Analytical challenges in XPS: understanding corrosion and tribological tested samples.

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Research in the field of corrosion and tribology aims to understand the chemical reactions occurring at the surface of a material when it is in contact with the environment, e.g. the atmosphere, a solution or a lubricant. Increasing attention both from the academic and the industrial world it has been dedicated in the last decades to rationalize this interaction, especially the growth and the stability of protective films formed. These layers reduce corrosion and wear and control friction, especially under severe conditions as in marine environments or in the lubrication of mechanical parts under harsh engine oil conditions. Such protective films are very often only few nanometers thick and have a chemical composition that differs from the substrate. The synergic combination of various surface analytical resources and corrosion and tribological experiments carried out under controlled conditions has the potential to lead to the discovery either of new molecules to be added in the lubricant or to add new elements to the alloys that bring significant innovations in their functional properties. As a result, new functional materials will be able to reduce energy consumption, be environmentally compatible and sustainable.

In this presentation, I will review the challenges in obtaining well-defined passivated surfaces and tribological films with reproducible chemical properties, such that the corrosion rate and the coefficients of friction and wear can be rationalized knowing the changes in the surface properties.

Three case studies will be presented: I will discuss why it is important to determine not only the composition of the surface layer but also the composition of the material beneath the surface film when investigating the pitting resistance of stainless steels exposed to chloride solutions. In a second example, I will highlight the problem of historical brass wind instruments that are corroded during and after playing due to the high degree of humidity inside. The correlation between surface composition and corrosion rate of surfaces inside brass instruments (tuning slides) is obtained thanks to the combination of XPS and X-ray induced Auger electron spectroscopy (XAES) and electrochemical measurements carried out on reference brass alloys and on old brass instruments exploiting an electrochemical sensor and endoscopy. A third case study will be dedicated to the effect of load in the tribological performances of films formed in the presence of zinc dialkyldithiophosphates (ZnDTPs). Special emphasis will be given to the progress achieved by the application of surface-analytical techniques in determining the composition and the structure of the tribological films.