

Impact of non-phosphorus and non-ash engine oil on after-treatment devices

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Abstract: Automobile exhaust gas contains various harmful substances other than carbon dioxide, so exhaust gas post-processing devices have been developed to reduce their environmental load. It is generally known that phosphorus in engine oil is adsorbed on the surface of an automotive exhaust catalyst and reduces the performance of the catalyst. We have developed non-phosphorus and non-ash engine oil (NPNA), in which metal-based detergents and zinc dialkyldithiophosphate (ZnDTP) were not contained. In a performance test for catalyst, the exhaust gas purifying ratio was higher when NPNA was used than when commercially available engine oil was used.

Keywords: Engine oil, Lubricants, Additives

1. Introduction

Some reports describe how metallic elements contained in engine oil such as calcium (Ca) and zinc (Zn) become ash due to combustion, the ash is deposited onto a DPF(Diesel Particulate Filter), and consequently, the DPF is clogged; a catalyst is thermally deteriorated due to exhaust gas; and sulfur (S) and phosphorus (P) contained in fuel or engine oil poison the active spot of a catalyst, and consequently, the exhaust gas purifying ratio of the catalyst decreases.¹⁾²⁾ We have been developing non-phosphorus and non-ash engine oil (NPNA), in which no ZnDTP and metal-based detergent are mixed. The use of NPNA is thought to enable us to make a DPF and a catalyst small in size and light in weight, resulting in improving vehicle fuel efficiency; consequently, the environmental load can be reduced further. We evaluated the usefulness of NPNA for catalysts. The evaluation results are described below.

2. Experimental

Figure 1 shows an overview of the accelerated deterioration test of catalysts. Two catalysts were attached in parallel to an inline-six gasoline engine with a piston displacement of 3.0 L, and NPNA was evaluated. The engine was operated for eight cycles under the condition, in which Federal Test Procedure (FTP) 75 mode (LA-4) was combined with US 06 mode, which were proposed by the United States Environmental Protection Agency (Figure 2). Subsequently, the engine was steadily operated and the exhaust gas purifying ratio of each of the catalysts was measured using analyzers that were installed before and after each of the catalysts. This measurement was performed eight times. The engine was operated for 52 h in total, which was equivalent to a vehicle travel distance of approximately 100,000 km. To accelerate the deterioration of the catalyst due to engine oil, 8 L of engine oil (obtained based on an engine oil consumption of 0.8 L/10,000 km) was injected into the fuel, and the injected engine oil was combusted together with the fuel. Table 1 shows the properties of test oils used for the accelerated deterioration test of catalysts.

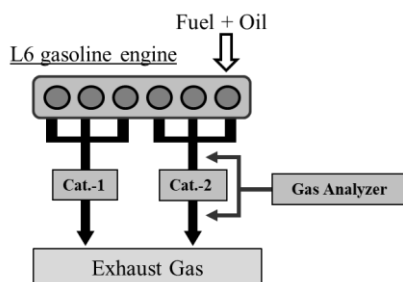


Figure 1. The accelerated deterioration test of catalysts

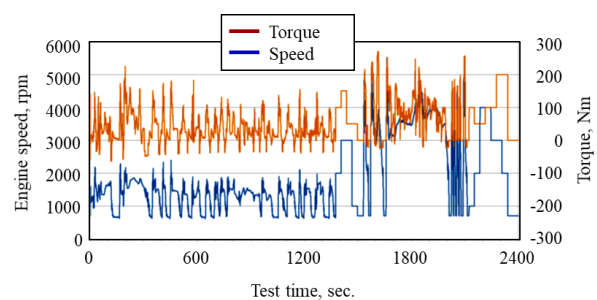


Figure 2. Engine operating condition during the accelerated deterioration test of catalysts

3. Results and discussion

Table 1 shows the properties of test oils. To examine the effect of P, Oil-A in addition to NPNA were used as test oils. Oil-A contained ZnDTP and a metal-based detergent and satisfied the ILSAC GF-4 Standards. The viscosity grades of NPNA and Oil-A were adjusted to 0W-30.

In the accelerated deterioration test of catalysts, the performance of a catalyst was evaluated using the NOx purifying ratio. The NOx purifying ratio calculated after measuring the amounts of NOx before and after the catalyst using gas analyzers. Figure 3 shows the results of the accelerated deterioration test, expressed by the average of the NOx purifying ratios of the two catalysts. The NOx purifying ratio was continuously high when NPNA was used. When the engine was operated for more than 50 h, which was equivalent to a vehicle travel distance of approximately 100,000 km, the amount of NOx released into the atmosphere for NPNA was approximately half that of Oil-A. Figure 4 shows the color mapping results obtained by analyzing the catalyst surface after the test using an electron-probe microanalysis (EPMA) apparatus. The distribution and concentration of each element are expressed by hues and shades. The concentration of an element increased as the color turned red. Although P was strongly detected in terms of red on the catalyst surface for Oil-A, no P was detected for NPNA. This tendency was also observed in Ca and Zn. Therefore, the difference in the NOx purifying ratio between NPNA and Oil-A was considered to be due to ash deposition in addition to P poisoning. S was detected for both of NPNA and Oil-A.

Table 1. Properties of oils tested

			NPNA	Oil-A
kinematic	40°C	mm ² /s	60.7	56.7
viscosity	100°C	mm ² /s	12.4	11.9
viscosity index		-	207	211
sulfated ash		wt%	0.02>	0.80
element	S	wt%	0.20	0.23
	P	wt%	nil	0.08
	Ca	wt%	nil	0.21
	Zn	wt%	nil	0.09

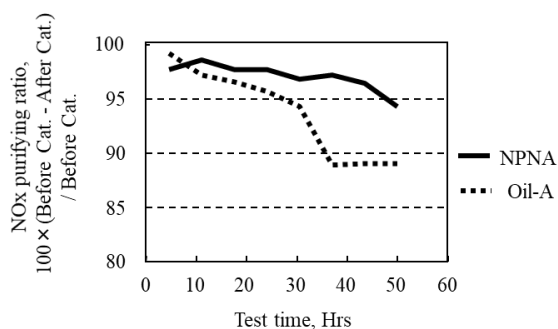


Figure 3. NOx purifying ratio

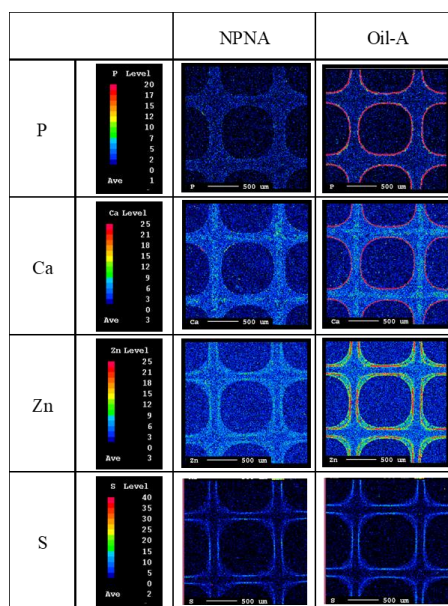


Figure 4. Analytical results of the catalyst surface after the accelerated deterioration test

4. Conclusions

The present study examined the effects of NPNA on catalysts for purifying exhaust gas by performing the accelerated deterioration test of catalysts. Consequently, the NOx purifying ratio was higher when NPNA was used than when commercially available engine oil was used.

Since NPNA is useful for three-way catalysts, the lifetime of an exhaust gas post-processing device can be prolonged and its size and weight can be reduced. Therefore, the use of NPNA is expected to reduce the amount of precious metals used.

References

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