seen by using 0.5% of copper nanoparticles with chemically modified Sal oil
Jojoba oil *(Simmondsiachinensis)*	Sadriwala et al., (2019)	Pin on disk tribometer	The blend with 10% of Jojoba oil shows better tribological properties
	Gupta et al., (2020)	Pin on disk tribometer	The blend with 10% of jojoba oil shows better tribological properties when Al-7%Si alloy and steel materials were used for pin and disc, respectively
Jatropha oil	Khasbage et al., (2017)	Four-ball tribotesting machine	0.1%CuO blended Jatropha oil shows the maximum viscosity, viscosity index and developed maximum pressure under lubrication of hydrodynamic journal bearing
	Begum et al., (2019)	Pin on disc tribometer	By the addition of nanoparticles in jatropha oil, the viscosity increased and the fire point increased.
Moringa oleifera oil	Ozioko et al., (2014)	Pin on disc tribometer	The blend with 10% of moringa oil fulfills the condition for SAE 30 and SAE 40 grade
	Nwokocha et al., (2017)		Rheological characteristic of moringa shows that it is solid at 10 ℃, liquid at 30–70 ℃, and thermally unstable at 90^0c
	Singh et al., (2020)	Pin on disc tribometer	0.5% of SiC nanoparticles with chemically modified moringa oil show better result in terms of reducing coefficient of friction, wear rate, and less damage to the surface
Neem oil	Mahara et al., (2020)	DUCOM tribometer	At 0.3 percentages of SiO2 nanoparticles, improved results in terms of wear of the parts have been observed with comparison to the raw neem oil
Sandbox (*Huracrepitans*) seed oil	Popoola et al., (2021)	Anton Paar ball on disc tribometer	The overall results revealed that enrichment of sandbox oil with copper (II) oxide nanoparticle improved the tribological behavior of the oil
Thumba (*Citrullus colocynthis*) oil	Kamalakar et al., (2015)		Epoxy thumba oil shows higher viscosity, thermal stability and oxidative stability from the other two base stocks. polyol esters show low pour point compared to epoxy thumba oil
Euphorbia Lathyris	Singh et al., (2021)	Pin on disc tribometer	0.5% concentration of ZnO nanoparticles demonstrated a reduction in the coefficient of friction (COF) and wear of the pin of about 8.23% and 5.13% respectively

Figure 3 showed the journals and the conference proceedings where the articles reviewed were published. The trend showed Elsevier published 11 out of the 30 articles reviewed and Springer published 7 of the articles, and this speaks volume to the quality of the articles reviewed. Figure 4 showed the network visualization of the bibliometric analysis of the articles reviewed in this study based on key word co-occurrence and citations. This network showed the connections between the articles and how interconnected they are to each other. Singh, Y has a lot of connections with other authors, which shows level citations from his work.

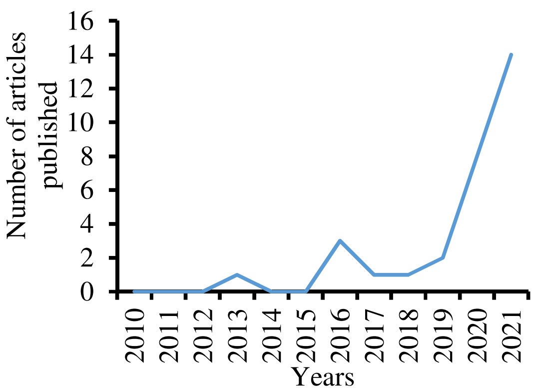

Figure 2: Yearly publication of articles on non-edible oil as biolubricant

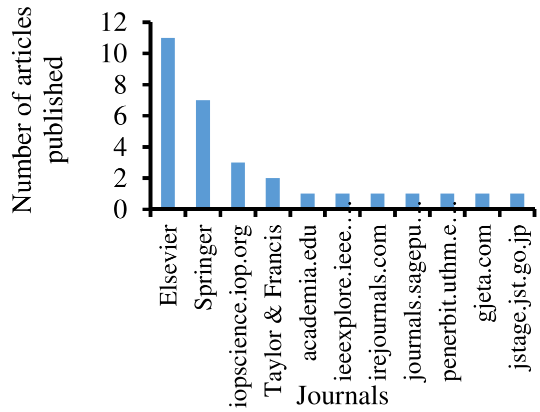

Figure 3: Distribution of the articles published according to journals

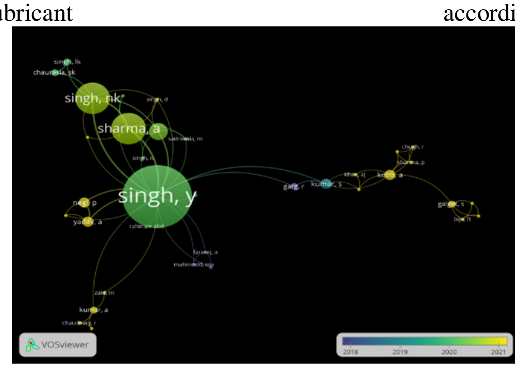

Figure 4: Network visualization analysis of the articles reviewed using Vos viewer

4. CONCLUSION

From the literatures reviewed, it has been found that an attempt has been made to obtain an alternative to petroleum-based lubricating oil using non-edible oil. In addition, it was found that the analysis of tribological behavior of chemically and non-chemically modified biolubricant with nanoparticles as additives was carried out. Non-edible oils are biodegradable and have better physicochemical properties than petroleum-based lubricating oil but shows less thermal and oxidative stability. These studies did not conclude that biolubricant obtained with the application of nanoparticles has greater tribological properties together with thermal stability and oxidation stability. Nanoparticle as additive is a recent fresh topic for research, there is need to develop a nanolubricant having good oxidation stability without reducing its friction and wear characteristics

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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