Abstract

The traditional greases are composed of mineral or synthetic oil, thickening agent, additives, and fillers. Thickeners having fibrous matrices are generally made of fatty acid soaps (calcium, lithium, aluminum, sodium) and non–soaps (clay, PTFE, polyurea, silica). A variety of additives and fillers are added to grease to obtain the desired properties for performance enhancement. Lubricating greases are widely used in locomotive, automotive, mining, steel, food, textile, and agriculture industries. Besides this, greases are extensively used in extreme operating environment, viz. higher temperature, higher load, speed, and extreme pressure.

The purest form of any grease cannot accomplish all lubrication criteria desired by machine/equipment/engine manufacturers. Therefore, a package of different additives is added to enhance tribo–performance of greases substantially. In the last decades, researchers have contributed for the enhancement of the tribological performance of grease with various fillers, including variable types of nanomaterials.

The lubricating oil, thickener, and additives play a synergistic effect in lubricating the interacting surfaces and protecting them against friction and wear. The tribological performance of the grease depends upon the viscosity of the base oil, type, and concentration of the thickening agent. A significant amount of power is lost due to friction. By reducing the frictional losses, a significant amount of power can be saved, and this will improve the efficiency and service life of the machine and spare parts.

Further, the conventional greases are made of mineral or synthetic oil and metallic or non–metallic soaps that are non–biodegradable. Therefore, the disposal of conventional grease in the environment leads to adverse effects on living beings. Due to environmental

concerns, researchers and lubrication engineers are extending their efforts to develop sustainable alternatives that can perform at par or better than conventional grease.

The present work focused on developing lubricating greases with renewable resources (i.e., vegetable oil), which can be suitable alternatives to conventional greases. In this context, castor and coconut oils were selected as base stocks and thickened with lithium soap for obtaining stable and consistent greases. The thickener concentration was fixed at 14 wt%. In the past two decades, various nano–sized materials have been evaluated as additives in grease to improve the tribological performance. The nano–sized additives demonstrated excellent antiwear and load–bearing capacity than prevailing additives. In this context, the nanostructured materials of different shapes and sizes have been synthesized (i.e., MoS_2, MoS_2–ODT, GO, rGO, GO–ODA, and SiO_2) and used as nanoadditives in variable concentration. The characterization techniques viz. XRD and FTIR confirmed the synthesis of these nanoadditives. The shape, size, and microstructural characterization of these nanoadditives were analyzed using HRTEM.

A comparative tribological study of paraffin, castor, and coconut oils–based lithium grease samples without additives were carried out as per ASTM standard under the boundary lubrication regime. Paraffin oil–based grease was used as reference grease for comparing the various physicochemical and tribological properties of castor and coconut oils–based grease samples. The tribological results revealed that vegetable oil–based greases have significant potential to minimize friction and wear. Moreover, vegetable oil–based greases have the equal load–bearing capacity to paraffin oil–based grease.

The variable nanoadditives were blended with the paraffin and castor oils–based samples. The concentration of nanoadditives was varied in a range of 0.01 to 0.05 wt%. Further, the effect of nanoadditives on the physicochemical and tribological properties of the greases was evaluated as per ASTM standards. The results signified the improvement of tribological performance of grease in the presence of nanoadditives. However, castor oil–based grease samples with nanoadditives exhibited par better tribological properties than paraffin oil–based grease samples.

In another quantum of the work, coconut oil–based grease samples were dispersed with the blend of two different types of nanoadditives having variable morphologies (SiO_2 nanospheres and MoS_2 or GO nanosheets) in different weight ratios as additives. The total concentration of nanoadditives mixture was fixed to 0.05 wt%. Further, the synergistic effect of nanoadditives on the physicochemical and tribological properties of the coconut oil–based greases was evaluated as per ASTM standards under a boundary lubrication regime. The nanomaterials blend of optimized doses furnished the maximum reduction in friction and wear.

The worn surfaces of steel balls lubricated with different grease samples were analyzed using SEM, EDX, SPM, and XPS techniques to understand the role of nanoadditives. The results unveiled that the deposition of nanoadditives formed a tribo–film on interacting surfaces, which protected the tribo–interfaces against friction and wear. These findings suggest that using binary or synergistic blends of variable nanoadditives to vegetable oil–based greases can pave a direction for new generation lubricant formulation, where environmental sustainability and energy conservation are of prime importance.