Study on Anti-wear and Anti-friction Properties of Graphene and T203 Complexity

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Abstract: In order to study the lubrication properties of graphene and T203, graphene was first characterized by scanning electron microscopy (SEM). After understanding the basic conditions of graphene, the oil additives of different concentrations of graphene and T203 were configured. The lubrication performance and synergistic lubrication effect of graphene with T203 were experimentally tested by four-ball friction and wear testing machine, and the mechanism of the joint action was analyzed. The experimental results show that the graphene materials used in this paper are multi-layered and have some impurities and defects. Adding a small amount of graphene in base oil can significantly improve lubrication, and in the test sample range, the best quality score of graphene used with dispersant span - 80 is 0.03%. Graphene and dialkyldithiophosphate zinc phosphate(T203) additive have good synergistic effect.

Key words: grapheme, anti-wear and anti-friction, complexity, synergistic effect

Introduction

Graphene has a good self-lubricating property, having a lower coefficient of friction than graphite in theory. Some progress has been made in the study of graphene as a lubricant additive. Huang Haidong [1] and others using the method of mixing ball mill prepared nano-graphite, the thickness of 10 ~ 20nm, the average diameter of about 1um. He Qiang [2] and othersmade the oil-based nano-Cu particles with an average particle size of 10 nm were prepared by liquid phase preparation. Nanometer copper particles of different mass fraction were added to N40 base oil, and their properties were investigated by four-ball testing machine. They found the 0.5wt% oil-soluble nano-copper is the best, grinding spot diameter and friction coefficient are significantly lower than the base oil, while the spindle noise, vibration velocity RMS and temperature rise are reduced. Jiao Da [3] made the AL_2O_3 / SiO_2 composite nanoparticles were prepared by hydrothermal method. The composite nano-particles were modified and added to the base oil, and the friction test was carried out. It was found that the friction coefficient was the smallest when adding 0.5wt% composite particles; the composite nano-particles get the best anti-friction effect when adding 0.5wt% concentration of nano-particles, Al_2O_3 less friction effect than SiO_2. Yu Xuguang [4] prepared by thermal decomposition of different forms of MoS_2 nano-particles, with a dispersant is added to the test 350SN base oil, we found that addition of 1.5wt% MoS_2 nano-particles and base oil wear scar diameter fibers MoS_2 nano were less than the pure base oil, the maximum bite load is improved, and the MoS_2 particles are better than the nano MoS_2 fiber. Xiong Kun [5] prepared the nanocomposite particles of boron nitride / calcium borate. After adding 1wt% nanocomposite particles, the friction coefficient and the wear spot of the base oil were significantly reduced and the maximum bite load increased obviously. Zhang Lin [6] modified stearic acid and methyl acrylate nano-yttrium oxide particles; found that liquid paraffin added 0.25wt% stearic acid modified nano-yttrium oxide PB value than the base oil increased by 37.5%, friction reduction of 39.6 %. Lin [7] and others to oleic acid and stearic acid on the surface modification of graphene to enhance its lipophilicity, in the four ball verification machine compared with the modified flaky graphite tribological properties, It was found that the modified graphene could be stably present in the base oil without precipitation, and the base oil to which the modified graphene was added was better than the base oil without the addition of the base oil and the modified flaky graphite got better Anti-wear and anti-friction effect. Zhang Wei [8] and others in the graphene preparation process with oleic acid on the graphene modified and found that the addition of 0.06wt% modified graphene base oil grinding spot is more smooth than the base oil, roughness decreased, while adding 5wt% gravel of the modified base oil of the modified graphene surface is undulating and the roughness is significantly higher than that of the base oil. The reason may be that the excess graphene is accumulated on the friction surface and becomes the abrasive, causing more wear. QiaoYulin [9] and other grapheme directly into the liquid paraffin, in the multi-functional reciprocating testing machine to study the different load and frequency of the two kinds of oil lubrication

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characteristics, found that the liquid paraffin and add 0.025wt% graphene friction coefficient and the wear volume of the liquid paraffin increased with the increase of the load. However, the friction coefficient and the wear volume of the paraffin wax were relatively small. The friction coefficient of the two kinds of oil samples decreased with the increase of the frequency, but the graphite liquid paraffin of olefins is not affected by frequency. Sandoz-Rosado EJ [10] studied the properties of graphene as a solid lubricant, and that the graphene has a high bearing capacity because the larger van der Waals force between the graphene layers makes the stress dispersal, and many studies have shown that the lubricating oil Add the right amount of graphene can effectively reduce the wear and tear.

In summary, graphene lubricants not only have high efficiency lubrication characteristics, but also contribute to energy-saving emission reduction, predecessors on the graphene launched all aspects of research and achieved some results, but the paper graphene and dioxane (T203) is very rare, and it is very important to study the application of graphene in lubricating oil additive.

1. Characterization of graphene

In order to reveal the high efficiency lubricating properties of graphene, it is necessary to characterize graphene. In this study, graphene was characterized by scanning electron microscopy (SEM). The microstructure of graphene was observed by JSM-7500F made by Japan JEOL company field emission scanning electron microscopy (SEM), and the maximum voltage was 100 million times. The scanning electron microscopy of graphene was shown in Fig. 1. It can be seen from Figure 1 that the graphene has a regular lamellar structure with an average particle size of 10um or less and a certain wrinkle and curl on the surface of the lamellae. The multilayered graphene is deposited by the van der Waals forces; Electron microscopy can only see the selected graphene for multi-layer graphene.

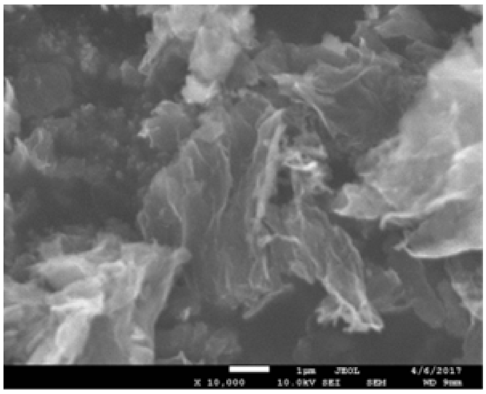


Fig.1 SEM image of numerous multi-layersGraphene

2. Gritene and T203 complex test

2.1 Compound test oil sample configuration

Base oil and additives mixed with magnetic stirring and ultrasonic oscillation for 30min each.

(1) 1 wt% T203 was added to the base oil and stirred to prepare an oil sample.

(2) 1 wt% T203 and 3 wt% graphene oil additive treated with dispersant span-80 were added to the base oil, stirred to prepare an oil sample, and the final mass fraction of graphene was 0.03 wt%.

2.2 Effect of graphene and T203 on the diameter of abrasive

Zinc dithiophosphate (T203) is a very common type of anti-oxidation anti-wear additives, the current market, most of the lubricants contain such ingredients, T203 is thiophosphoric acid, The grain diameter (WSD) values obtained from the combination of graphene and T203 are shown in Table 1, where G is graphene.

Table.1 the diameter of each oil-sample grinding under the test of graphene and T203 complex

Material	Base oil	Base oil +0.03wt%G	Base oil +1wt%T203	Base oil+0.03wt%G +1wt%T203
Diameter (mm)	0.559	0.471	0.458	0.434

Table 1 can be seen in the base oil to add graphene and T203 after the wear spot diameter are reduced, add 1wt% T203 than the addition of 0.03wt% graphene better, graphene and T203 after the combination of wear diameter the amount of a single additive is smaller, indicating that the two complex can play a synergistic effect.

2.3 Effect of graphene and T203 on the friction coefficient

The coefficient of friction (COF) of the graphene and T203 complex test is shown in Table 2. The friction coefficient of the base oil was 0.116, the coefficient of friction of the graphene oil was 0.096, 17.2% lower than that of the base oil, the coefficient of friction after adding 1wt% T203 of base oil was lower than that of the addition of 0.03wt% graphene alone, The friction coefficient of the two kinds of additives is the smallest, which is about 31.9% lower than that of the base oil, and the friction coefficient of the oil is close to that of the 1 wt% T203 alone.

Table.2 the friction coefficient of the oil samples of graphene and T203complex test

Material	Base oil	Base oil +0.03wt%G	Base oil +1wt%T203	Base oil+0.03wt%G +1wt%T203
COF	0.116	0.096	0.081	0.079

2.4 Effect of graphene and T203 on PB value

The maximum card bite load (PB) values obtained from the graphene and T203 complex test are shown in Table 3. It can be seen from Table 3 that the maximal bite load of the graphene oil sample and the T203 oil sample is larger than that of the base oil, and the oil sample with 1 wt% T203 added more than 0.03 wt% graphene oil large, the combination of the two after the largest card bite load than a single addition of a single amount of graphene and T203 are greater, it should be the effect of the two together.

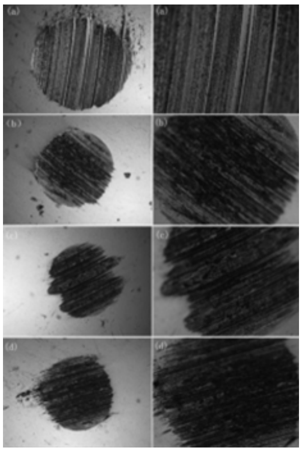
Table.3 PB value of the oil samples of graphene and T203 complex test

Material	Base oil	Base oil +0.03wt%G	Base oil +1wt%T203	Base oil+0.03wt%G +1wt%T203
PB value（N）	686	853	990	1009

2.5 Study on the Synergistic Mechanism of Grain and T203

Figure 2 for the graphene and T203 complex test corresponding to different oil-like steel ball wear surface morphology map. Figure 2 on the left side of the optical microscope under the magnification of 100 times after the ball surface morphology, the right side of the magnification of 200 times. It can be clearly seen that the surface of the oil sample is much smoother than the base oil, and the base oil exhibits more abrasive abrasive wear. Although the oil sample has a certain number of microkits, it is much flat relative to other oil samples.

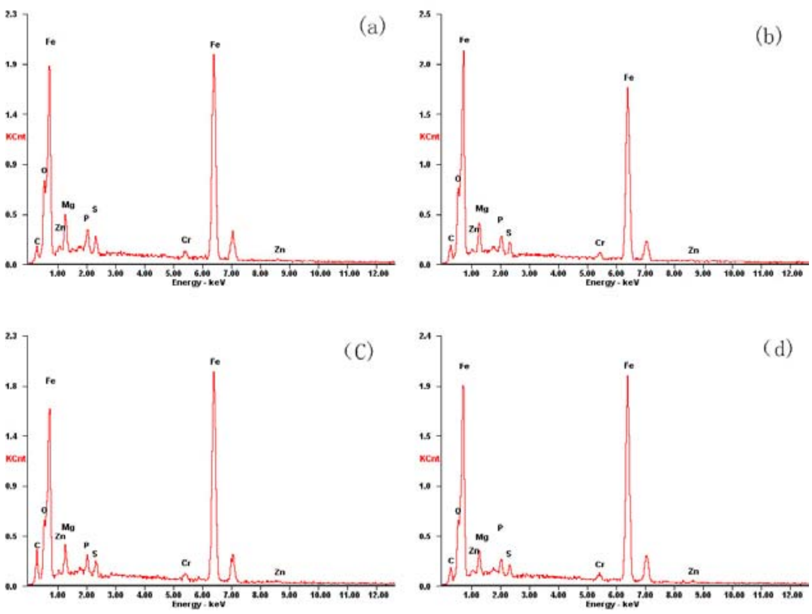
Fig.2 Surface topography of steel beads of graphene and T203 complex test



(a) base oil
(b) base oil+0.03wt%G
(c) base oil+1.5wt%T203
(d) base oil+0.03wt%G+1.5wt%T203

Figure.3 shows EDS energy spectra of the steel bead surface with oil sample and graphene and T203 complex oil-sample lubrication.

Fig. 3 EDS spectra of four different oil samples



(a) base oil
(b) base oil+0.03wt%G
(c) base oil+1.5wt%T203
(d) base oil+0.03wt%G+1.5wt%T203

The content of ESD energy spectrum elements in the surface of steel ball ground surface under four kinds of lubrication conditions is shown in table 4.

Table.4 content of the surface element of four oil - sample steel beads with graphene and T203 complex test

Oil sample	C	O	Mg	P	S	Cr	Fe	Zn
Base oil	7.16	9.04	5.18	1.78	0.98	1.56	74.06	0.24
Base oil+G	9.44	9.25	5.08	1.74	1.14	1.40	71.66	0.3
Base oil+T203	14.50	7.68	3.41	1.24	1.07	1.22	70.56	0.33
Base oil+G+T203	8.64	7.66	3.67	1.15	0.84	1.32	76.42	0.30

According to the related literature on the mechanism of T203 study, after T203 added to the base oil, the low temperature will be adsorbed on the surface of the friction to form a physical adsorption film, when the temperature increases, T203 decomposition, and chemical reaction in the surface of the friction, generate phosphate, sulfate, iron sulfide, iron oxide and other complex components of the lubricating oil film. Graphene and T203 together with the base oil added to the lubricating effect is better, which may be T203 and graphene interaction results.

3. Conclusions

In this paper, the effect of graphene and T203 oil additive is studied. The synergistic effect of grapheme and zinc dialkyldithiophosphate (T203) was studied by four-ball machine long grinding. The surface morphology of different oil samples was observed by scanning electron microscopy and EDS equipment. The synergetic mechanism of graphene and zinc dialkylthiophosphate (T203) additives. The results show that the combination of graphene and zinc dialkyldithiophosphate (T203) has a certain synergistic effect. The friction coefficient, the wear spot diameter and the maximum bite load of the oil sample are improved with the addition of the equivalent T203 alone , Which may be due to the combination of graphene and T203 in the joint effect.

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