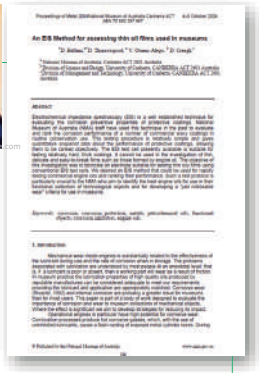
Do the Lubricating Oils Used in Scientific-Technological Objects Protect Metals Against Corrosion?

Emilio Cano[1] ecano@cenim.csic.es
Blanca Ramirez Barat[1] blanca.ramirez@csic.es
Joaquina Leal[2] joaquina.leal@muncyt.es
Maria Teresa Molina[1] mt.molina@cenim.csic.es

[1] *National Center for Metallurgical Research (CENIM), CSIC. Madrid, Spain*
[2] *National Museum of Science and Technology (MUNCYT). Alcobendas, Spain*



One of the challenges in the conservation of scientific and technological (S&T) heritage objects is their use and operation, which distinguishes them from works of artistic heritage and complicates the establishment of conservation criteria with respect to their maintenance, restoration and valorization. Moreover, these objects are often machinery made up of several materials, including those related to their operation and mechanisms, such as greases, waxes and lubricating oils, whose preservation, renewal or elimination must be decided upon.

The aim of this work was to evaluate whether the lubricating oils in S&T objects, given their ageing and lack of use, have a corrosive or protective effect on the objects' metals.

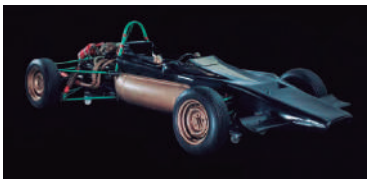
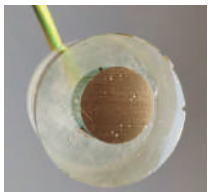


Figure 1. Two objects from MUNCYT from which lubricants oils were taken for analysis: Fórmula 1430 ME-PRE 002 race car (left) and OSSA VI-C cinema projector (right)

Methodology

We based our study in the work by Hallam et al. presented at Metal 2004. **Brass and steel** were used as representative metals of S&T heritage. Some refinements were made to improve the reproducibility of EIS. Metal cylinders, embedded in epoxy resin, abraded and to 600P grit have been used as test samples. **Electrochemical Impedance Spectroscopy (EIS)** was used to assess the protective properties of oil films and **External Reflection Fourier Transform Infrared Spectroscopy (ER-FTIR)** to characterize the oils. First tests showed low reproducibility due to the movement of oil in the electrolyte. Good reproducibility was achieved with 10 min immersion, 24 h drain, and cleaning oil remains in epoxy.



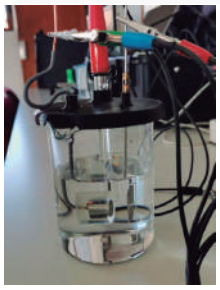


Figure 2. Preparing samples for EIS. Soaking and draining of oil (left). Sample before test, some particles remain in the oil film. The presence of these impurities has been shown to affect the reproducibility of EIS measurements (center). EIS cell (right) .

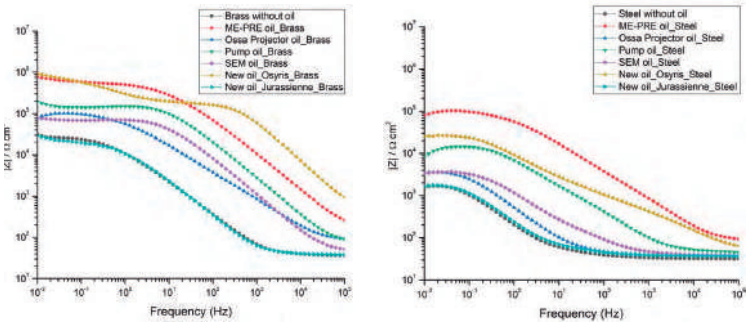
Lubricants tested

Two sets of lubricants were tested: used oils, taken from objects in the MUNCYT collection (Fig. 1) and new oils provided used by a clock restorer (X. Alvarez). Table shows the six oils analyzed.

Used oils (objects in MUNCYT)	New oils (commercial name)
Formula 1430 ME-PRE race car	OSYRIS DWL 3550
OSSA cinema projector	La Jurassiene clock fine oil
Pump (unknown origin)	
Scanning Electron Microscope	

EIS

Gamry Ref. 600 potentiostat, 3 electrode cell (stainless steel CR, Ag/AgCl RE), 0.1 M NaCl electrolyte, 10 mV amplitude, 100kHz-10 mHz frequency.

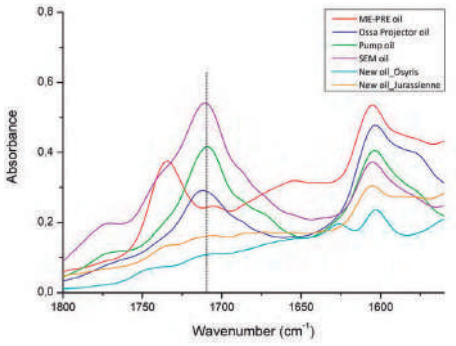


EIS of oils is similar in both metals, although impedance for bare metal is much higher for brass. Large differences (up to two orders of magnitude) can be observed between oils. Jurassiene oil does not offer any protection, EIS is similar to bare metals. Best performance is shown by ME-PRE (used) and Osyris (new) oils.

ER-FTIR

Bruker Alpha II + external reflection module. Spectra were taken on oil applied to an aluminum plate.

Evidence of the contamination and ageing of the oils shows in ER-FTIR, which revealed peaks indicative of oxidation (1710 cm^{-1}), nitration (1600 cm^{-1}) and water. The band in ME-PRE, at 1735 cm^{-1} can be attributed to contamination by fuel.



Conclusions

Refinements introduced in the EIS methodology (new sample design and long draining times) resulted in more homogeneous and reproducible oil layers. EIS allows to compare the performance of different oils, showing large differences in their performance. ER-FTIR has showed signs of ageing and contamination in oils, although there is not clear correlation between oxidation state of the oils and the protective properties shown by EIS. Results show that protective properties of lubricants can be very different, and conservation decisions regarding preservation, renewal or elimination of oils in S&T heritage should be made on an individual case to case study.

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