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Catalytic metal oxide nanopowder composite Ti mesh for electrochemical oxidation of 1,4-dioxane and dyes

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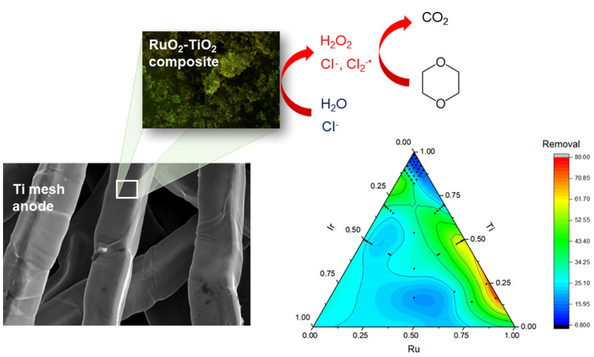
HIGHLIGHTS

- Metal oxide composite Ti mesh anodes for efficient 1,4-dioxane removal were designed.
- The most active metal oxide structure (RuO_2-TiO_2) and composition were identified.
- The 0.6RuO_2-0.4TiO_2 composite anode outperformed a boron-doped diamond electrode.
- Forming a proper coating layer thickness is required for optimal 1,4-dioxane removal.
- Reactive chlorine species and H_2O_2 oxidants are predominant at the composite anode.

GRAPHICAL ABSTRACT



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ABSTRACT

Electrocatalytic degradation of micropollutants is an attractive strategy for advanced wastewater management, but the development and optimization of innovative anodic materials are needed. This study investigated newly designed metal-TiO_2 nanopowder composite coated Ti mesh anodes for enhanced degradation of 1,4-dioxane (10 mg/L spiked) and dyes present in real industrial wastewater effluents. Based on multi-component mixture coating tests, a metal-TiO_2 composite for the most efficient electrocatalytic degradation of 1,4-dioxane was attained in the binary molar composition range of Ru:Ti = 0.6:0.4–0.9:0.1. Interestingly, Ir addition (i.e., ternary metal oxide composite) always had an antagonistic impact on the electrocatalytic performance. The binary metal oxide composite structure was X-rayed and identified as comprising RuO_2-TiO_2 crystals. Substantive removal of 1,4-dioxane and color was achieved with a small coating amount, but thicker coating had no or negative effects. This is possibly because the production of the oxidants responsible for organics degradation (reactive chlorine species and hydrogen peroxide) decreases with excessive coating layers. A properly coated binary RuO_2-TiO_2 composite Ti mesh anode was as effective (or more so) than the boron-doped diamond electrode in terms of 1,4-dioxane degradation and decolorization of real textile wastewater.

1. Introduction

Electrochemical processes have attracted much attention in recent years owing to their advantages over other removal processes, such as compact system design and ease of operation and maintenance [1–4]. Electrolyzers have small footprints, no requirement for chemical injections (e.g., oxidants), and entail no secondary problems (e.g., sludge production) [5]. Rather, they exhibit the potential to degrade dissolved

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