A novel activated carbon-coated carbon cloth electrode for the capture and electrolytic destruction of methyl bromide from post-harvest fumigations

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Abstract

Methyl bromide (CH_3Br) is a widely used fumigant for post-harvest and quarantine purposes in agriculture. The strong ozone depletion potential of CH_3Br has raised concerns about its continuous use. Previously, we reported the capture of gaseous CH_3Br on granular activated carbon. The activated carbon bed was subsequently filled with phosphate-buffered deionized water and converted to a cathode within an electrolysis cell. CH_3Br was reduced to release bromide. However, 90% removal of CH_3Br required ~15 hours due to the low conductivity of the granular activated carbon capture bed as cathode. Here we report a novel activated carbon-based electrode that is more conductive, reactive and robust. Micro- to nano-scale activated carbon particles were coated on a piece of carbon cloth via an easy dip-and-dry process to form an integrated electrode. This electrode can effectively capture gaseous CH_3Br due to the coated activated carbon particles. The electrode then received direct electrolytic treatment as the cathode at high current density (10 - 100 mA) due to its high conductivity given by carbon cloth. Over 90% CH_3Br removal was achieved over 6 hours during the electrolysis, with bromide as a major product. The removal efficiency increased with decreasing applied voltage down to ~ -1.2 V vs. the standard hydrogen electrode, and was highest at pH 7. The removal rate was maintained when the platinum anode is replaced with alternative anodes (activated carbon-coated carbon cloth electrode, sheet graphite) or cathodic chamber is filled with artificial seawater instead of phosphate buffer (pH=7, 10 mM). Thus, the process could potentially employ cheaper anodes and seawater available at port facilities. A long-term cycling

experiment evaluated the sustainability of the electrode, and no significant decrease in the capture or removal rate was observed over > 20 cycles. This new electrode could facilitate the application of electrolytic treatment of CH_3Br due to its easy preparation process, low cost, high capture and removal efficiency, long lifetime and high compatibility. The efficient removal technique based on this electrode can mitigate the environmental impact of using CH_3Br and thus enable its continued usage pending the identification of suitable CH_3Br replacements.