



## Effect of Temperature, Concentration and Aggregation on the Rheological Behavior of $ZrO_2$ - Avocado Oil Nanolubricant

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### Keywords:

Lubrication  
Rheology  
Nanoadditives  
Viscosity  
Aggregation

### ABSTRACT

The paper investigates the effect of dispersed  $ZrO_2$  nanoparticles on the rheological behavior of avocado oil.  $ZrO_2$  nanoparticles are added in three weight percentages and their effect on viscosity is measured on Anton par's MCR 102 in accordance with DIN EN ISO 3219 international standard. The shear rates and temperatures are varied from 500 - 4000  $s^{-1}$  and 40-100  $^{\circ}C$  respectively. The effect of low temperatures (20  $^{\circ}C$  to -20  $^{\circ}C$ ) on the viscosity of oil is also evaluated designating the pour point and cloud point of the avocado oil. The addition of nanoparticles increases the viscosity of avocado oil and preserves the Newtonian behavior of oil at all particle fractions and temperatures. The Newtonian behavior of avocado oil and the nanolubricants are quantified by the Ostwald-e-Waale power law equation. The measured values of viscosity are correlated with the existing theoretical viscosity models and a disagreement between the two is observed.

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Received: 27 March 2020

Revised: 30 April 2020

Accepted: 5 June 2020

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## 1. INTRODUCTION

Automotive tribology is one of the concerns in today's era and sustainable lubrication is an important part of it. Petroleum-based oils are non-replenishable sources of energy that are depleting continuously. Further, mineral oils release harmful elements in the environment resulting in ecological degradation. Hence, mineral oils need to be replaced by sustainable lubricants. Bio-oils are emerging as potential substitutes for petroleum-based lubricants. Bio-oil possesses excellent thermo-physical

(viscosity, viscosity index, and flashpoint) and biodegradable (non-toxicity) properties [1]. Fatty acid composition plays an important role in determining the effectiveness of bio-oils as a lubricant. There are two types of fatty acids present in bio-oils: Saturated fatty acids and Unsaturated fatty acids. Unsaturated fatty acids include monounsaturated fatty acids that contain a single double bond and polyunsaturated fatty acids that contain two or more double bonds in their fatty acid chain. Saturated fatty acids are associated with excellent tribological and oxidative properties. However, these fatty acids