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, some are difficult to disperse and tend to 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 chloride, decanoyl chloride and palmitoyl chloride. The reaction (Figure 1) between nanoparticles and the different organic chlorides was run in dichloromethane under inert atmosphere (N_2). Triethylamine reacted first with the organic chloride and formed an intermediate reactive which then reacted with the ZrO_2 nanoparticle. After 24 hours reaction the yellow suspension formed was thoroughly cleaned with a mixture of solvents. The synthetized nanoparticles were characterized by FTIR spectroscopy and RMN.

The nanoparticles were dispersed in a lubricant base oil using an ultrasonic probe. The stability of the corresponding suspensions was studied and results compared with those obtained using non-functionalized nanoparticles. The different factors affecting the sonication process were studied using a two level experimental design. Nanoparticles concentration, time and sonication cycle resulted to be significant.

The stability was measured using a Turbiscan AGS equipment. The variation of the backscattering and transmission indicated the stability of the suspension. In Figure 2, we can observe that, after 24 h, the backscattering variations on the top and on the bottom of the measurement cell were lesser for decanoyl grafted ZrO_2 nanoparticles than for the raw ones.

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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[4] D. Kim and L.A. Archer, Langmuir 27, *Nanoscale organic-inorganic hybrid lubricants* (2011) 3083-3094

Figures

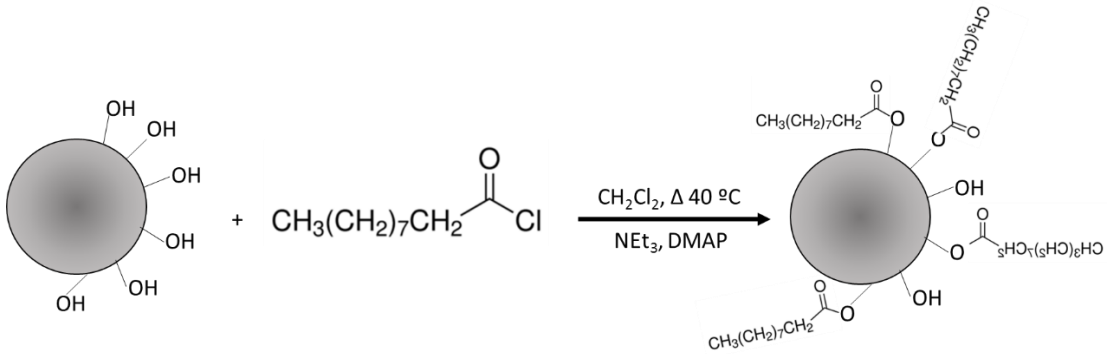
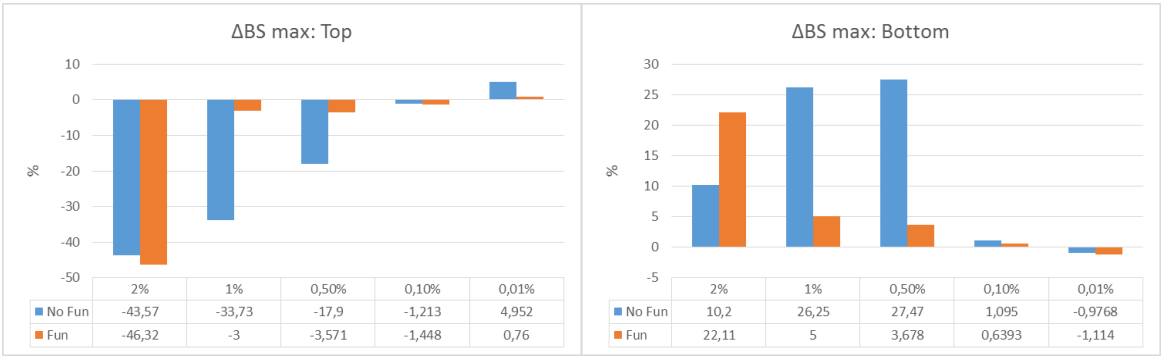


Figure 1: Reaction conditions between ZrO_2 nanoparticles and decanoyl chloride.



	2%	1%	0,50%	0,10%	0,01%
No Fun	-43,57	-33,73	-17,9	-1,213	4,952
Fun	-46,32	-3	-3,571	-1,448	0,76

	2%	1%	0,50%	0,10%	0,01%
No Fun	10,2	26,25	27,47	1,095	-0,9768
Fun	22,11	5	3,678	0,6393	-1,114

Figure 2: Backscattering variation after 24 hours on the top and the bottom of the measure cell