PO1077

Carbon coatings doped by copper: tribological behavior in olive oil lubrication

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DLC coatings are used in many industrial areas due to their excellent mechanical and tribological properties. Doping DLC coatings by metallic or non-metallic elements can significantly modify the mechanical and tribological properties. One of the main issues of DLC films is their low interaction with lubricants; in fact, the oil lubrication exhibit in many cases higher friction coefficients than the dry sliding in humid air. Typical synthetic lubricants are detrimental to the environment and their use will be more and more limited in the near future.
In this work, we will show our attempt to face two problems referred to above. We deposited DLC films doped with Cu in order to increase the interface tribo-interaction of oil and coating surface; moreover, we selected olive oil as environment-friendly lubricant, which can be used in many mechanical systems, particularly in agriculture engineering.
The coatings were deposited in a four unbalanced magnetron Teer Coatings sputtering device (C and C/Cu targets) in argon atmosphere (hydrogen-free films) and in Ar/CH4 atmosphere (hydrogenated films). Cu content of the films was in the range 5-13 at.%. The structure of the films was nanocomposite with small Cu grains, in the range 2-5 nm, embedded in an amorphous C-rich matrix. Surprisingly, the hardness of the films was almost constant regardless on Cu content. On the other hand, a huge difference in hardness was observed for hydrogen-free (about 15 GPa) and hydrogenated films (about 4 GPa). The coatings were tribological tested in SRV equipment with a load of 50N and 200000 cycles at 25-120°C in lubricated contact with olive oil. The wettability of the films was analyzed and compared with SRV tests results. It was observed that the increase of the Cu content, in non hydrogenated coating, led to the increase of both the friction and the contact angles. Nevertheless, the friction increased only slightly from 0.10 to 0.11. For hydrogenated films, the coatings peeled off during the SRV test.

Keywords
DLC-Cu
wettability
tribology
olive oil