

Electrochemical conversion of chromium from tannery effluents for recycle in industrial applications



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Introduction

Electrochemical treatment of tannery effluents is gaining interest nowadays, although various other methods (ozonation, activated carbon adsorption, chemical treatment) have also been used to **remove or recycle chromium**.

Because of these methods facing operational problems or involving large amounts of chemicals, **electrochemical treatment appears to be greener and more effective** in comparison with most other commonly applied technologies.

An alternative **electrolytic method of converting Cr(III) to Cr(VI)** with the aim to be reused in other appropriate industrial applications (electroplating and chemical etching processes), is that of **electrochemical oxidation**.



Figure 1: Electrochemical Batch Reactor for Cr conversion

Cr(III) electrooxidation was carried out in an 400 ml electrochemical batch reactor (**Figure 1**) both **with non-separated and separated cathode** and anode compartments (separation helps avoid the conversion of Cr(IV) back to Cr(III) at the cathode).

Electrodes were arranged to face each other at a **distance of 5 cm** and the effluent was continuously **stirred under magnetic stirring** to enhance mass transfer.

In separated cells the **cathode** was inserted into a porous plastic envelope retrieved from a **commercial lead acid battery**.

Results & Discussion

The **choice of suitable (anode/cathode) electrode** material plays a vital role in electro-oxidation. **PbO₂** was found as the **optimum anode electrode** and **Pt/Ti** as the **cathode**.

A **thin lead dioxide layer** was formed on the surface a lead sheet (3.5cm x 6cm) using anodization for 1800 sec at a current of 3.15 A, applied through an Autolab (PGSTAT302N, Metrohm) potentiostat/galvanostat.

A DC-ELECTRONICS power supply was used to apply the desired current (at 0.5 A) at the electrodes. Using **H₂SO₄** and **NaOH** the **initial pH** was adjusted to values in the **0-3 range**.

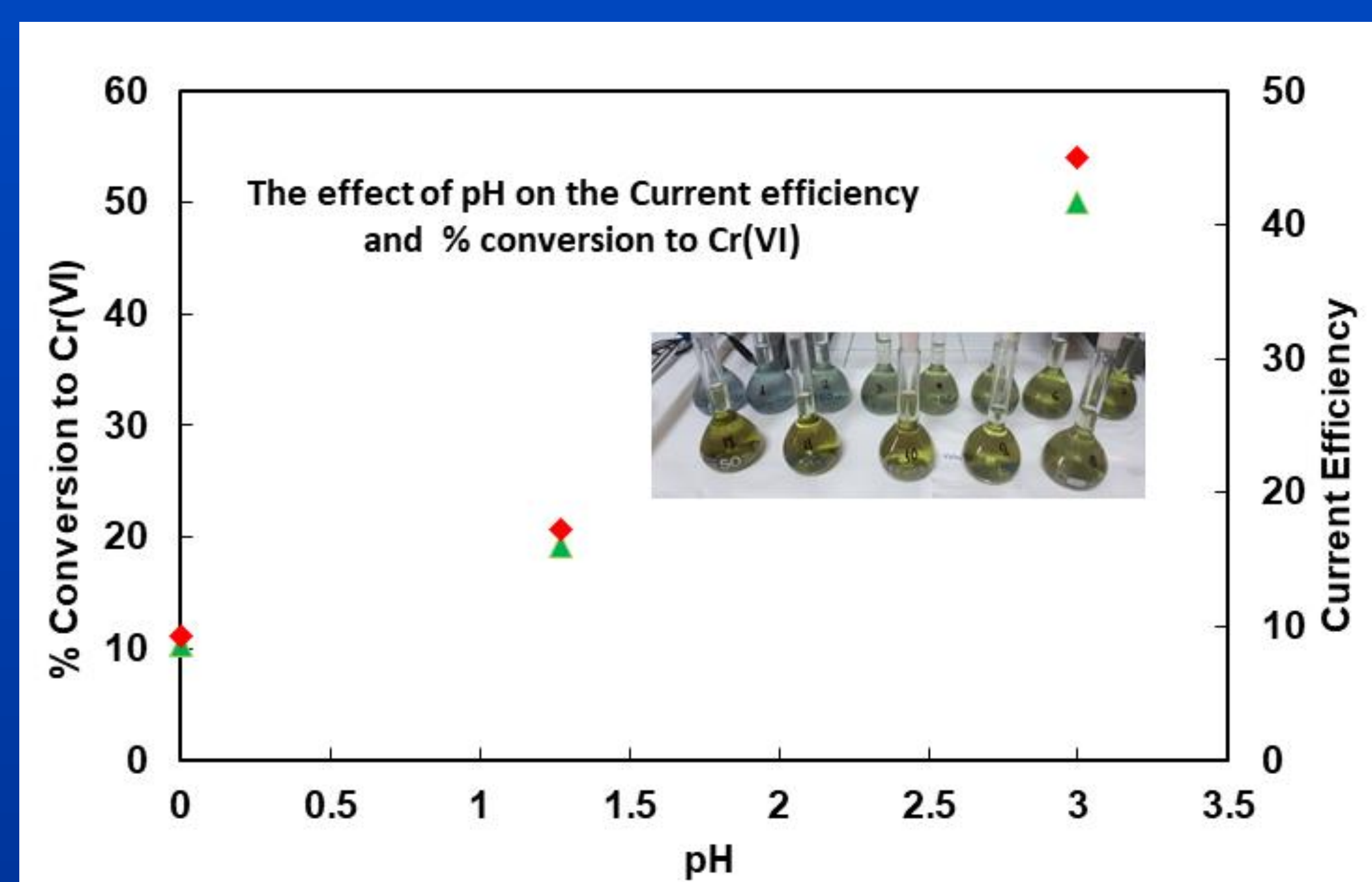


Figure 2: % conversion to Cr(VI) and the current efficiency as the effect of pH.

After 2 h of electrolysis of the effluent, a **change in colour from green to yellow** was observed while the **pH value dropped**. This is the result of the following reactions occur during electrolysis:

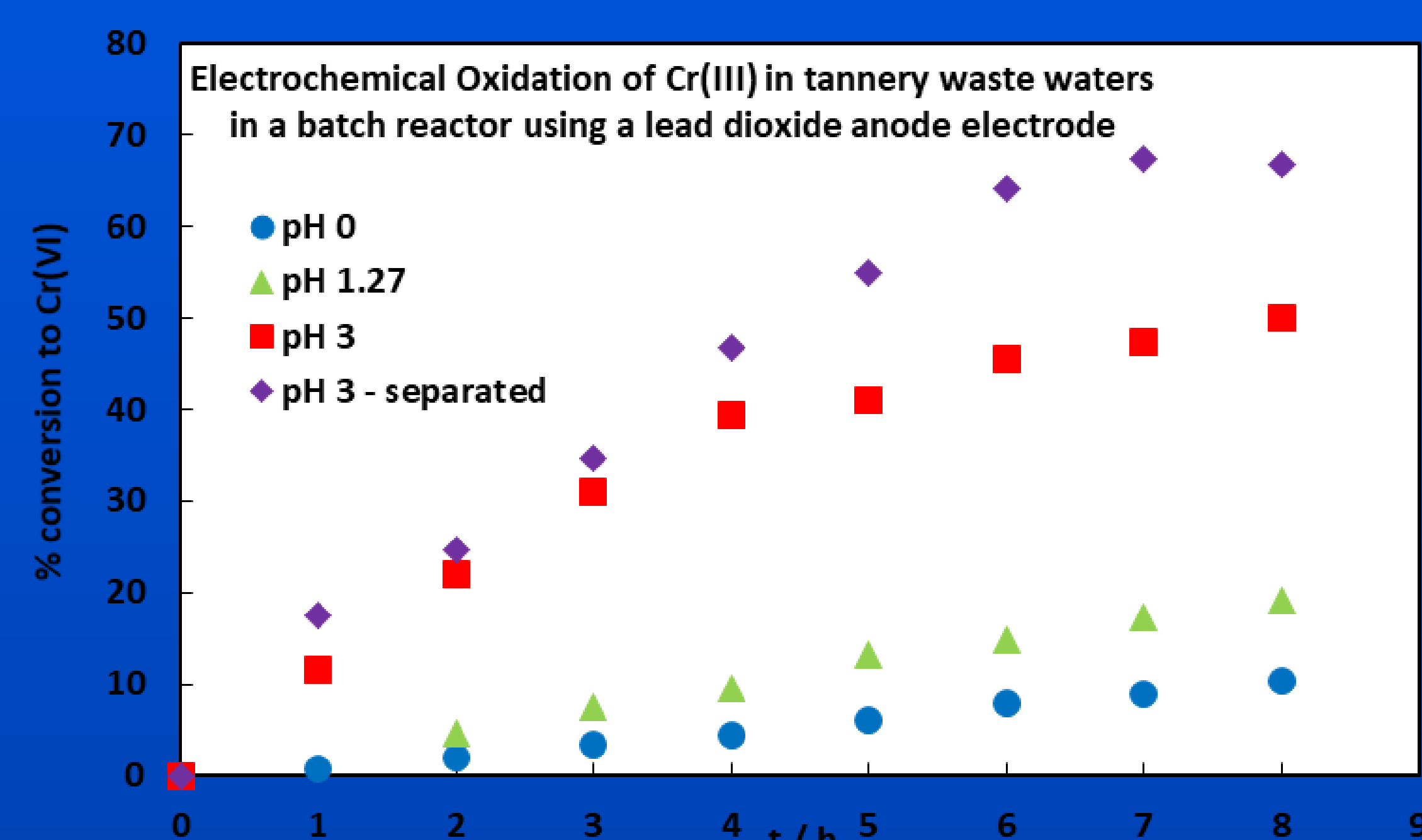
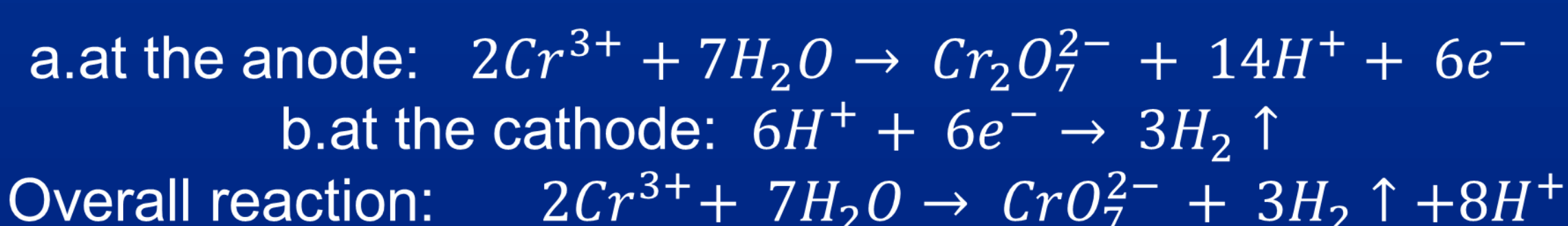


Figure 3: Conversion of produced hexavalent chromium during electrolysis' time (h) at a current of 0.5 A

The removal reaction followed **pseudo-first order kinetics**. The change in color of tannery effluent was checked at 1h intervals. Sample Cr(III) concentration was estimated by the diphenylcarbazide method at 540 nm, using a UV-spectrophotometer (HACH DR6000 Benchtop).

Figure 3 represents the resulting Cr(VI) production from **anodic oxidation of Cr(III) after 8h of electrolysis**, with initial concentration of trivalent chromium equal to 5.82 g L⁻¹.

Maximum conversion (68%) was obtained in cells with a separator, at pH=3 (current efficiency of 60%), **while the current efficiency was 45%** in case of **non-seperated cathode** and a 50% electrochemical conversion of trivalent chromium at the same optimum pH value. After 6h the conversion stopped, most likely due to the observed decrease of pH and its effect on reaction a. above.

Conclusions

The obtained results allows us to conclude that:

- **PbO₂/Pb anodes** are promising electrodes for electrochemical recycling of Cr(III)
- **Maximum conversion** (68%) was obtained in cells with a separator, at **pH=3 (current efficiency of 60%)**
- The **current efficiency was 45%** in case of **non-seperated cathode** and a 50% electrochemical conversion of trivalent chromium at the same optimum pH value.
- **After 6h the conversion stopped**, most likely due to the observed decrease of pH and its effect on reaction a. above.

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