Electrochemical reduction of nitrate using TiO2 nanotube arrays

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Abstract
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Abstract

Nitrate can be reduced on the surface of a cathode at a voltage determined by the electrode material. The choice of electrode material is key in achieving the nitrate removal with high efficiency. During the cathodic reaction, nitrate can be reduced to ammonia or gaseous products (N2 and N2O). Denitrification can be achieved by combining cathodic reduction of nitrate with anodic oxidation of ammonia. It has been reported that ammonia can be efficiently oxidized with RuO2/Ti anode and the major product is nitrogen.
The purpose of this research is to investigate the possibility of using a Ti plate with TiO2 nanotube arrays as a novel cathode for nitrate reduction. TiO2 nanotube arrays were grown on the Ti plate by anodization in a glycerol based electrolyte and annealed to change crystallographic structure. Morphological and crystallographic structures of Ti plates with TiO2 nanotubular layer were analyzed before and after anodization or annealing by using scanning electronic microscopy, energy-dispersive spectroscopy, Brunauer-Emmett-Teller analysis, and X-ray diffraction. Cyclic voltammetry and electrochemical impedance spectroscopy were also performed to test the electrochemical reactivity towards nitrate reduction. A lab-scale electrochemical reactor with RuO2/Ti anode and Ti plate with TiO2 nanotubular layer as a cathode was operated to treat the synthetic wastewater containing up to 600mg/L of nitrate-N. The Ti plate with TiO2 nanotubular layer was compared with other cathodes such as Ti, Cu, Ni, and Stainless Steel. Ti plate with anatase TiO2 nanotubular layer with the layer thicknesses higher than 45 μm was able to show the most efficient nitrate reduction.

Keywords: *Advanced oxidation process, TiO2 nanotube, Anodization, Nitrate reduction, Electrolysis, Electrochemical reduction*