Removing Cork Taint From Contaminated Cork Discs: Electrochemical Process Towards Zero Waste

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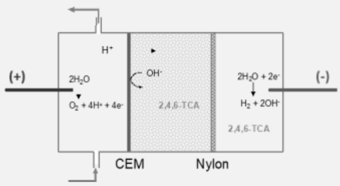

The electrochemical (EC) process was studied fort the remove 2,4,6-trichloroanisole (2,4,6-TCA) from cork discs. By applying a low-level direct current for 8 hours, the 2,4,6-TCA levels decreased in 78% of the discs to below the limit of detection (<0.49 ng/L). The best reactor design was to place the cork discs in a middle compartment separated by a passive membrane and a cation exchange membrane. 2,4,6-TCA removal was improved by 10-15% by immersing the discs in a saline solution for 24 hours before applying the current. The EC system could be a viable method for removing 2,4,6-TCA from cork discs.

Introduction

Cork is the most suitable material for sealing wine bottles due to its physical and chemical properties, biodegradability, renewability, and recyclability. Portugal leads the world in cork production, with wine stoppers representing 70% of its industrial production. However, 2-7% of wine stoppered with corks may develop an off-flavour known as cork taint, caused by cork contaminated with 2,4,6-trichloroanisole (2,4,6-TCA). 2,4,6-TCA has a low perception threshold (starting from 1.5–2 ng/L) [1] and can cause significant economic losses in the wine and cork industries. Eco-friendly processes must be used to remove 2,4,6-TCA from cork to develop sustainable and safe industrial practices. While 2,4,6-TCA removal methods are available for water treatment [2], only a few are applicable to cork stoppers [3]. This study introduces the electrochemical (EC) process as the first attempt to remove 2,4,6-TCA from contaminated cork discs [4]. EC-based technologies were tested on cork discs contaminated with 2,4,6-TCA using six different reactors, and four process variables were investigated to optimise the best-suited reactor. The study aims to provide an economical and eco-friendly solution for cork stoppers contaminated with 2,4,6-TCA, improving product quality, and reducing industry losses.

Material and Methods

Amorim Cork Research S.A. gave all cork discs naturally contaminated with 2,4,6-TCA that were used in the experiments. The EC process development was carried out in five sequential steps with a total of six different EC reactors (based on a 3-compartment setup) and four process variables being tested. Each reactor compartment presented an internal diameter of 80 mm and a length of 50 mm. The compartments were separated by membranes according to reactor design (cation exchange membrane, CEM; anion exchange membrane, AEM; nylon mesh, NY), and the DC field (10 mA; 0.16 mA/cm2) was applied for 8 hours [4]. In total, nineteen experimental setups were used. All TCA analyses were performed by Amorim Cork Research S.A following ISO 20752: "Cork stoppers – Determination of releasable 2,4,6-trichloroanisole (TCA)"

Results and Discussion

The application of a DC field was found to be effective in reducing the 2,4,6-TCA levels in contaminated cork discs, regardless of the reactor design used. The most efficient method involved placing the cork discs in the cathode area, separated from the electrode by a passive membrane made of NY, and from the anode compartment by a CEM (Graphical Abstract). To improve the removal of 2,4,6-TCA, the cork discs were immersed in a water bath for 24 hours before applying the DC field, as cork is an electrical insulator. When highly contaminated cork discs (2-5 ng/L) were subjected to the best EC treatment, 41% of the treated discs had 2,4,6-TCA levels below the limit of detection (0.49 ng/L). The catholyte and anolyte solutions showed 2,4,6-TCA levels of 1.98 and 1.04 ng/L, respectively [4]. It is worth noting that the 2,4,6-TCA concentration in the liquid samples was lower than the total 2,4,6-TCA removed from the discs, which may be due to dilution or electrochemical degradation. Organic electrochemical degradation can occur via two mechanisms: direct anodic oxidation, where the contaminants are adsorbed on the anode surface and destroyed by the anodic electron transfer reaction, and indirect oxidation in the liquid bulk, which is mediated by the oxidants formed electrochemically. Despite this, the best EC system described in this study was able to reduce the 2,4,6-TCA levels in cork discs to below the perception threshold (1.5 ng/L) in 85% of the samples. These results demonstrate the viability of the EC process for removing 2,4,6-TCA from cork discs and suggest that further technological development and scaling up should be pursued.

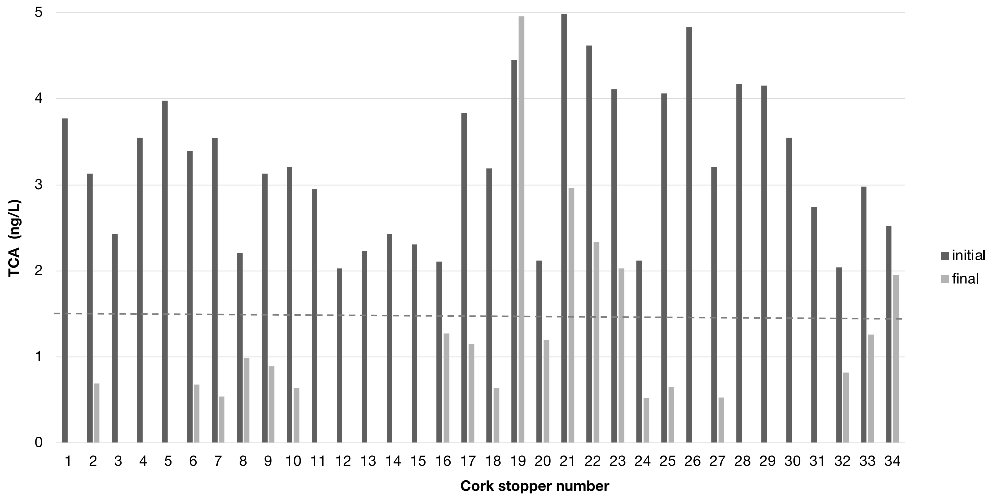

Figure 1. 2,4,6-TCA concentration *per* disc before and after EC treatment for the best set-up (Graphical Abstract). Dot line marks 2,4,6-TCA perception threshold of 1.5 ng/L. Missing bars refer to cork stoppers with 2,4,6-TCA final concentration below the Limit of detection (0.49 ng/L) (adapted from [4)].

Conclusions

In this work, the EC process was tested for removing 2,4,6-TCA from cork discs. The application of a low-level direct current for 8 hours was effective in removing TCA, independently of the reactor design used. When the cork discs were placed in a middle compartment of a 3-compartment cell, separated from the cathode by the use of a passive membrane of NY, and from the anode by a CEM, 2,4,6-TCA levels decreased to below the limit of detection (0.49 ng/L) in 78% of the cork discs. The study shows the EC system as a viable method for removing 2,4,6-TCA from cork discs.

Acknowledgments

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