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Degradation of acetone and isopropylalcohol in electronic wastewater using Fe- and Al-immobilized catalysts

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HIGHLIGHTS

- Preparation and characterization of Fe/Al immobilized catalyst.
- Oxidation of low-molecular-weight organic compounds in electronic wastewater.
- Optimal selection and mixture ratio of metals.
- Optimization of operational factors such as pH, H_2O_2 concentration, the amounts of catalysts and various acids.
- Long-term life time of catalyst.

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ABSTRACT

This paper describes a novel technology for the reuse of electronic wastewater by advanced oxidation process (AOP) using an Fe/Al-immobilized catalyst. The metal catalyst in the AOP improved the oxidation of low-molecular-weight organic compounds, such as acetone and isopropylalcohol, in electronic wastewater. The removal efficiency of acetone and isopropylalcohol were 78.5% and 99.9%, respectively. The optimal combination of metal catalysts in the oxidation of acetone was Fe and Al—10% Al in various Fe/Al catalysts. The optimal pH was less than 3, and the proper addition of H_2O_2 and catalysts was an important factor in the AOP. Using optimal metal catalysts, significant amounts of organic compounds were removed from raw electronic wastewater using a continuous flow reactor. We conclude that an AOP with a metal catalyst removes low-molecular-weight organic compounds (91% removal efficiency of isopropylalcohol) and can be implemented as a wastewater treatment and reuse system.

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1. Introduction

Electronics manufacturers must innovate and produce at tremendous speed and volume to survive technology cycles. Increasing capacity, reducing costs, and meeting the demand for more complex products require innovative technologies for water reuse as a water-consumable industry [1,2]. With the recent growth of the thin-film transistor-liquid crystal display (TFT-LCD) and organic light-emitting diode (OLED) industries in Korea, water consumption has risen significantly, raising the issue of maintaining sufficient water supplies by reducing and reusing wastewater. However, low-molecular-weight organic compounds, such as acetone and isopropylalcohol, exist in the wastewater that is discharged by electronics industries. Because such organics are not removed completely through reverse osmosis, they limit the reuse of electronic wastewater.

Advanced oxidation processes (AOPs) are used to destroy organic compounds in water by generating hydroxyl radicals (·OH) that have much stronger oxidation potentials than agents that are used in conventional oxidation processes. AOPs have been examined with regard to high-energy oxidants, such as ozone and H_2O_2, and photons that generate highly reactive intermediates.

Methods of generating ·OH radicals can be classified by Fenton oxidation [3,4], UV oxidation [5,6] and metal-catalyzed oxidation [7,8]. Fenton oxidation requires the continuous addition of ferric chloride and secondary treatment of the sludge that is generated as a byproduct [9]. Also, UV oxidation fails to oxidize many of the persistent organic pollutants into small molecules, such as H_2O and CO_2, and its operating costs are relatively high [10]. These drawbacks can be overcome with heterogeneous catalysts [10–12], the use of which is typically called heterogeneous Fenton oxidation. Transition metals, primarily iron, are used as the active phase. Due to differences in catalytic methods, Fenton's reaction is distinct from other metal- and metal oxide-catalyzed oxidation reactions.

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