Nitrate reduction reaction using bimetallic alloy nanoparticles as catalyst

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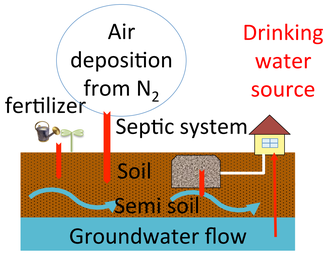
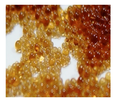
Introduction and Objectives

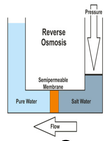
Origin of Nitrate



Traditional methods to remediate



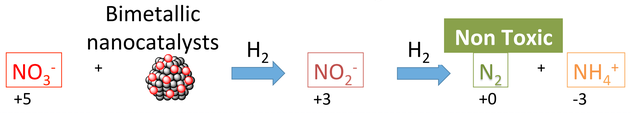
Ion Exchange



Reverse Osmosis

Concentrated phase still needs to be disposed

New technology to Reduce NO_3^- [1]



Objective

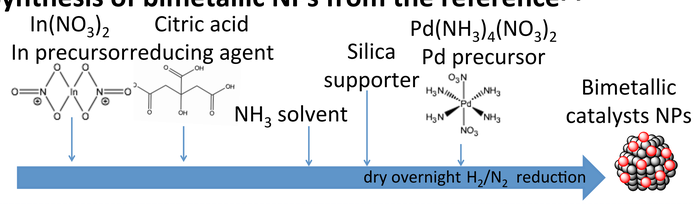
Understand the mechanism of the reaction of nitrate degradation in water and improve the activity of catalysts and selectivity to N_2

Approach

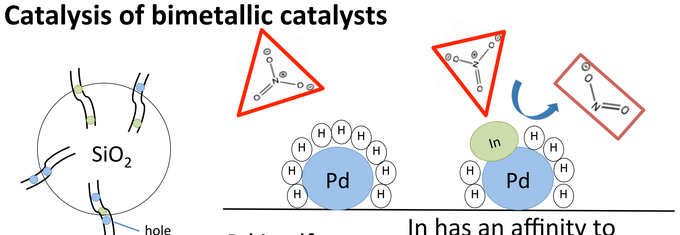
Compare the effeteness of Pd-In/SiO_2 and Pt-In/SiO_2 nanoparticles (NPs)

Materials and Methodology

Synthesis of bimetallic NPs from the reference[2]



Catalysis of bimetallic catalysts



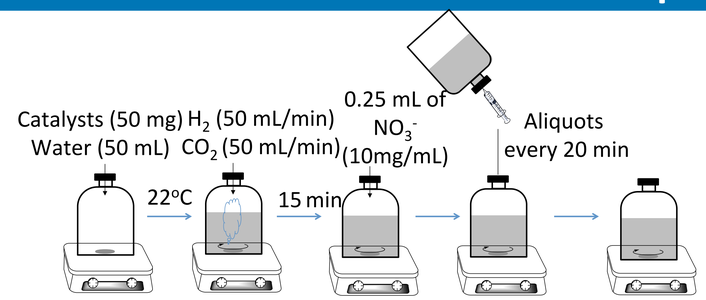
Pd itself cannot reduce nitrate

In has an affinity to absorb nitrate and activate the reaction

Testing methods

- NO_3^- testing with nitrate selective electrode
- NO_2^- testing with Griess reagent
- NH_4^+ testing with Nessler reagent

Nitrate reduction reaction set up

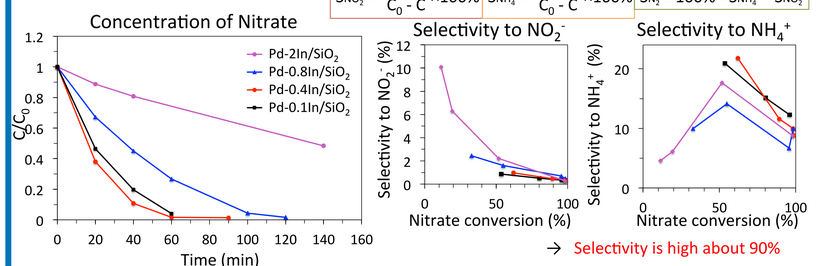


- Initial NO_3^- concentration: 50 mg/L
- H_2 addition to degrade NO_3^- and then NO_2^-
- CO_2 addition to adjust pH to around 5
- Determination of NO_3^-, NH_4^+ and NO_2^-

Results

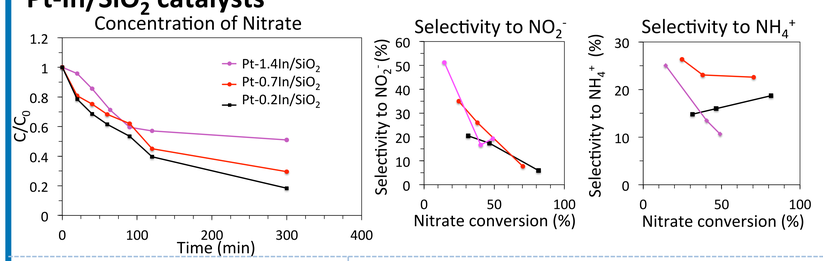
Pd-In/SiO_2 catalysts

$$S_{NO_2^-} = \frac{C_{NO_2^-}}{C_0 - C} \times 100\% \qquad S_{NH_4^+} = \frac{C_{NH_4^+}}{C_0 - C} \times 100\% \qquad S_{N_2} = 100\% - S_{NH_4^+} - S_{NO_2^-}$$

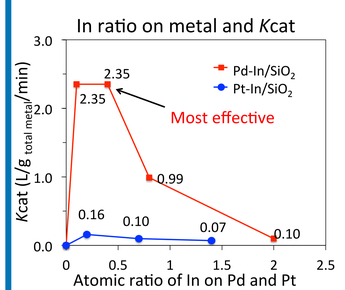


→ Selectivity is high about 90%

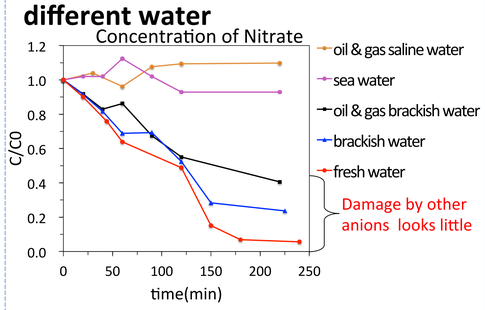
Pt-In/SiO_2 catalysts



Pd-In/SiO_2 vs. Pt-In/SiO_2



Performance of Pd-0.4In/SiO_2 in different water



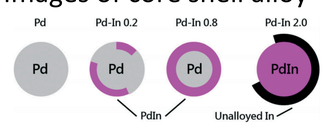
Discussion and Conclusions

- Pd-based bimetallic catalyst has better ability to remove nitrate from water than Pt-based bimetallic catalyst
- Pd-In catalyst has structure-dependent activity for nitrate reduction
- The produced water has different anions, which compete and block the absorption or active sites for nitrate reduction
- The selectivity to N_2 is high almost at 90 % in the case of Pd-In/SiO_2 catalysts

Next steps

- Catalyst recyclability study repeated for several cycles of reaction to check the evidence of metal separation and find out the deactivation mechanism
- Poisoned mechanism by other anions in water
- More characterizations before and after nitrate reduction reaction
- Better combination and composition of bimetallic catalysts
- Morphology and structure study of the bimetallic nanoparticles

Images of core shell alloy[2]



References

[1] Shuai, D., Choe, K. J., Shapley R. J., and Werth, J.C., (2012) Enhanced Activity and Selectivity of Carbon Nanofiber Supported Pd Catalysts for Nitrite Reduction , *Environnemental Science & Technology* , 46(5), pp 2847-2855

[2] Wu, Z., Wegener, C.,E., Tseng, H., Gallagher, R., J., Harris, W., J., Diaz, E., R., Ren, Y., Ribeiro, H., and F., Miller, T., J., (2016) Pd-In intermetallic alloy nanoparticles: highly selective ethane dehydrogenation catalysts, *Catalysis Science & Technology*, 6 , pp 6965-6976

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