# The influence of nanocomposite carbon additive on tribological behavior of cylind...

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Nanocomposite Carbon additive were dispersed at varying concentrations (1, 3, 5wt%) in SN/GF-5 lubricants for automotive engines. Raman spectroscopy is used to characterize the morphology of carbon. The effect of Nanocomposite Carbon additive on the friction and wear properties of the piston ring friction pair is investigated by using UMT friction tester. The tribological mechanism of Nanocomposite Carbon additive is further investigated by scanning electron microscopy, energy dispersive spectrometer and three-dimensional shape spectrometer.

The results show that Nanocomposite Carbon additive exhibits excellent antifriction performance at high load and friction coefficient at low load. The effect of the nanocomposite carbon additive is the best when the mass fraction is 3%; however, the nanocomposite carbon additive concentrations is too high, which will lead to increased wear under high load. The nanocomposite carbon particles can smooth the micro-convex of the friction pair surface and reduce the surface roughness. The contact area of the friction pair is significantly increased, and the pressure is significantly reduced. The nano-composite carbon avoids the breakage of the bearing oil film when the metal surface peaks contact each other, ensuring the integrity of the oil film and uniformly carrying a large load. The nanocomposite carbon lubricant additive shown in this study can reduce energy consumption and extend engine life, resulting in significant cost savings.

# Introduction

Reduction in friction and wear is one of the most important objectives of tribological research [1]. With the rise of nanotechnology, many studies have been conducted in recent years using carbon nanomaterials as additive in lubricating oil to improve the tribological properties of lubricants. There are few commercial additive containing carbon nanomaterials, mainly because the dispersion and stability of nanoparticles in lubricants are not well solved[2]. The extremely fine grains of the nanoparticles, which have a large surface energy.

Large self-aggregation tendency between particles, which form large aggregates after a period of time[3]. Nanocomposite carbon additive mainly contains Ultra-dispersed diamond graphite powder manufactured from explosives, which will not cause chemical pollution. Russia's Yu. Neverovskaya has successfully modified the surface of diamond with a coupling agent to improve the lipophilicity of the diamond and the suspension in the organic phase, which proposed a dispersion model for surface modification of diamond with silane coupling agent[4-5]. Red' kin et al. added a composite additive containing nanodiamond-graphite to the engine oil, and the antifriction and antiwear properties were significantly improved[6].

At the same time, the contents of elements such as sulfur, chlorine, phosphorus, and fluorine are lowered. The friction coefficient is lowered, the smoothness of the friction pair is increased, and the noise is lowered[7]. After mechanochemical modification of nanocomposite carbon, it can form a stable colloidal system in various lubricating oils. And, it can fill the micro-cracks and unevenness on the metal surface, freely grind the sharp protrusion on the friction surface, and remove the uneven peak of the friction pair. The addition of Nanocomposite Carbon additive to the lubricating oil can improve the working life of the engine and transmission, and it can reduce friction surface wear[8]. The authors used the UMT friction and wear tester to carry out the reciprocating friction and wear test.

The effects of the content and load of the Nanocomposite Carbon additive on the tribological properties of the friction pair were investigated. The morphology and EDS analysis of the wear scar of the cylinder liner were used to explore the Nanocomposite Carbon. The tribological mechanism of Nanocomposite Carbon additive under the frictional pair of cylinder liner/piston ring is discussed.

## Experimental section

### Materials

Ultra-dispersed diamond graphite powder was purchased from Nanjing XFNANO Materials Tech Co., Ltd. SN/GF-5 lubricant were provided by Tianjin Co., Ltd. T-161A High Molecular Weight Polyisobutylene Succinimide was supplied by Jinzhou Runda Chemical Co., Ltd. T-109 calcium alkyl salicylate was purchased from Xinxiang Richful Lube Additive Co., Ltd. Coupling agent of organic titanate were provided by Dalian Richon Chem Co., Ltd. Nanocomposite Carbon Lubricant fluid Density(15 °C) and Viscosity(40 °C) are 1. 00g/cm3 and 79. 15 Cst. Ultra-dispersed diamond graphite nanoparticle size is 3-10nm. The upper and lower friction pair properties are 6×17×10mm , 45×34×8mm, Ra= 0. 43μm and hardness: 55 HRC.

## Characterizations and measurements

Configuring nano-composite carbon lubricant additive. Ultra-dispersed diamond graphite powder is mechanically chemically modified by a ball milling method to remove hard agglomeration of the nanoparticles. The nanomaterial is wrapped with a titanate coupling agent. The surface agglomerates are agglomerated by mechanical stress and activated to modify the surface crystal structure and physicochemical structure. The nanoparticle lattice undergoes displacement and internal energy increases. Under the action of external force, the titanate coupling agent acts as a surfactant to participate in the reaction and achieve the purpose of surface modification. The surfactant is coated with the surface of the particle by chemically adsorbing or chemically reacting the surface-active organic functional group with the surface layer of the nanoparticle. Nanocomposite Carbon additive with good lipophilic dispersion properties was prepared. The treated Nanocomposite Carbon additive was added to the SN/GF-5 lubricating oil, and the detergent T-109 and the dispersing agent T-161A were added. Different proportions of 1%, 3% and 5% Nanocomposite Carbon lubricant additive were prepared.

### Tribotest rig description

The upper and lower specimens are obtained from the engine piston ring and the cylinder liner, and the dimensions are as shown in the table1. The main structural features of the test rig are shown in Fig. 1. The oil sample was dripped 1 ml before the test. The test was divided into a 30 s run-in and a 30-minute test phase. The run and phase load was 50 N. The test phase loads were 50, 100, 250 and 400 N, respectively, with a temperature of 100 ° C, a stroke of 1 mm and a frequency of 10 Hz. The cylinder liner was placed in petroleum ether before and after the test and ultrasonically cleaned. The weight loss percentage of the liner is measured on the balance. Then, the three-dimensional surface topography instrument was used to observe the wear profile of the liner. Scanning electron microscopy and energy spectrometer were used to observe the wear profile of the liner and analyze the surface element composition of the wear scar.

## Results and Discussion

Raman spectroscopy Raman spectroscopy is a means of studying carbon structure efficiently and can characterize the morphology of carbon. The Raman spectroscopy of the Nanocomposite Carbon additive are shown in Fig. 2. As can be seen from the figure, the broad Raman peak near 1329 cm-1 is the characteristic peak of the sp3 structure nanodiamond, and the Raman peak observed near 1580 cm-1 is the sp2 structure nanographite. Since the Raman scattering cross section of diamond is 1/60 of graphite, this indicates that nano-composite carbon has both nano-diamond and sp2 structure nano-graphite residue [9-10].[image: ][image: ]Fig. 1 Photograph of sample holders in UMT.

### Effect of Nanocomposite Carbon additive Content on Friction and Wear Properties of Cylinder/Piston Ring Friction Pairs

The friction coefficient curve and cylinder liner wear percentage loss for a sn/gf-5 engine oil with different mass fractions of nanocomposite carbon additive at 250n load. the addition of nanocomposite carbon reduces the coefficient of friction. as the nanocomposite carbon in the oil increases the friction coefficient decreases first and then increases. when the nanocomposite carbon additive in the oil is 3% the friction coefficient is the lowest. the nano-composite carbon additive has anti-friction performance and the nano-composite carbon has a micro-polishing effect on the friction pair and the surface micro-convex body is smoothed to increase lubrication [11]. by the unevenness of the friction pair the contact surface between the friction pairs rapidly increases and the pressure between the friction pairs is directly absorbed. as can be seen from the figure. as can be seen from figure 4 the addition of nanocomposite carbon can reduce the wear of the liner compared to the sn gf-5 diesel engine oil. as the nanocomposite carbon in the oil increases the wear of the cylinder liner first decreases and then increases. especially after the carbon mass fraction of the nanocomposite of sn gf-5 reaches 3% the wear amount of the cylinder liner increases.

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