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# Simple Signal Processing of Linear Voltammetric Data With Matlab: Interpolation Function for Lacking Data and Filtering (Smoothing)

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## Abstract

Output data of measurements is not seldomly affected by unwanted irregularities, like noise or data lacks. Therefore signal processing, defined as signal manipulation aiming at minimizing distortions is an important step in data elaboration.

In this work Matlab was used for simple signal processing of voltammetric data registered by a Polarograph. Interpolation and filtering (smoothing) was performed.

## Introduction

Copper, either almost pure or alloyed with tin or zinc as in bronze or in brass, is one of the most common metals constituting cultural heritage objects. Among other reasons this use guarantees good preservation by the protective characteristics of copper corrosion products. This is true in many cases, except when copper chlorides are formed. Copper chlorides are in fact troublesome for stability of the objects, known as 'bronze disease' [1].

Various strategies can be adopted to preserve copper objects from damage by chloride corrosion. One of these are corrosion inhibitor treatments.

During our study on corrosion inhibitors for copper in chloride environment linear scan voltammetry was performed to evaluate the inhibitor action. As voltammetry is a very sensitive technique experimental variability easily affect measurements. In our case data were affected by an experimental error due to the $H_2$ bubbles produced on the working electrode's (WE) surface during the initial cathodic polarisation. These remained attached during on-going polarisation scan thus varying the real surface area of the WE. This irregularity forced us to not use single polarisation curves but a mean curve, obtained after various measurements, to compare data with and without inhibitor. This statistical approach should prevent from the experimental variability. Further the instrument used produced some incomplete data series due to little jumps during registration. For both reasons the obtained output data had to be processed.

While signal processing toolboxes are often included in recent voltammetry software, they are not in older ones, as in our case. Therefore data had to be processed externally. But even if these toolboxes are included, external data processing can be useful because of the variety of possible processing techniques offered, which allow more case tailored data elaboration.

## Materials & Methods

Cathodic and anodic polarisation curves were registered performing linear scan voltammetry measurements with an Polarograph (AMEL 433-A Polarographic Trace Analyser, Milan, Italy) in a thermostatted external glass cell, containing HCl 0,5 mol/L and using a platinum electrode as counter electrode, a Crison saturated calomel electrode (SCE) as reference electrode and a working electrode made of a copper bar, embedded in a epoxy resin coating. Copper was of electrolytic quality (>99,9 % Cu) and supplied by Calò Metalli s.r.l. Polarisation scan was performed from –800 to + 600 mV/SCE.

For signal processing the data points are extracted by means of Amel software in a mV - mA table and Matlab [2] hand made routine was used for calculation.

## Results

For signal processing two possible ways were explored:
1) To generate a mean curve with the data series how they were and then, to avoid irregularities in the mean curve due to inhomogeneous data series, do filtering (smoothing) (see Fig.1)
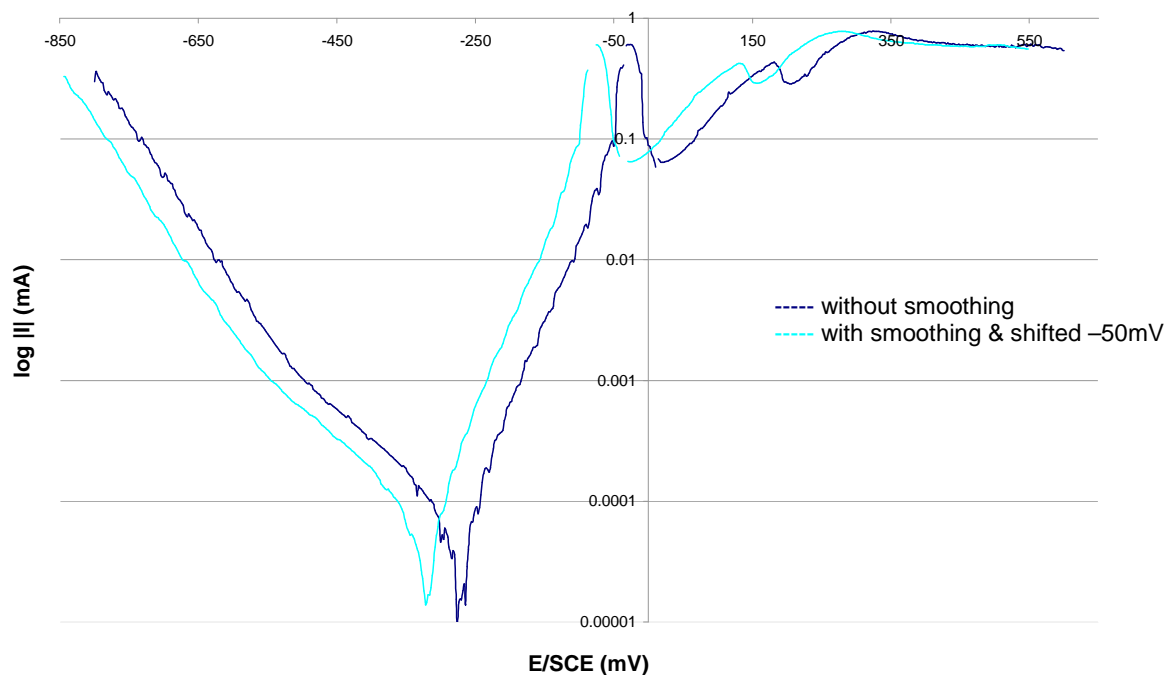


Fig. 1; The effect of a smoothing filter on data. Please note that for better visualisation the smoothed data are shifted -50mV on the x-axis

2) To firstly integrate lacking data series by an interpolation function to obtain complete series and then to generate a mean curve.

This second way seemed a more simple one to achieve the desired result as we do not need to smooth data after calculating the mean curve. In fact, irregularities in the mean curve generated with the first method were caused by lacking data points. As these are substituted by interpolated data no irregularities appear in the mean curve generated with the second method.

## Conclusions

Once accepted that Matlab operations on data rows and not on data columns, signal processing was easy, due to simple language and the availability of predefined functions. The possibility to perform different types of data interpolation (linear, cubic, etc.) is interesting for case tailored elaboration.

## References

1) D.A.Scott, Copper and Bronze in Art, Corrosion, Colorants, Conservation, Getty Trust Publications: Getty Conservation Institute, (2002), ISBN 0-89236-638-9
2) M.H.Trauth, MATLAB Recipes for Earth Sciences, 2 Ed., Springer, (2007), ISBN 978-3-540-72748-4