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

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BACKGROUND

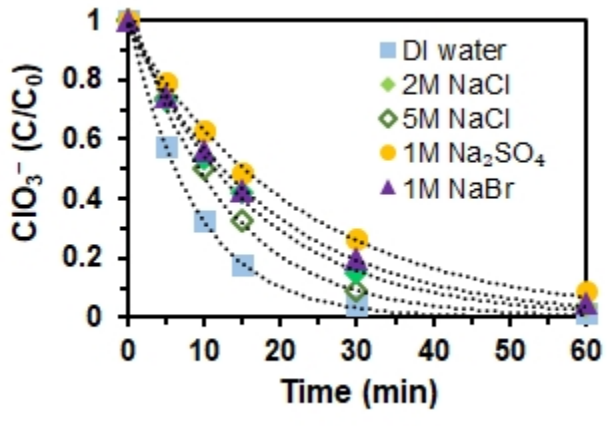
Both chlorate (ClO_3^-) and perchlorate (ClO_4^-) have negative effects on both human health and manufacturing process. In chlor-alkali plants (whose by-product is chlorate) the chlorate is currently remediated by either comproportionation reaction or catalytic reduction by H^2. Catalytic reduction of $ClO3^-$ by platinum group metal catalysts and H_2 gas allows clean conversion of $ClO3^-$ to innocuous Cl^- (the only byproduct is H_2O). However, practical applications of previously reported catalysts are challenged by:

- limited activity at ambient temperature and pressure;
- severe inhibition by concentrated salts in the brines; and,
- require high catalytic loadings to achieve a satisfactory reaction rate.

Similarly, abiotic reduction of aqueous perchlorate usually requires harsh conditions and a large excess of reducing agents.

BRIEF DESCRIPTION

Inspired by biological systems, Prof. Jinyong Liu's lab at UCR has developed a novel heterogeneous, bimetallic catalyst MoO_X-Pd/C. The catalyst contains earth-abundant molybdenum (Mo) and the carbon support of Pd/C has a high capacity to accomodate MoO_X species. The incorporation of a Mo^{VI} yields a highly active and robust catalyst. The porous carbon mimics the enzyme protein pocket (of microbes) to accommodate the oxygen atom transfer metal site. The representative figures shown below demonstrate the high activity and robustness of the catalyst for both chlorate and perchlorate reduction.



The effect of concentrated salts on the reduction of 1 mM ClO_3^- by the MoO_X-Pd/C catalyst at a loading of 0.2 g/L. The reactions were conducted at 25 ^oC and under 1 atm H_2.

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OTHER INFORMATION

KEYWORDS

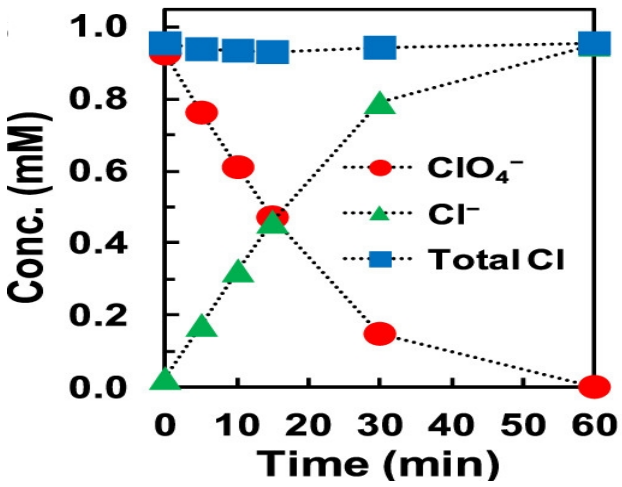
Chlorate reduction, wastewater treatment, water treatment, chlor-alkali process, molybdenum, palladium, hydrogenation catalysts

CATEGORIZED AS

- Environment
  - Other
  - Remediation
- Materials & Chemicals
  - Other

RELATED CASES

2020-216-0



Chlorine balance for ClO_4^- reduction

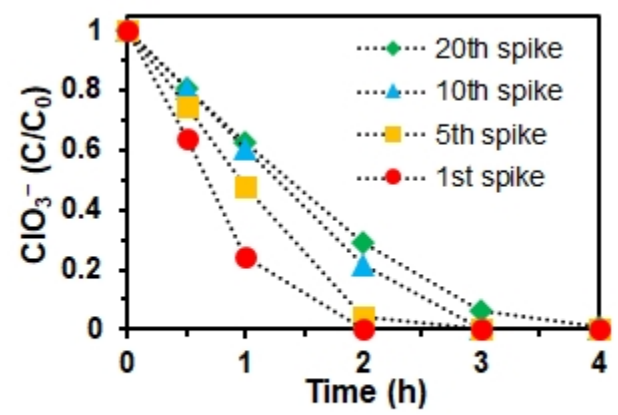


Fig. 3 shows the profiles of the reduction of 0.18M ClO_3^- spikes in a multiple-spike reaction series. The decrease of activity was only caused by the gradual build-up of concentrated Cl^- (see details in the publication).

ADVANTAGES

- 55-fold more active than palladium on carbon (Pd/C). Under 1 atm H_2 and room temperature, the (MoOx−Pd/C).
- Enables rapid and complete reduction of ClO3$^-$ in a wide concentration range (e.g., 1 μM to 1 M) and ClO4- concentration ranges from 10μM to 0.1 M.
- 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 ClO3$^-$ reduction and no activity loss was observed.

APPLICATION

The high activity, outstanding stability, and strong resistance to common salts make the MoO_X–Pd/C suitable for removing ClO3$^-$ and ClO4- and other oxyanions in the brine and in the chlor-alkali process and other scenarios such as water purification, wastewater treatment, and waste brine valorization.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	11,819,835	11/21/2023	2020-216

RELATED MATERIALS

- A Bioinspired Molybdenum Catalyst for Aqueous Perchlorate Reduction
- Catalytic Reduction of Aqueous Chlorate With MoOx Immobilized on Pd/C

RELATED TECHNOLOGIES

Please review all water treatment technologies at UCR.

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