Nitrate reduction on bimetallic nanoparticles supported by soil minerals

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Since the dawn of industrial and agricultural revolutions, the water bodies are always under severe stress due to excessive usage, climate change, and pollution by numerous chemical pollutants. Nitrate is one of such pollutants which can be discharged from domestic, agricultural, and industrial origins. Nitrate appearance in water bodies poses serious environmental problems, i.e. 1) it is toxic to human life thus making water unfit for human consumption, and 2) it can disturb global food chain due to the depletion of dissolved oxygen in water bodies by excessive algal growth. Global and local nitrate pollution problems demand rapid, stable, and efficient denitrification treatment methods. Recently, catalytic nitrate reduction by bimetallic catalysts has emerged as a feasible solution due to its high nitrate removal capacity and selective conversion of nitrate into eco-friendly nitrogen. Intensive research works have been carried out to improve the reactivity of bimetallic catalysts and their application to the real environmental problems. Satisfactory experimental results have been reported by focusing on the optimization in catalyst synthesis methods, catalyst compositions, and relevant reaction conditions. However, the selection of support material is still under development. To date, the support materials widely used and reported are mostly refined and synthetic ones. To the contrast, natural soil minerals and naturally originated materials have not been fully explored despite their huge potential reactivity, economical value, and abundance in environment. Here, we have reported use of natural soil mineral and soil, i.e. sodium montmorillonite and modified red mud as support materials for Sn-Pd-bimetallic catalysts to develop a reactive and selective nitrate reduction process. Two bimetallic catalysts i.e. Sn-Pd-Na montmorillonite, and Sn-Pd-red mud were synthesized by developing synthesis methods. Sn-Pd-montmorillonite showed 80% removal while Sn-Pd-red mud showed 100% of (30 mg/L NO_3-N) nitrate removal. Sn-Pd-red mud has shown fastest reaction kinetics ($k=7.5\times10^{-2}$ min^{-1}) followed by Sn-Pd-Na montmorillonite ($k= 0.75\times10^{-2}$ min^{-1}). The Sn-Pd-red mud catalyst also showed highest (81%) N_2 selectivity. The experimental study shows that natural soil minerals and soil can be used for a good support material of bimetallic catalyst having significant potential for the application to environmental remediation sites.