New Characteristics of Lubricants for Electric Vehicles

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Introduction

The rise of electric vehicles (EVs) and battery hybrid electrical vehicles (BHEVs) comes with the need to produce dedicated lubricants that enhance EV performance. These lubricants need to maintain compatibility with EV components and maximize vehicle efficiency. Current lubricants used in internal combustion engine vehicles do not possess all of the specialized characteristics needed for EVs. To achieve the desired characteristics of EV lubricants, various technologies used in internal combustion engine vehicles may be applicable in the development of new EV lubricants.

Properties Needed for Ideal EV Lubricants

Mechanical Properties	Electrical Properties	Chemical Properties
- Ability to reduce friction	- Dissipation factor	- Oxidative & thermal stability
- Appropriate viscosity	- Dielectric strength	- Resistance to corrosion
- Cooling properties	- Volume resistivity	- Copper compatibility
- Increase in useful torque	- Electrical conductivity	- Chemically modified if needed
- Resistance to wear & physical degradation	- Compatibility with EV components	- Biodegradability

Bio-Lubricants

Bio-lubricants will improve the sustainability of EVs. Bio-lubricants are formulated using oils made from renewable resources such as vegetable oil, animal fat, and other types of biomass. The polarities of the esters and polyalkylene glycols(PAGS) that make up the molecular backbones of most bio-lubricants exhibit enhanced lubrication properties, such as improved thermal and oxidative stability. Bio-lubricants are also ready/ultimate biodegradable, which caters to the growing concern for eco-friendly technologies.

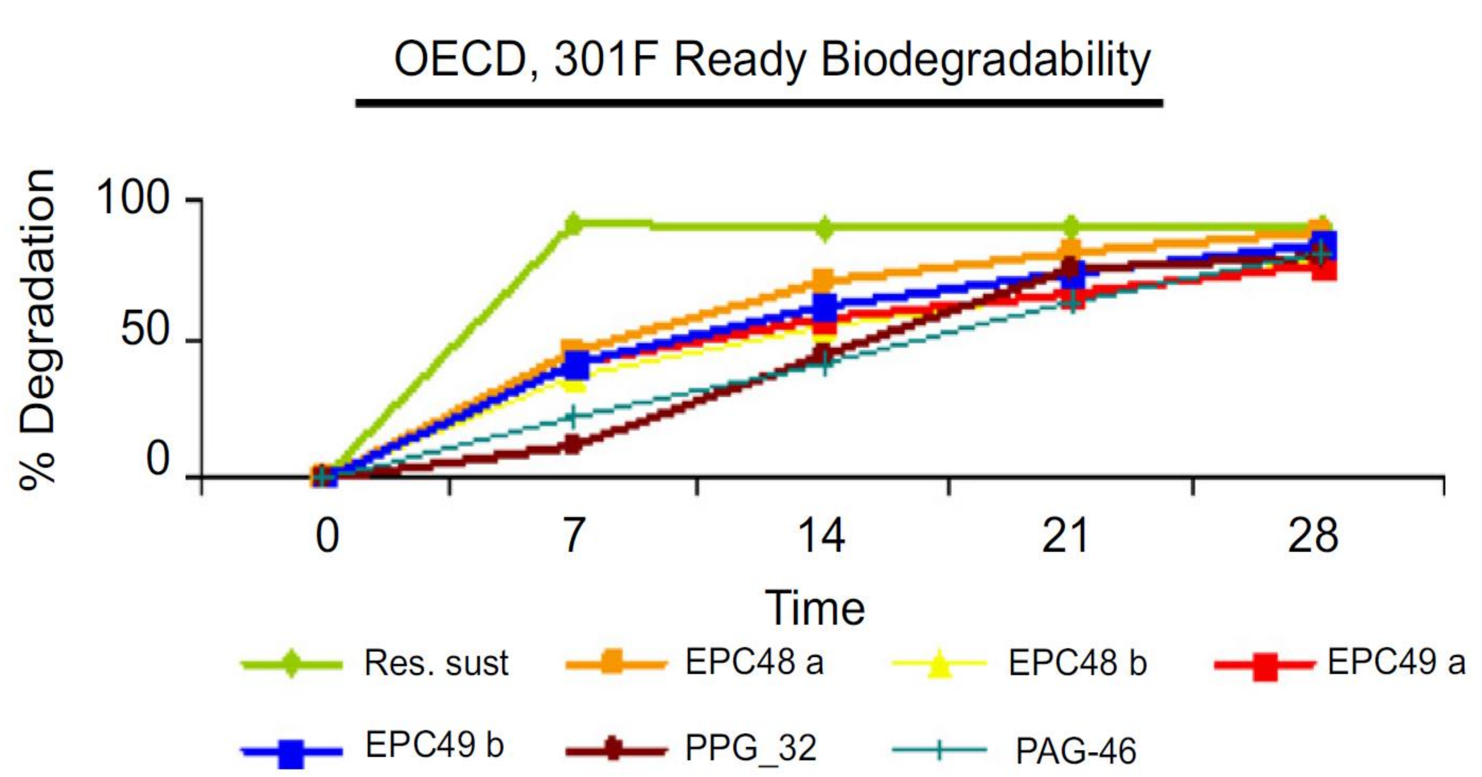

Figure 1. The biodegradability of oils made with water soluble PAG (PAG-46), oil tolerant polypropylene glycols (PPG-32), bio-based SW-30 synthetic oil (Res. sust), and blends of hydrocarbons with esters (EPC-48a, EPC-48b, EPC-49a, EPC 49b). https://doi.org/10.1016/j.triboint.2008.10.015

Applications of Nanotechnology

The incorporation of nanoparticles into EV lubricants has to potential to enhance multiple aspects of EV performance. Multi-walled carbon nanotube (MWNT) additives have been shown to decrease the wear and friction of mineral gear oils, with the most effective concentration of MWNTs being 0.5 wt%. Solid nanoparticle increases thermal heat capacity and conductivity.

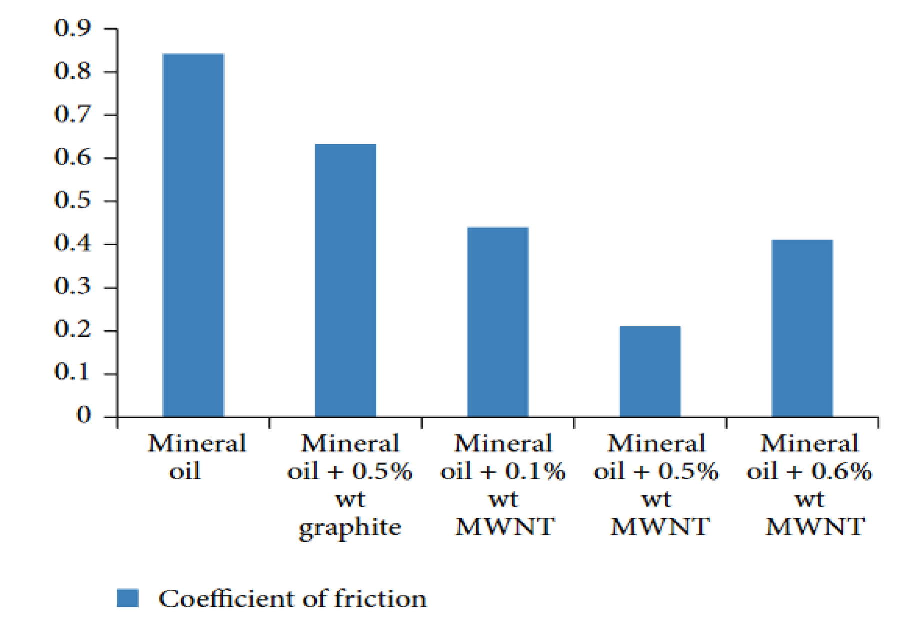

Figure 2. The coefficient of friction for unenhanced mineral oil and mineral oil with varying concentrations of MWNTs. https://doi.org/10.1155/2014/341365

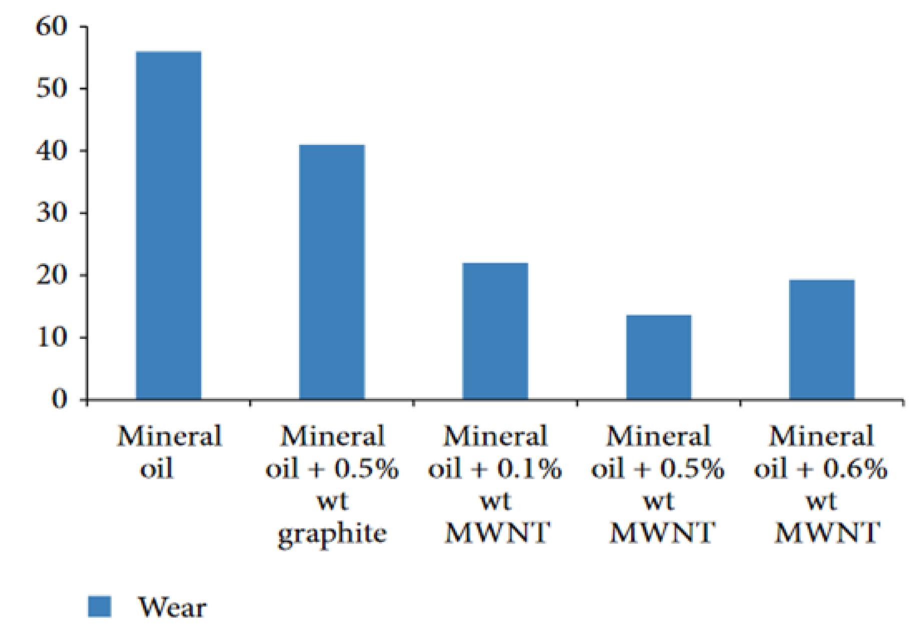

Figure 3. Wear for unenhanced mineral oil and mineral oil with varying concentrations of MWNTs . https://doi.org/10.1155/2014/341365

Other nanoparticles can also be used to enhance EV lubricants. The performance of gears can be improved with nanoparticles such as alumina, rutile, carbon, and graphene. Lubricant grease containing 0.3 wt% silicon dioxide nanoparticles had a low coefficient of friction and helped to reduce wear. The incorporation of electrically conductive nanoparticles can improve thermal and oxidative stability, which is useful for in high speed applications.

Non-metal Additives

Conventional synthetic or mineral lubricants can be modified to fulfill the needs of EVs through additives. Some examples of non-metal additives that improve thermal and oxidative stability include:

- antioxidants
- pour point depressants
- additives that are chemically modified through transesterification and epoxidation
- graphite additives (which are especially effective for greases)

Metal-based Additives

Numerous metal additives have been shown to enhance lubricant properties. Adding metal to gear coatings increases efficiency. Fully formulated oils containing zinc dithiophosphate additives were found to promote micro-pitting, which is beneficial for sliding contacts. Metal additives can also work well with nonmetal additives. For instance, metal additives that contain phosphorus, and sulfur acting together synergistically showed a reduction in the friction coefficient.

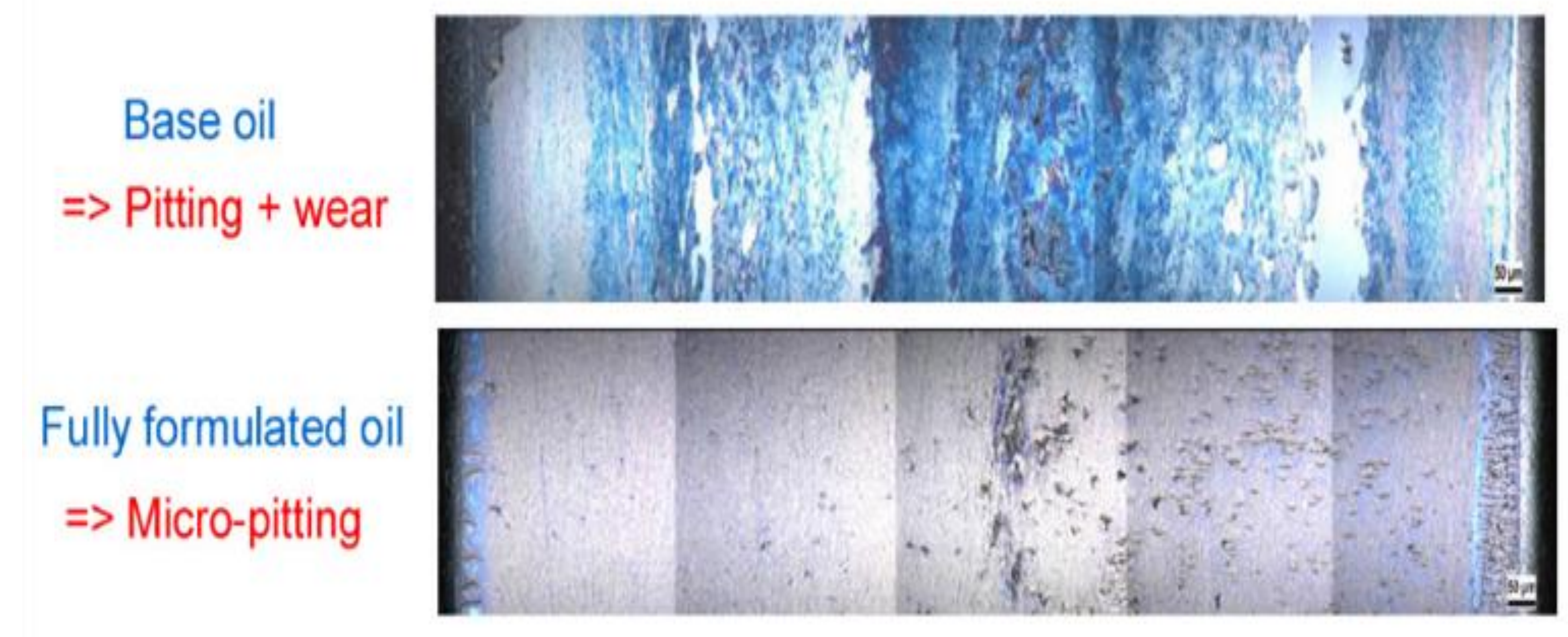

Figure 4. Incorporation of zinc dithiophosphate into fully formulated oils showed micro-pitting compared to untreated base oils. https://www.jstor.org/stable/26277852

Conclusion

Bio-lubricants, nanoparticles, and specialized additives all have the potential to enhance the functional characteristics of EV lubricants. These technologies have worked in internal combustion engine vehicles and show great promise for applications in EV lubricants. More testing still needs to be done in EVs to determine the electrical properties of these technologies and their compatibility with EV components. After EV lubricants have been developed, thoroughly tested, and perfected, EV efficiency can be maximized. EV lubricants will pave the way for electrified drivelines to dominate the future.

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