Introduction

During the cold rolling of steel, the thickness of the steel strips is reduced by applying a high pressure with two rolling cylinders. These cylinders have to be protected from the harsh conditions. Hence, they are coated with a hard chromium layer which is typically electrodeposited from an aqueous solution containing Cr(VI). Powered by the quest to a sustainable production process and by the incentive of new European legislations, OCAS NV has already been working for six years on a patented Cr(VI)-free alternative. This new hard chrome-plating process is established by the electrodeposition from a Cr(III) containing ionic liquid (IL) on a steel substrate\textsuperscript{1}.

Research goal

Due to the lack of fundamental knowledge of the deposition mechanism, it is far from straightforward to predict the in-use properties of the layer. Therefore, this project focuses on the elucidation of the coordination chemistry of the Cr(III) species in the IL as a function of composition and the presence of additives, and the link of this knowledge with the properties of the eventual hard chromium layer.

MCR-ALS of Cr(III) in Ethaline200

MCR-ALS

Multivariate Curve Resolution - Alternating Least Squares is a statistical method based on Principal Component Analysis (PCA) to find the ‘pure’ spectra of compounds contained in a mixture. It is performed on a series of UV/Vis spectra originating from samples where the composition is slightly varied. Hence a continuous variation in peak position and intensity can be observed (Fig. 1a). Five different chromium(III) species where found (Fig. 1b), which each have a concentration profile along series of spectra (Fig. 1c).

Aqueous Cr(VI) vs. Cr(III) IL ED Process

Fig. 1: (a) Series of UV/Vis absorption spectra of 0.02 M Cr(III) in water - ethylene glycol - Ethaline200. (b) Spectra of the five chromium(III) species contained in the IL mixture, calculated by MCR-ALS analysis. (c) Concentration profiles of the five compounds.

MCRALS vs. Ion Exchange Chromatography (IEC)

Fig. 2: (a) Series of UV/Vis absorption spectra of 0.02 M Cr(III) in water with increasing amount of LiCl (0 - 18 mol/kg). (b) Spectra of the four chromium(III) compounds contained in the water/LiCl samples. (c) Concentration profiles of the four species.

Semi-industrial Pilot Line

Fig. 3: The UV/Vis spectra of all five analysed Cr(III) species are presented and compared with three compounds, obtained by Ion Exchange Chromatography (IEC).

Conclusion

The pure UV-Vis spectra of five chloro-aquachromium(III) species where unraveled by means of MCR-ALS analysis in both Ethaline200 and aqueous LiCl solutions. These results were compared with results obtained by ion exchange chromatography and literature data to assign the different coordination compounds to the calculated spectra\textsuperscript{2}. These data can be used to study the ratio of the species in a large range of solvents, including ILs.

References


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