DISPERSION OF INORGANIC WS_2 FULLERENE-LIKE PARTICLES AND ITS INCORPORATION INTO CARBON CVD FILMS FOR PRODUCTION OF NANOCOMPOSITE COATINGS

R. Torres, J. Buijntsters, R. Escobar, C. Gómez-Aleixandre, J. M. Albella and I. Jiménez.
Instituto de Ciencia de Materiales de Madrid, CSIC, C/ Sor Juana Inés de la Cruz 3, Campus de Cantoblanco, 28049 Madrid (Spain).

Ricardotg@icmm.csic.es

A new trend in the area of protecting coatings for mechanical applications is the incorporation of lubricant nanoparticles into hard matrixes to combine lubricantion and wear resistance in the same composite coating. However, the dispersion and incorporation of the nanoparticles in a coating remains a scientific and technological challenge. In particular, achieving a good disperion of nanoparticles is a major problem because they tend to agglomerate, both in air, in vacuum and in most solvents.

In this work we are considering WS_2 inorganic fullerene-like materials (IFLM) as the nanoparticles with extreme lubricating properties. WS_2-IFLM consists in onion-like arrangements of curved basal planes of the chalcogenide WS_2 with an average particle diameter of ~80 nm. As the hard matrix, we used carbon films partially hydrogenated, deposited by Electron Cyclotron Resonance Chemical Vapor Deposition (ECR-CVD) with a hardness of ~20 GPa. To obtain a nanocomposite coating, we are using a two step process: first, we cover the substrate surface with isolated and well dispersed WS_2-IFLM particles, and second we deposit a by ECR-CVD a carbon layer thicker than the particle diameter.

To obtain a homogeneous coverage of the sample surface with well dispersed particle, we have studied first the dispersion of the WS_2-IFLM nanoparticles in liquids, by testing the effect of sonication (with ultrasounds) in solutions of various concetrations of IFLM partciles in different alcohols of increasing aliphatic chain length. Afterwards, these solutions were used to deposit the IFLM's on Si (100) substrates by dip coating. Two effects could be observed: firstly, the linear dependence in a log-log scale of the surface coverage with the solution concentration and, secondly, the decrease of the IFLM agglomerate size on the Si surface with the average solvent polarity, i.e. with increasing alcohol chain length. The best agglomerate mean diameter was 450 nm in case of pentanol (C5 alcohol), despite being still far away from the single particle mean diameter of 80 nm.

On these pre-treated substrates some carbon coatings have been deposited by Electron Cyclotron Resonance – Chemical Vapour Deposition (ECR-CVD). SEM observations as well as profile analysis and composition depth profiling by Glow Discharge Optical Emission Spectroscopy (GDOES) confirm that the IFLM's remain buried under the coating. Finally, tribological measurements by pin-on-disk tests indicate that incorporation of 8% of IFLM in the surface coverage allows a reduction of 15% in the friction coefficient from a value of 0.10 in the reference carbon coating to 0.085.