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Effect of CuO nanoparticles on Tribological Properties of Lubricating Oil

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Abstract *Nanolubricants is an emerging area in the field of tribology it has been found in recent researches that nanoparticles of Copper Oxide (CuO) improves the anti-wear and thermophysical properties of base oil significantly. This review gives basic understanding about Copper Oxide nanoparticle's influence on the anti-wear and thermophysical properties of base oil.*

Key Words: Tribology, Nanolubricants, Copper Oxide Nanoparticles

1. INTRODUCTION

Nanoparticles of Copper Oxide (CuO) when mixed with base oil i.e. mineral oil, vegetable oil, synthetic oil results in nano lubricant. Nano-lubricant has been area of interest of many in the last couple of decades. It has been found that nano-lubricants have immense potential over the lubricants without nanoparticle. Many researchers have found significant change in properties of base oil with the addition of nanoparticles like increase in anti-wear, anti-friction, thermal conductivity, viscosity, flash point and pour point. Usually to increase the stability of nano-particles, surfactants like sodium dodecyl sulphate, oleic acid, triton x-100 etc. are used[1]

1.1 Influence on Tribological Properties

In the last couple of decades many research work has been carried out to determine the influence of nanoparticles on tribological properties. This section deals with the review of Copper Oxide (CuO) nanoparticles on tribological properties of lubricating oil. The review is based on the past research, which is summarized on **Table 1.** In most of the reviewed research work the CuO nanoparticle is dispersed with Oleic Acid (OA) and then kept under ultrasonic probe to increase the stability of nanoparticles[2].After this to determine tribological properties, tribometer is used under varying parameters like concentration of nanoparticle, load, speed, and temperature.

CuO when mixed with castor oil performs better than copper oxide with mineral oil, it improves anti-wear property and anti-friction, around 28.3 % reduction in WSD and 34.6 % COF with castor oil whereas 22.2 % and 17.3 % with mineral oil[3]. When compared to Al_2O_3, CuO performs better and reduces wear upto 18% and COF 14%[4] CuO performs well with engine oil also it was concluded it can reduce coefficient of friction upto 50 % in the mixed lubricant regime[5]. CuO nanoparticles with palm kernel oil based nanolubricant , when tested on pin-on-disc tribometer gives reduction of 48% in wear and 56% in COF[6] When it was studied with synthetic oil and vegetable oil it was found that CuO nanoparticles dispersed in synthetic oil reduces more wear comparatively to vegetable oil[7]. CuO performs well with water based lubricant also , it gives COF reduction 69.2% and wear around 55.1% [8].

1.2 Influence on Thermophysical Properties

CuO nanoparticles also influences the thermophysical properties like thermal conductivity, viscosity, flash point and pour point, **Table 2.** summarizes the various thermophysical properties evaluated by different researchers. The effect of CuO nanoparticles on these properties are discussed below:

1.2.1 Thermal Conductivity

One of the most important function of lubricants is to dissipate heat, higher the thermal conductivity greater amount of heat can be transferred. The thermal conductivity of Al_2O_3 and CuO mixed nanofluid increases with decrease in particle size and increase in concentration [9]. The addition of 0.1% of CuO increases thermal conductivity by 3%[10]

1.2.2 Viscosity

The viscosity is the most important property of any lubricant, the effectiveness of lubricant depends on this. It is observed that with the increase in concentration increases viscosity[11]. The experimentation with CuO found that viscosity increases three times with gear oil[12]. At 2% concentration viscosity increases to 150 cP to 180 cP[13].

1.2.3 Specific Heat

This is also a property which plays important role in heat dissipation apart from thermal conductivity. Al_2O_3 and CuO nanoparticles (100 nm) increases the heat capacity of engine oil with increase in temperature [14].

1.2.4 Flash Point and Pour Point

When Cuo used as nanoparticle, pour point is the lowest temperature at which oil stops flowing and thus become important for low temperature application areas. It is observed that the flash point has a direct relationship with nano-additive concentration with maximum flashpoint observed at 0.5 wt. % CuO concentration and is equal to 253°C. However, lower concentrations are more effective in increasing the pour point with 0.2 wt. % CuO concentration increasing the pour point from −27°C to – 28°C [10]

Table 1: Tribological Studies with CuO nanoparticle Additives

Base Oil	Tribotester	Results	Ref.
Castor Oil(CO) Mineral Oil (MO)	Four Ball Tester	28.3 % reduction in WSD (CO)and 22.2% (MO)	[1]
SAE75W85 PAO8	Optimal SRV4 tester	Upto 18% wear reduction and 18% COF	[2]
Engine Oil	Pin-on-Disc	50 % reduction in COF	[5]
Palm Kernel Oil	Pin-on-Disc	Reduction in Wear 48% and COF 56%	[6]
Vegetable Oil Synthetic Oil	High frequency reciprocating test rig (HFRR	Wear reduction was more Synthetic oil	[7]
Water based Lubricant	Four Ball Tester	At 0.2 wt.% of CuO the friction reduction is around 69.2% and wear reduction is 55.1% under different load	[8]

Table 2. Studies on influence on Thermophysical Properties by CuO nanoparticles

Properties	Base Oil	Concentration	Results	Ref.
Thermal Conductivity	20W50	0.1 %, 0.2 %, 0.5 wt.%	Thermal Conductivity increases by 3 %	[10]
	Engine Oil	2-10 %	As the conc. Increases thermal conductivity increases	[9]
Viscosity	Oil	2%	Increases 150cP to 180cP	[13]
	Gear Oil	0.005-0.0025 vol.%	3 times increase	[12]
Specific Heat	Engine Oil	-	Increases with increase in temperature	[14]
Flash Point & Pour Point	Engine Oil	0.5 %	Lower concentration increases pour point and with the increase in conc. Flash point incraeses	[10]

2. MECHANISM OF LUBRICATION

In this section mechanism of lubrication is discussed due to which improvement in tribological properties are observed. It was concluded that the protective film on interacting surfaces is produced by a reaction between additives and interface material under appropriate lubrication conditions, and it aids in increasing oil's tribological properties. It was found that CuO nanoparticles reduces wear and friction due to tribo-sintering effect [4], another mechanism was credited i.e. polishing effect in which CuO nanoparticles polishes the surface due to inherent hardness which smoothens the surface and thus reduces COF[15]. Nanoparticles are sacrificial in nature, this contributes to different lubrication mechanisms like mending effect, protective film formation etc. and this leads to improvement in anti-wear properties of the lubricating oil.

3. CONCLUSIONS

The following conclusions can be drawn from the past literature:

- CuO can enhance the tribological and thermophysical properties of base oil significantly.
- It depends on size and the medium i.e. base oil, due to this optimum concentration is different for a particular base oil. According to area of application it can be varied.
- Many researchers reported that after a certain time period stability is an issue which influences the effectiveness of the nanolubricant greatly.
- Some researchers used CuO nanoparticles as additive with vegetable oils and found very promising results. Thus nanoparticles can increase the applicability of vegetable oils also. This is important for the development of biodegradable lubricants.

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