# Glycerol/ionic liquids mixture as potential candidate for superlubricity on W-DLC surface under boundary lubrication conditions

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## KEYWORDS

***Lubricant additives; Mixed Lubrication; Coating, superlubricity (ultralow friction)***

## ABSTRACT

In this report we present ultralow friction obtained with green glycerol/ionic liquid mixtures on tungsten doped diamond-like-carbon (WDLC) coatings produced with physical vapour deposition (steel ball with 5 mm diameter were used as counter body) under severe mixed and boundary lubrication regime ($\lambda$<1). We investigated different ionic liquids as additives in glycerol to study the effect of contact pressure and temperature on coefficient of friction (COF) and wear. We observed that increase in contact pressure from 0.2 to 1 GPa significantly reduces COF from 0.1 to 0.02 for all mixtures with additives. The mechanism of low friction under high contact pressures with glycerol is still unknown however some authors (e.g. Martin *et al.*) associate such phenomena to friction induced dissociation of glycerol to form a network of water-like species on the surface which provides easy shear under high pressures. In this report we discussed tentative lubrication mechanism which fits nicely with our results. The effect of the temperature on COF was found to be significant for all mixtures. The obtained results for WDLC with 1 GPa contact pressure were compared with steel surface. The surface of the disks (steel and WDLC) and the steel balls were examined with 3D Bruker interferometer, SEM+EDS and AFM. The WDLC coating had much better wear resistance and lower COF than the steel surface at 1 GPa, indicating that combination of glycerol/ionic liquids on WDLC coatings constitute very prosperous solutions for providing anti-wear and low friction properties for many applications. In order to determine the corrosive effect of the ionic liquids on the disks (steel and WDLC) corrosion tests at 100 ºC were performed. Results indicate that steel surface was corroded due to aggressive reactive nature of the ionic liquids however no deterioration was observed for WDLC surface, possible reason why steel surface showed higher COF and wear rate. Thus, this investigation enabled us to determine the important influencing parameters for WDLC and glycerol/ionic liquid mixtures which are of crucial importance for designing new, efficient and environmentally-friendly, lubricants for the coated and other advanced functional surfaces.

**Conclusion**

- Full solubility of the ionic liquids with 1wt% concentration was achieved in glycerol base oil.
- Ionic liquid additives are not active at low loads (< 1 GPa) thus there is no significant difference in COF as compared to pure glycerol.
- Overall COF reduces with ionic liquid additives progressively at higher loads as compared to pure glycerol. Ultralow COF of 0.02 on WDLC surface was achieved. Temperature effect on COF was significant.
- Wear rate k on WDLC coated disks is negligible for all mixtures at different loads and temperatures. However wear rate is high for steel surface especially at higher temperature 100ºC.
- Ionic liquid additives caused corrosion on the steel surface at higher temperature 100 ºC however WDLC surface remains unharmed. Further chemical analysis with FTIR and XPS is on the way. Such studies will help us to co-relate the chemical structure of ionic liquids (cations and anions) with their tribological properties as well. Such study can also help us understanding tribofilm formation on WDLC surface.
- Wear rate on the counter body (steel) is observed to be associated to the different loads on WDLC coatings. Steel/WDLC tribopair performed better than steel/steel.

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