Functional ZrO_2 nanoparticles as lubricant additives.

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Abstract

In the last decade considerable effort has been devoted to the development of organic-inorganic hybrid lubricants by introduction of different kind of nanoparticles within the base oil. When nanoparticles are added in small concentration a significantly improved performance of the base oil is observed: reduction of interfacial friction and improvement of the load-bearing capacity of the parts [1-4]. However, when using raw nanoparticles there are some withdraws that limit any benefit. Due to their high surface energy, nanoparticles tend to aggregate and sediment. Some of disadvantages can be solved or minimized by surface functionalization of the nanoparticles. In fact, it has been demonstrated that surface grafting of nanoparticles using amphiphilic organic chains is an effective way to get stable dispersions and strengthen the tribological properties of the oil.

In this work, we describe the functionalization of ZrO_2 nanoparticles with three different long-chain hydrocarbons, octanoyl-, decanoyl- and palmitoyl chlorides. The reaction between nanoparticles and the different organic chlorides was performed in dichloromethane under inert atmosphere (N_2). The synthetized functional nanoparticles were characterized by TEM, FTIR spectroscopy, RMN and Thermogravimetric analysis.

The nanoparticles were dispersed in a lubricant base oil using an ultrasonic probe. The different factors affecting the sonication process were studied using a two level experimental design measuring the size or presence of agglomerates by dynamic light scattering. The stability was measured using a Turbiscan AGS equipment. The variation of the backscattering and the transmission with time are a measure of the stability of the suspension. In Figure 1, we can observe that, after 24 h, the backscattering variation at the top and at the bottom of the measurement cell were lesser for decanoyl grafted ZrO_2 nanoparticles than for the raw ones. The tribological properties of the functional and non-functional ZrO_2 nanoparticles were measured and the results in Figure 2 showed a significant improvement using not only the raw ZrO_2 nanoparticles as additive but also with functional ZrO_2, with better results in the latter case.

These results are highly promising and work aimed to use these functional nanoparticles as lubricant additives for industrial applications is currently in progress.

References

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Figures

Top	ZrO_2	ZrO_2 Decanoyl	ZrO_2 Octanoyl	ZrO_2 Palmitoyl
0.01%	5.0	0.8	2.8	2.2
0.10%	-1.2	-1.4	-2.8	-3.1
0.50%	-17.9	-3.6	-5.1	-14.9
1%	-33.7	-3.1	-32.2	-29.7
2%	-43.6	-46.3	-11.3	

Bottom	ZrO_2	ZrO_2 Decanoyl	ZrO_2 Octanoyl	ZrO_2 Palmitoyl
0.01%	-1.0	-1.1	-1.2	-0.4
0.10%	1.1	0.6	2.4	2.1
0.50%	27.5	3.7	5.6	6.1
1%	26.3	5.1	36.9	8.8
2%	10.2	22.1	18.6	

Figure 1: 24 hours backscattering variation at the top and the bottom of the measurement cell

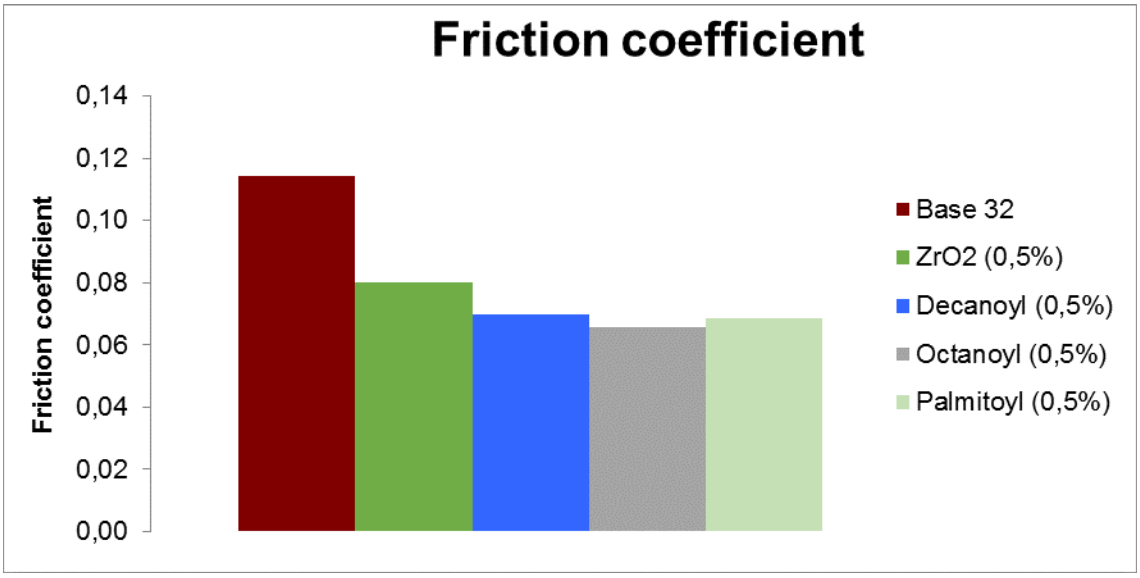

Figure 2: Friction coefficient with a 0,5% concentration of nanoparticles (Standard four ball assay, ASTM 4172-94)