Application of Suspended Nanoboric Acid as an Efficient Lubrication Additive in Engine Oil

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Abstract

Boric acid is widely used in industrial processes and agriculture, is not classified as a pollutant by EPA and produces no serious illnesses or carcinogenic effects from exposure to solutions or aerosols. It is the common term for orthoboric (or boracic) acid H_3BO_3, which is a hydrate of boric oxide B_2O_3. When in contact with water, boric oxide will readily hydrate, converting to boric acid. In the early 1990s, the lubricity of boric acid, an overlooked but extremely available and environmentally benign lamellar solid, was demonstrated by Erdemir, et al. [1, 2].

This is a new invention of nano boric acid (BA) additive hold in suspension and added into 5W-40 fully synthetic commercial lubricating oil. This invention is confidential and realized by Tribor ARGE Co. in Teknopark of YILDIZ Technical University in Istanbul-TURKEY. Turbiscan TOWER Stability Analyzer results proved that BA nano boric acid particles were in suspension.

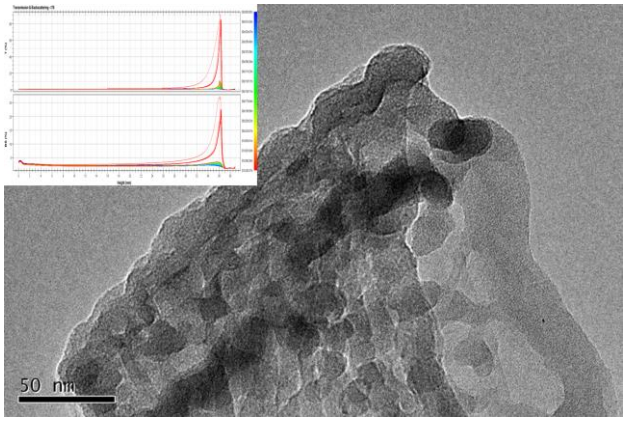

Fig.1 Turbiscan and TEM of BA prepared with Hexane.

Figure 1 proves Turbiscan (T-BS)% for suspension and shows TEM (Transmission Electron Microscopy) of BA (black patches). The size of BA varies between 50nm to the 200nm. This size is well acceptable and appropriate passing nanoparticles from engine oil filter.

In this study, ball and disk specimens were tested in ball-on-disk reciprocating (UMT 3 CETR) tribometer under boundary lubrication conditions, 100C, 3N using BA particles suspended in engine oil to investigate their wear and friction behavior.

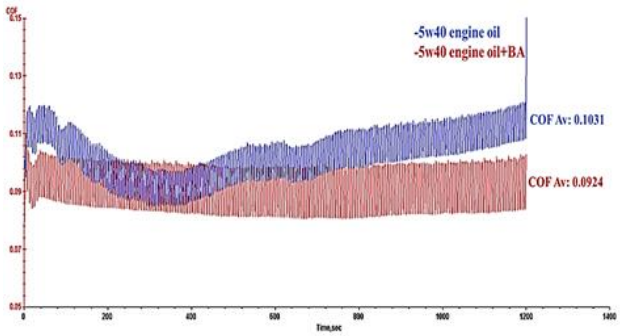

Fig.2 Friction coefficient of 5W-40 engine oil with suspended BA additive via 5W-40 engine oil in ball-on-disk reciprocating tribometer test.

According to the results, it has been found that engine oil with BA showed less friction, better lubrication and protective performance then oil without containing BA (0.0924 with BA-0.1031 non BA) (See Fig 2).

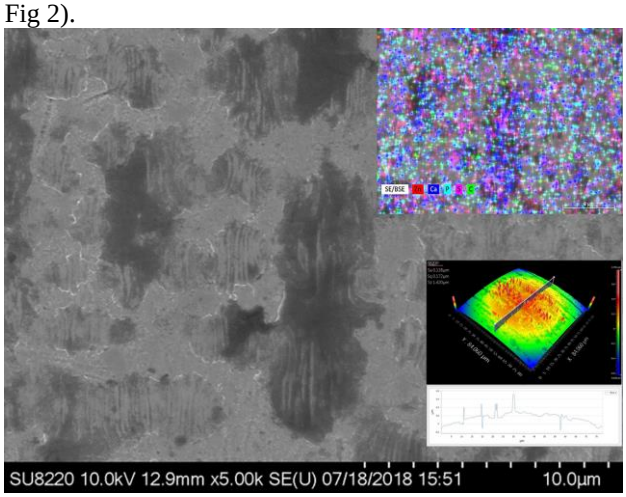

Fig.3 FESEM and 3D roughness of rubbed ball wear track with X-Ray mapping tested with 5W40 engine oil.

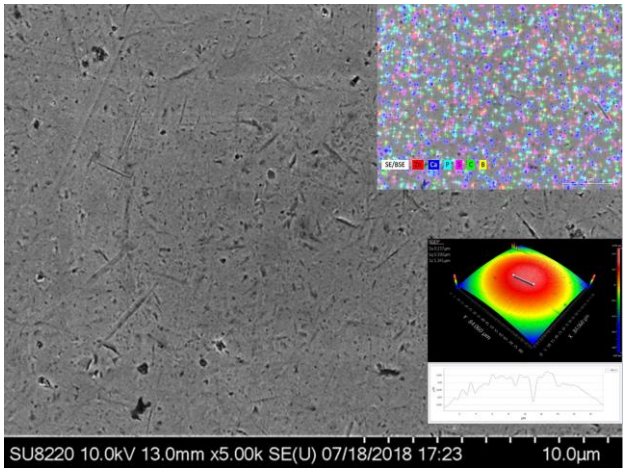

Fig.4 FESEM and 3D roughness of rubbed ball wear track with X-Ray mapping tested with 5W40 engine oil + B.

Figures 3 and 4 are FESEM and 3D roughness of rubbed ball wear track with X-Ray mapping tested with 5W40 engine oil and 5W40 engine oil + B, respectively. Protective layer of boric acid is well determined with B element on the surface examination with FESEM and mapping for the ball smooth surface. The roughness of the surface of the ball tested with engine oil + BA was less then 5W-40 engine oil. 5W-40 engine oil is well known fully formulated oil marketed in the world.

Protective layers were formed as the surfaces became smooth and well degraded on the rubbed surface of both balls. Test with 5W40 engine oil + B was very successful and wear lines, abrasive wear could not be determined as B and other elements were detected on the surface tribofilm. Good lubricity of BA helps to protect the surface during sliding.

This experimental research is a part of 1501-1507 TEYDEP TUBITAK project and engine tests will be carried out in the next step of the project.

Keywords：Nano boric acid, lubricity, friction, wear

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References

[1] Gregory Sawyer, W., Ziegert, J. C., Schmitz, T. L. and Barton, T. “In Situ Lubrication with Boric Acid: Powder Delivery of an Environmentally Benign Solid Lubricant”, Tribology Transactions, 49: 284-290, 2006

[2] Erdemir, A., Fenske, G.R., Erck, R.A., Nichols, F.A. and Busch, D, “Tribological properties of boric acid and boric-acid-forming surfaces: Part 2, Formation and self-lubrication mechanisms of boric acid films on boron and boric-oxide-containing surfaces”, Annual meeting of the Society of Tribologists and Lubrication Engineers (45th), Denver, CO (USA), 7-10 May 1990. Sponsored by Department of Energy, Washington, DC.