A Novel Catalyst for Aqueous Chlorate Reduction with High Activity, Salt Resistance, and Stability

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BACKGROUND
Chlorate ($\text{ClO}_3^-$) is an undesirable byproduct formed at the anode in chloro-alkali process and other electrochemical technologies such as water splitting. $\text{ClO}_3^-$ has also been heavily used in various industrial and agricultural applications, leading to widespread environmental pollution and challenges for water supply. Since $\text{ClO}_3^-$ has negative effects on both human health and manufacturing process, an efficient and robust approach for its removal is of great interest. Catalytic reduction of $\text{ClO}_3^-$ by platinum group metal catalysts and $\text{H}_2$ gas allows clean conversion of $\text{ClO}_3^-$ to innocuous $\text{Cl}^-$ (the only byproduct is $\text{H}_2\text{O}$). However, practical applications of previously reported catalysts are challenged by (1) limited activity at ambient temperature and pressure, (2) severe inhibition by concentrated salts in the brines.

BRIEF DESCRIPTION
Prof. Jinyong Liu’s lab at UCR has developed a novel heterogeneous catalyst for aqueous $\text{ClO}_3^-$ reduction. The catalyst contains earth-abundant molybdenum (Mo) and is 55-fold more active than palladium on carbon (Pd/C). Under 1 atm $\text{H}_2$ and room temperature, the bimetallic catalyst (MoOx–Pd/C) enables rapid and complete reduction of $\text{ClO}_3^-$ in a wide concentration range (e.g., 1 $\mu$M to 1 M) and exhibits strong resistance to concentrate salts such as chloride, sulfate, and bromide at 1 to 5 M. In a batch reactor setup, the catalyst was reused for twenty cycles of 0.18 M $\text{ClO}_3^-$ reduction and no activity loss was observed.

Fig. 1 shows the effect of concentrated salts on the reduction of 1 mM $\text{ClO}_3^-$ by the MoOx–Pd/C catalyst at a loading of 0.2 g/L. The reactions were conducted at 25 $^\circ$C and under 1 atm $\text{H}_2$.

Fig. 2 shows the reduction of 1 M $\text{ClO}_3^-$ in DI water and the treatment of a synthetic chlor-alkali waste brine sample (0.17 M of $\text{ClO}_3^-$ in 3.6 M of NaCl) by 0.5 g/L MoOx–Pd/C.
Fig. 3 shows the profiles of the reduction of 0.18M ClO$_3^-$ spikes in a multiple-spike reaction series. The decrease of activity was only caused by the gradual build-up of concentrated Cl$^-$ (see details in the publication).

APPLICATION
The high activity, outstanding stability, and strong resistance to common salts make the MoO$_x$-Pd/C suitable for removing ClO$_3^-$ and other oxyanions in the brine in the chlor-alkali process and other scenarios such as water purification, wastewater treatment, and waste brine valorization.

PATENT STATUS
Patent Pending

RELATED MATERIALS
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