Catalytic Reduction of Nitrate in Drinking Water

Nanette Zahrtmann

DTU Chemistry, Technical University of Denmark

Pollution of drinking water by nitrates is globally a large and growing problem as mineral fertilizers are becoming accessible to an expanding population. The problem arises from fertilizer being washed out of the soil and into ground and surface waters making it unsuited for drinking. In Denmark clean and safe drinking water is provided by rich groundwater resources. Polluted wells can often be retired in exchange of new, deeper, clean wells. Areas with surface water in the drinking water supply do not have that opportunity and the pollution is typically resolved by reverse osmosis. Drawbacks of this technique are the production of waste, high energy consumption and re-ionization of the water to make it fit for drinking water. Another available method for nitrate removal is bio-reduction but it can be problematic in drinking water supplies due to bacterial spill-over (Barrabés & Sá, 2011).

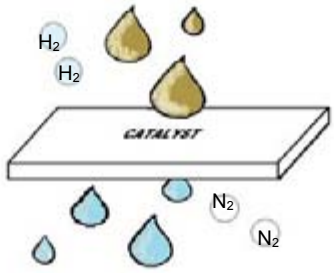

Figure 1 Water purification by catalytic reduction

An alternative method to provide clean drinking water is the catalytic reduction of nitrate to nitrogen using either hydrogen or formic acid (Barrabés & Sá, 2011). The reaction proceeds in the liquid phase at temperature and pressure of ground water and utilizes a solid catalyst with metal particles for instance palladium and tin. When formic acid is used as a reductant it forms H_2 and CO_2 in the reaction.

In this project a palladium and tin catalyst was examined. To investigate the dependence of the amount of active phase the catalyst was prepared with four different metal ratios. The catalyst activity was tested in a bubble column under flow of hydrogen and CO_2. Each catalyst was tested in model drinking water with nitrate, model drinking water with nitrate and chloride and polluted drinking water obtained from a well in North Zealand. Samples were analysed for nitrate and the unwanted reaction products nitrite and ammonia.

Conversion of nitrate was found for each of the four catalysts in each of the three examined media. Formation of nitrite and ammonium was not detected during the reaction. The optimised catalyst was found to fully reduce nitrate within reasonable time and practical applicable process conditions.

In conclusion, efficient nitrate to nitrogen reduction was accomplished with a solid palladium-tin catalyst without the formation of unwanted or environmentally harmful products. The major contribution to the carbon footprint of the process stems from the use of hydrogen. This can be circumvented by applying hydrogen generated from waste biomass as the source of hydrogen.

REFERENCES

Barrabés, N., & Sá, J. (2011). Catalytic nitrate removal from water, past, present and future perspectives. *Applied Catalysis, 104*(1-2), pp. 1-5.