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Avocado oil mixed with an antiwear additive as a potential lubricant – Measurement of antiwear and extreme pressure properties

Wani Khalid Shafi and M.S Charoo

Abstract

The paper aims to study the antiwear (AW) and extreme pressure (EP) properties of avocado oil mixed with zinc dialkyl dithiophosphate (ZDDP) in concentrations of 1% to 3% by weight for lubrication purposes. The AW and EP tests are conducted as per ASTM-4172 and ASTM-2783 standards respectively. Further, the rheological behavior of avocado oil mixed with ZDDP is determined for varying shear rates of 50 – 2000 s^{-1}. The maximum improvement in the wear properties for avocado oil is equal to 39.8% at 1 wt.%. The load wear index of pure avocado oil increases from 32.6 to 80.3 at 3 wt.% ZDDP whereas, the weld point increases to 252 kgf at 3 wt.% ZDDP. The improvement in the antiwear and extreme pressure properties are attributed to the protective film formation on the tribopairs as characterized by SEM and EDX analysis. Also, the addition of ZDDP increases the viscosity of the oil at all concentrations and maintains the Newtonian behavior of oil.

Keywords

Bio-oils, lubrication, antiwear, extreme pressure, ZDDP

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Introduction

The hazardous effects and rapid depletion of petroleum-based lubricants are driving the environmental legislation authorities to find its suitable replacement for industrial applications.[1] The petroleum-based lubricants are non-renewable with low biodegradability and high ecotoxicity. As a result, researchers have suggested the use of bio-oils as a suitable replacement for petroleum-based lubricants. Vegetable oils possess high viscosity index, high lubricity, excellent biodegradability, and low-temperature properties making them suitable for lubrication purposes.[1] A lubrication system is required to decrease friction and wear, inhibit corrosion, remove wear debris, and transfer heat. However, the base oil is unable to perform the desired functions owing to its limited physiochemical properties. The properties of base oils (mineral, synthetic, and bio-oils) are improved using different types of additives viz antioxidants, antiwear, dispersants, pour point depressants, etc.[2] ZDDP is the most widely used antiwear additive in engine oils from the last 6 decades.[3] ZDDP possesses both antioxidant and antiwear (AW) capabilities for improving the tribological characteristics of oil.[2] It is reported that ZDDP improves the antiwear properties by forming a thick protective film on the tribo-surfaces, reducing adhesion between them and consequently decreasing the wear. ZDDP films consist of two layers: pyro and orthophosphate near the substrate, and polyphosphate close to the top of the tribo-film.[4]

The effect of ZDDP on the mineral and synthetic oils are studied by various researchers. Zhang and Spikes[4] investigated the mechanism of ZDDP in two hydro-carbon fluids, DM2H (traction base fluid) and synthetic oil (PAO). The tests are conducted on a pin-on-disc tribometer with tungsten carbide as a tribo-pair. It is observed that ZDDP forms a tribofilm on the surface lubricated with DM2H base fluid. Further, the rate of formation of tribofilm is dependent on the applied shear stress. Morina et al.[5] investigated the effect of ZDDP and MoDTC on the

National Institute of Technology, Hazratbal, Srinagar, India

Corresponding author:
M.S Charoo, National Institute of Technology, Hazratbal, Srinagar 190006, India.
Email: shafcharoo123@nitsri.net