

Industrial lubricants are invariably used with organo-metallic additives (such as complex sulphates and phosphates Zinc dialkyl dithio phosphate or ZDDP) for tribological performance enhancement. However, these additives are environmentally harmful and they also have damaging effects on steel components. Hence, there is an urgent need to find alternative solutions for enhancing the tribological performance of lubricants and components without the use of harmful additives. Epoxy-based composites are promising tribological coatings, which can provide low friction and high wear life under dry, as well as base-oil lubricated conditions. Thus, the present work focuses on achieving improved mechanical properties with a low coefficient of friction ≤ 0.1 and a minimal wear rate $\leq 10^{-7} \text{ mm}^3 / \text{Nm}$ for such coatings. The applications of epoxy composite coatings can be in extreme contact conditions such as engine piston rings and bearings. The present work is divided into five parts. The first part involves tribological and mechanical investigations of epoxy and its composites adding graphene and graphite by 10 wt. %, coating on steel substrate under dry and lubricated conditions at different loads and speeds. It was observed that epoxy/graphene composites exhibit a lower coefficient of friction (~ 0.18) and a wear rate of $5.5 \times 10^{-6} \text{ mm}^3 / \text{N-m}$ at 3 N load and 0.63 m/s sliding speed under dry contact condition, when it was compared to epoxy. The second part of the thesis includes investigations of tribological and mechanical properties of epoxy composite that is filled with nano-particles and liquid lubricants coated on D2 steel. Friction reduction by liquid lubricant (SN150 and PFPE by 10 wt. %) filled epoxy composites and associated lubrication mechanism has been studied. It was observed that the presence of in-situ lubricant at the interface assisted in making partial fluid film, which reduced the coefficient of friction drastically. The wear life further improved by more than 200 times and the coefficient of friction became half that of the composite without the lubricant. The third part of this thesis is a discussion of the lubrication mechanism of epoxy/graphene and epoxy/graphene/SN150 composites at 10 N load and 0.63 m/s speed. It was found that epoxy/graphene lubricated with base-oil SN150 showed the lowest coefficient of friction (0.08) amongst all composites. In the fourth part of this work, hard (DLC, WC and TiAlN) and soft (epoxy/graphene/SN 150) coatings were investigated. It was found that DLC+epoxy/graphene/SN150 coating exhibited lowest coefficient of friction (0.08) with negligible wear. In the last part of the work, the best suitable coating, namely epoxy/graphene/SN150 with DLC and WC as the intermediate hard coatings, were applied on the piston rings of a diesel engine and experiments were performed in order to perform wear analysis of the coated rings. The important conclusion of this work is that lubricant-filled epoxy-based composites are suitable as tribological coatings for load bearing applications in journal bearings, engine piston rings and other similar components. These coatings can work well under dry contact conditions as well as external liquid lubrication conditions.