7th World Tribology Congress, WTC 2022
July 10-15, 2022, Lyon, France

Separation Mechanisms and Applications of a Gas Phase Synthesized Graphene Lubricant Additive

Gordon G. Krauss[1)*], Albert Dato[1)] and Matthew Siniawski[2)]

[1)]Department of Engineering, Harvey Mudd College, Claremont, California USA
[2)]Department of Mechanical Engineering, Loyola Marymount University, Los Angeles, California, USA
*Corresponding author: gkrauss@hmc.edu

Gas Phase Synthesized Graphene (GSG) has been observed to function well as an anti-wear lubricant additive in biologically derived, petroleum based and fully synthetic base oils and in fully formulated motor oils with performance superior to platelet graphene such as AO-3. In part, the effectiveness of GSG may be due to its ability to remain in suspension for long times (weeks) compared to platelet graphene. The observed separation of GSG under certain conditions is believed to adversely impact its anti-wear function. This work explores factors leading to separation of GSG in oil and the effectiveness of mitigating efforts.

Keywords (from 3 to 5 max): graphene, anti-wear additive, wear, lubricating oils

1. Introduction

Gas Phase Synthesized Graphene (GSG) is observed to function effectively as an anti-wear additive. [1][2] The crumpled morphology of the GSG is thought to improve its suspension in lubricants and has been observed to persist throughout loading cycles. [3] That is, it does not unfold to become flat even when deformed. Though it remains suspended for long periods in various oils, GSG is observed to diffuse into higher concentration "islands" under certain conditions. When oils containing GSG at low concentrations (~0.1%wt. or less) are placed on metal surfaces, this segregation is sometimes observed. Separation into high and low concentration regions within the lubricating oil is presumed to have significant disadvantages with respect to the anti-wear properties of the GSG as the consistency of the distribution will suffer. The cause of the segregations is explored in this work including the impact of GSG concentration, oil type, and processing.

2. Methods

Separation of GSG under some conditions is visibly apparent. The impact of the observed separation on the performance of GSG as an anti-wear additive had not been quantified. Separation of GSG is observed at different concentrations in base oils and fully formulated oils when in contact with aluminum and steel alloys and other materials of interest. Changes to the segregating behavior is observed due to concentration, heating of the GSG containing oil, and the inclusion of additives.

2.1. Results

Separation of GSG from the base oil occurs intermittently and has been observed when the oil is in contact with steel or aluminum substrate but has not been observed when in glass containers. The ability to limit separation is shown in Figure 1, part D, where the GSG remains suspended in the oil in the left and upper quadrants of the 52100 steel disc but is separated on the right quadrant.

3. Discussion

Methods to limit the separation of GSG from base oils of interest are explored including heating and formulation. Controlling GSG separation may prove useful for its use as an anti-wear additive and to facilitate recapture of GSG for reuse.

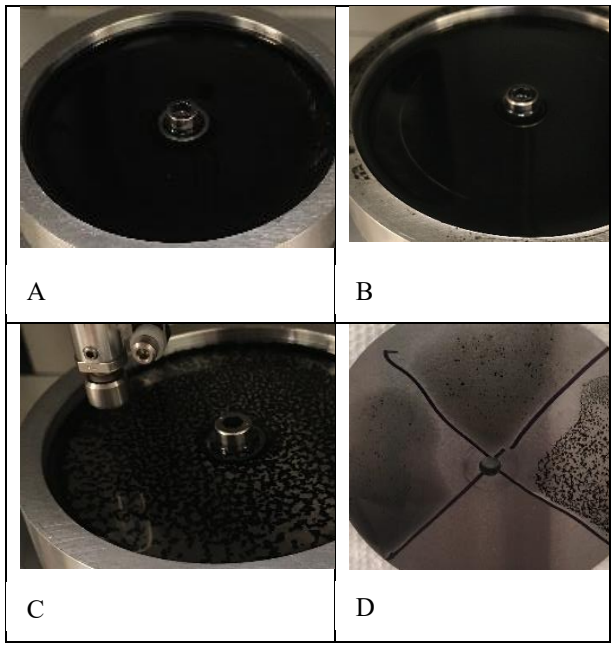

Figure 1: *A. GSG in base oil. B GSG in base oil, wear track visible post testing. C. GSG separating from base oil into regions of high and low concentration prior to testing. D. GSG remains in base oil A (left) and base oil B (upper) but separates from base oil C.*

4. References

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