# WEAR RESISTANCE OF ORGANIC COATINGS WITH NANOMETRIC FILLERS

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## 1. INTRODUCTION AND OBJECTIVE

Organic compounds polymerised by UV-radiation are used as coatings to protect materials of varying nature, enhancing the **tribological** performance of the surface of these materials (improving wear resistance). However, certain applications require this wear resistance to be even further upgraded. It has thus been attempted to incorporate inorganic fillers into organic compounds, obtaining composite materials [1]. In recent years, with a view to obtaining transparent coatings with enhanced performance, these inorganic fillers have been replaced with nanometre-sized fillers, giving rise to so-called nanocomposites.

This study describes the fine-tuning of a new test method that is able to predict the tribological service performance of thin protective **nanocomposite coatings**, in which a **pin-on-disc** tribometer is connected to a microindentation tester to reduce the applied loads and decrease the track depth produced in the coatings. In the work presented here, the influence of coating nanometric filler content on coating wear resistance was studied and coating mechanical properties, such as hardness, modulus of elasticity, brittleness index, and plastic deformation [2], were correlated with coating performance.

## 2. MATERIALS AND EQUIPMENT

The **nanocomposites** prepared in this study were obtained from mixtures of a photoinitiator, acrylate monomer, and acrylate oligomer (70/27/3 ratio), in addition to different additives to improve the rheological behaviour, application, and aging of the prepared compositions. Various percentages of micrometric alumina, ranging from 5 to 20%, were added to the original matrix in order to determine the influence of the inorganic filler on tribological performance.

The coatings were deposited on a glass substrate by means of a bar applicator of 60 µm. The coatings were then subjected to a polymerisation (curing) process with a UV lamp equipped with a mercury bulb. The power used was 160W/cm and belt speed was 15 m/min. These experimental working conditions assured complete cross-linkage of the polymer coatings.

The wear tests were conducted with a Micromaterials Nanotest **microindenter**, to which an accessory was coupled for pin-on-disc tests, with a Rockwell-type conical indenter of 25 µm radius. A load of 500 mN was applied, using a rotation speed of 120 rpm for 30 minutes. The equipment allowed the depth values to be recorded as a function of time and applied load.

## 3. RESULTS AND CONCLUSIONS

Figure 1 shows the evolution of the surface wear of the nanocomposite coating, produced by the pin-on-disc micro-tribometer, as a function of the nanoparticle filler addition to the original matrix.

The results of the specific wear rate, calculated from the slopes of the plots in Figure 1, are detailed in Table 1 together with the characteristic mechanical properties of each material (hardness, modulus of elasticity, brittleness index, and plastic deformation).

These last parameters were calculated in order to be able to study the possible relationships between the wear resistance of the material and its mechanical properties.

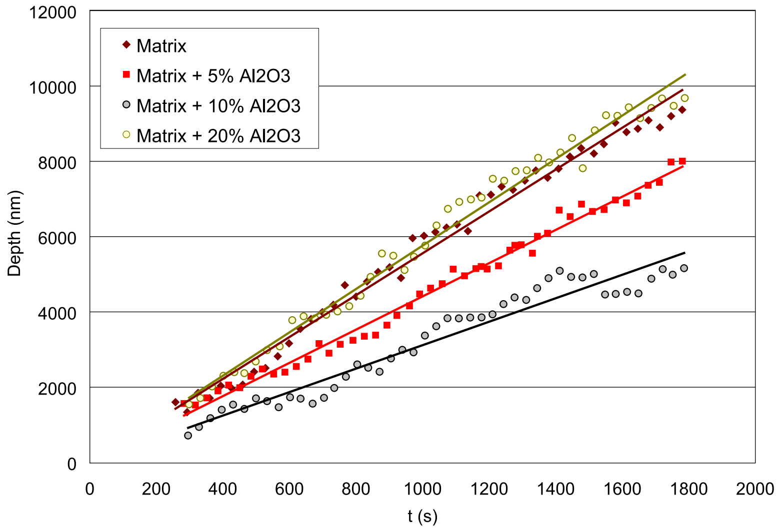


*Figure 1 Evolution of wear as a function of the nanoparticle filler addition*

| Sample | $V_e$ (μm³/m·N) | H (GPa) | E (GPa) | H/E | $H^3/E^2$ (GPa)·$10^{-4}$ |
|---|---|---|---|---|---|
| **Matrix** | 0.19 ± 0.01 | 0.19 ± 0.01 | 3.7 ± 0.1 | 0.051 ± 0.001 | 4.9 ± 0.1 |
| **Matrix + 5% $Al_2O_3$** | 0.12 ± 0.02 | 0.16 ± 0.01 | 2.9 ± 0.1 | 0.055 ± 0.001 | 5.0 ± 0.1 |
| **Matrix + 10% $Al_2O_3$** | 0.06 ± 0.01 | 0.20 ± 0.01 | 3.3 ± 0.1 | 0.060 ± 0.001 | 7.2 ± 0.1 |
| **Matrix + 20% $Al_2O_3$** | 0.21 ± 0.03 | 0.22 ± 0.01 | 4.3 ± 0.1 | 0.051 ± 0.001 | 5.7 ± 0.1 |

*Table 1 Values of the mechanical properties (brittleness index and plastic deformation) and tribological properties (wear) of each tested sample*

The results of the experiments performed indicate that an increase in the nanoparticle addition to the organic compound reduced the coating's specific wear rate, causing coating wear resistance to rise. However, this increase was not continuous since, beyond a threshold value, the coating became so rigid and brittle that the stresses generated during the friction process led to rapid wear of the coating owing to the flaking that occurred as a result of adhesive failure of the material.

The determination of the threshold value is of vital importance in the optimisation of the composition of these nanocomposite coatings in order to obtain competitive products with optimised wear resistance properties.

## ACKNOWLEDGEMENTS

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