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Liquid Crystal–Templated Silver Electrodeposits for the Electrochemical Detection of Haloacetic Acids

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Haloacetic acids (HAAs) are ubiquitous disinfection by-products (DBPs) in drinking and surface waters, and their routine monitoring is critical for the protection of public health. In recent years, electrochemical detection of HAAs has attracted increasing interest as a low-cost, rapid, and potentially on-site alternative to conventional chromatographic techniques [1,2].
Current research in this field primarily focuses on: (i) the development of tailored electrode materials and nanocomposites that enhance electrocatalytic activity and/or adsorption toward halogenated acetic acids; (ii) biofilm- and bioreceptor-based sensing platforms that probe HAA-induced toxicity rather than direct analyte concentration; and (iii) sensor arrays combined with chemometric analysis, which exploit electrochemical "fingerprints" to discriminate among individual HAA species in complex mixtures. While these strategies have demonstrated high sensitivity and selectivity, several challenges remain, including matrix interferences arising from natural organic matter and background halides, electrode fouling, the lack of standardized calibration against reference analytical methods, and limited long-term stability and interlaboratory validation.
In this study, silver was electrodeposited onto a gold substrate using liquid crystalline phases formed by self-assembled non-ionic surfactant molecules. The resulting silver deposits exhibited a substantially increased electroactive surface area and enhanced catalytic activity compared with conventional Ag nanoparticles. The modified electrodes were evaluated for the detection of monochloroacetic acid (MCAA), dichloroacetic acid (DCAA), and trichloroacetic acid (TCAA) by cyclic voltammetry. For each electrode, five to six independent measurement sessions were performed over a concentration range of 10–1000 µM, yielding stable and reproducible electrochemical responses. Notably, in comparison with Ag nanoparticle-based sensors reported in the literature, the proposed electrodes showed more consistent blank and analyte signals, indicating improved robustness and reliability.

[1] C. Gibi et al. 2023. Molecules. 28(23):7916. DOI:10.3390/molecules28237916
[2] W. Zhang et al. 2019. ACS Sensors. 4(5), 1138-1150. DOI: 10.1021/acssensors.9b00272