Development of Nitrate-ion Battery to Realize a Sustainable Denitrification System

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Nitrate (NO_3^-) ions pose a serious threat due to eutrophication and health issues such as blue baby syndrome, cancers, and diabetes; however, methods for sustainable denitrification have yet to be established. In this study, a nitrate-ion battery was developed for the removal of NO_3^- ions. The battery generated power using NO_3^- as a fuel and NO_3^- removal were achieved simply by placing the cathode and anode into water containing NO_3^-. The cathode facilitates NO_3^- removal from the water by reduction to N_2 gas or NH_4^+ ions. NH_4^+ was removed by oxidation to N_2 at the anode. The nitrate-ion battery yielded a power density of ca. 0.2 W/cm2 from 1 mol of NO_3^-, and NO_3^- removal was demonstrated. The cathode consists of a carbon electrode fixed with film-like graphitic carbon nitride ($g\text{-}C_3N_4$) by vapor deposition of a heterocyclic compound such as melamine at 550 °C. NO_3^- reduction was promoted by $g\text{-}C_3N_4$ fixed to the cathode after the removal of impurities by washing in NaOH solution at 80 °C. The $g\text{-}C_3N_4$, which has a layer structure similar to graphite, was refined and the surface area increased by the washing step, and the catalyst activity was improved. The anode consists of an activated carbon support with iron oxide particles fixed in the fine pores by heating at 600 °C. NH_4^+ oxidation increased significantly only when iron oxide was supported on the activated carbon, because NH_4^+ and H_2O are considered to be separated by voids formed between activated carbon and iron oxide.