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Catalytic ozonation of 2-isopropyl-3-methoxypyrazine in water by γ-AlOOH and γ-Al_2O_3: Comparison of removal efficiency and mechanism

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HIGHLIGHTS

- High removal efficiency of IPMP was obtained by γ-AlOOH or γ-Al_2O_3 catalytic ozonation.
- Surface reaction between ozone and catalyst determined the mechanism of catalytic ozonation.
- Intermediates of IPMP focused on aliphatic amines in catalytic ozonation were determined.

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ABSTRACT

Taste and odor (T&O) is a serious problem in drinking water. The T&O compound, 2-isopropyl-3-methoxypyrazine (IPMP), generates an earthy-musty odor in water. In this study, catalytic ozonation by γ-AlOOH (HAO) or γ-Al_2O_3 (RAO) was used as an effective method for removing IPMP in water. The comparative removal performance and reaction mechanism of IPMP in catalytic ozonation with different aluminum oxides was investigated. The removal of IPMP in neutral water pH by catalytic ozonation in the presence of HAO or RAO was 94.2% and 90.0%, respectively. Both HAO and RAO exhibited the good stability and a low leaching of aluminum ions. The effect of water pH and typical anion experiments indicated that surface hydroxyl group was key reaction sites for HAO but not for RAO. From results of *tert*-butyl alcohol inhibition, R_{ct} values and ozone consumption efficiency in catalytic ozonation, ·OH was generated in the solution in HAO catalytic ozonation or around the surface of catalyst in RAO reaction. The roles of oxidants, including ozone molecules and ·OH, were analyzed quantitatively, confirming that the surface hydroxyl group was key site for ozone decomposition to generate ·OH in solution in HAO catalytic ozonation. Ozone was adsorbed physically on the surface and concentrated ozone played an important role in IPMP removal in RAO catalytic ozonation. The nitrogen-containing IPMP intermediates generated in catalytic ozonation were determined quantitatively and qualitatively.

1. Introduction

Natural taste and odor (T&O) problems in drinking water increased in China's lakes or reservoirs recently and have receiving increased attention as the quality of human life improves [1]. One typical case of the national concern involved an outbreak of blue algae in the Taihu Lake (Jiangsu province, China) in May 2007, resulting in a T&O bloom in the lake water and severely affecting the tap water supply to the lakeside city [2,3]. As a result, the latest national sanitary standard for drinking water in China (GB 5749-2006) specifies a more stringent T&O threshold and lower concentration when compared with previous standards [4].

Natural T&O substances in the aqueous environment originate primarily from the secondary metabolic products of algae and other microorganisms [5]. These compounds primarily include geosmin, 2-methylisoborneol (2-MIB), isopropyl-methoxypyrazine (IPMP), 2-isobutyl-3-methoxypyrazine (IBMP), and 2,4,6-trichloroanisole (TCA) [6]. Conventionally, natural T&O substances can be removed from drinking water by activated carbon adsorption or oxidation [7]. To achieve better removal efficiency, a large amount of activated carbon or oxidant is required, which results in higher turbidity [8] or the generation of by-products [9]. Moreover, researches and publications on T&O removal from drinking water is limited mostly to 2-MIB, geosmin and TCA. Few studies was re-

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