**4. Conclusions**

ORP-EIS has been applied to study the initial stages after immersion of the corrosion protection of AA2024-T3 provided by lithium carbonate –based coatings. The reduction of the overall measurement time by using a broadband multisine excitation signal rather than subsequent single sine excitation signals is one of the main reasons for the use of this technique. However, ORP-EIS has many other advantages. In this work, it has been demonstrated that the extra information obtained by an ORP-EIS experiment, i.e. the noise level, the level of non-linearities and the level of non-stationarities, can be used in different ways.

Firstly, the estimation of the noise disturbances can be the verification criteria of the correctness of the experimental data. It can be verified whether the conditions of linearity and stationarity (time-invariance) are fulfilled. Qualitatively, the evolution towards a linear and time-invariant system can be followed. The presence of non-linearities and stationarities in a specific frequency range can be observed and attributed to process(es) with the specific time constant corresponding to that frequency range. Quantitatively, the time at which the system reaches linear and time-invariant can be determined more precisely. Moreover, the influence of the noise on the EIS measurement results can be quantified. The quantification of the information regarding the non-stationarities per frequency decade makes it possible to recognize the (un)stable behavior of different electrochemical processes possible.

Secondly, the information about the correctness of the experimental data can be used in practice and the fitting reliability can be determined. A specific weight can be attributed for the fitting according to the type of distortions present during the measurement. As such, while the system is still behaving unstable, the data points can be weighted in a more realistic way by using either the noise, non-linearities or non-stationarities as a weighting factor. This makes it possible to gain information about the electrochemical system with the presence of noise distortions. Moreover, apart from the relative errors on each circuit element, the quality of the fit can be evaluated by the modelling residual. When this modelling residual matches the level of noise distortions it indicates that the only difference between the experimental data and the fitting results can be linked to the noise present in the system and the non-stationary behavior of the system. Consequently, the proposed equivalent electrical circuit model is able to match the experimental data within the level of noise distortions and the model can be accepted.

Finally, by monitoring an electrochemical system over time, it is shown that ORP-EIS allows studying the initial, rapidly evolving stages of corroding systems correctly. The observed trend in the parameter evolution of the respective equivalent electrical circuits elements can be explained by the behavior of the non-stationarities in the corresponding frequency decade(s).

The behavior in a particular frequency decade can be linked to the morphological changes happening during immersion in the electrolyte.

These initial stages are de facto non-stationary, as shown for lithium carbonate leaching corrosion inhibitor systems. This information is crucial in obtaining the correct data and performing reliable EIS modelling, making ORP-EIS a useful technique for future corrosion research.