TS. DOBREV, M. MONEV,
I. KRASTEV, R. ZLATEV

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An Electrochemical Method for Determination of the Corrosion Protection Ability of Chromate Films onto Zn, Zn Alloy and Cd Electroplated Coatings

The determination of the corrosion protection ability (CPA) of chromate films onto Zn and Zn alloy coatings is carried out in chambers with neutral salt spray (NSS), and usually it continues several days [1].

Different methods for express evaluation of the CPA of chromate films are known, and they are based on**:** the stationary polarization [2], dynamic impedance measurements [3], the breakdown voltage through the films [4], the Faradaic distortion of the conversion film [5], the isopotential contour mapping [6], etc.

Using this information and our experience in the application enlargement of the STEP test of Harbulak [7, 8, 9, 10] for a quality evaluation and forecast of the CPA of Ni/Cr and Cu/Ni/Cr multilayer coatings, we have developed an electrochemical method for the estimation of the CPA of chromate films onto Zn, Zn alloy and Cd coatings [11, 12, 13].

The method is based on the measurement of the anodic potential maximum, E_{Amax} (φ_{Amax}) during galvanostatic polarization in a suitable electrolyte [11].

From the φ_A/τ relationships (Fig. 1) follows**:** a) φ_{Amax} is reached in 0.05 – 0.5 sec; b) as higher is the corrosion resistance of the chromate layer, as longer is the time needed for reaching of $\varphi_A$max; c) the φ_A/τ – curve of the more resistant films shows a slower potential decrease after the maximum, and the observed oscillations are of a higher magnitude.

Adresa autora: TS. Dobrev, M. Monev, I. Krastev, R. Zlatev , Institute of Physical Chemistry "Acad. R. Kaishev", Bulgarian Academy of Sciences , Sofia 1113, Bulgaria

On the base of parallel measurements of φ_{Amax} and corrosion tests in NSS of different chromate layers onto different type of coatings, it was established a correlation relationship between φ_{Amax} and CPA in NSS (Fig. 2). This relationship is logarithmic, with a correlation coefficient r = 0.9070. By measuring of $\varphi_A$max of the chromate films and comparison with the correlation curve it is possible to determine the forecast CPA of the coatings.

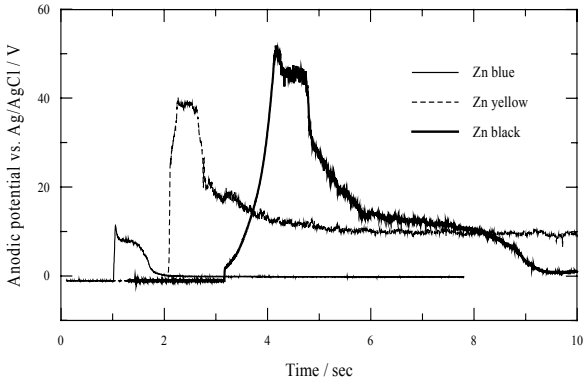

Fig. 1 - φ_A/τ relationship at i_A = 15 A/dm^2

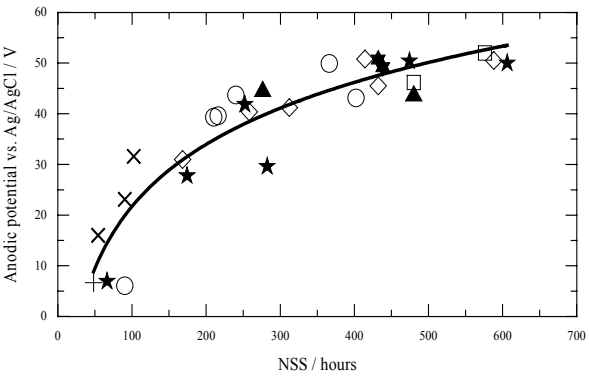

Fig. 2 - $\varphi_A$max/CPP at i_A = 15 A/dm^2

It was established that the φ_{Amax} values, determined immediately after drying the film, changed negligible in the time interval from 0 to 192nd hour. The negligible change of the φ_{Amax} in the process of aging of the conversion layer allows the measurement immediately after chromating and drying instead of after 24 or 48 hours [1].

Fig. 3 - Corrosion tester

The existing correlation between φ_{Amax} and the corrosion resistance in NSS for a large quantity of conversion chromate layers serves as a base for construction of a device (tester) (Fig.3). By this tester it is possible to measure φ_{Amax} and to transfer the data to a recorder or computer for additional calculations and storage.

The world trends for elimination of Cr^{6+} (or Cr) in the conversion films, as well as the usage of seal coatings (sealers or top coatings) onto the chromate layers – for improvement of the protective and ecological effects – are a strong challenge to further development of the express methods.

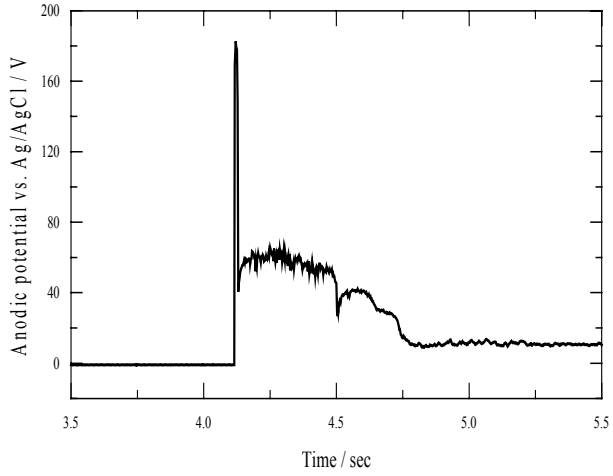

Fig. 4 - φ_A/τ relationship traced at i_A = 15 A/dm^2

Fig. 4 shows the φ_A/τ relationship on a sample with a top coating. The value of φ_{Amax} is logically several times higher than this without top coat, it increases from about 50-60 V for the chromate layer to 170-200 V for the top coat. The characteristic shape of the curve after φ_{Amax} is typical for the underlying chromate layer. We have also carried out measurements on the films without Cr^{6+} (only Cr^{3+}); on films without Cr; on phosphate coatings, etc. The establishing of a correlation with a fast standard corrosion tests for other types of conversion films would be enough for enlarging the application of the method.

The method allows forecasting the CPA of the chromate films in a few minutes, on small spots of the surface. It is possible to use the method during development of new processes for formation of conversion coatings, as well as for the quality control in the plating shops.

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