# PDMS-embedded palladium nanocatalysts for water treatment

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Conventional chlorinated hydrocarbons (CHCs) and emerging chlorinated contaminants are among the most widely distributed pollutants in water. Their dechlorination to environmentally harmless compounds is a significant contribution for a cleaner resource water. Palladium-based nanocatalysts have proved to have an extremely high intrinsic catalytic activity in hydrodechlorination (HDC) of such pollutants (Hildebrand et al. 2009). Nevertheless, the application of noble-metal based catalysts at larger scale is hindered up to now by their high sensitivity towards catalyst poisoning. Therefore, cost and time demanding techniques for periodic re-activations are necessary. The objective of our study is to efficiently prolong the catalyst life time by a protecting hydrophobic coating. It is known that poly(dimethylsiloxane) (PDMS) can in principle protect the palladium against ionic and macromolecular poisons (Fritsch et al. 2003, Navon et al. 2012). Contaminant enrichment in the vicinity of the catalyst and lack of Pd loss by catalyst leaching are additional benefits of PDMS coatings.

In the presented work we study the performance of PDMS-incorporated Pd catalysts in batch and long-term HDC. Further research has been carried out on the effect of the PDMS membrane on the catalyst performance and on means of improvement. Various coated Pd catalysts - nanoparticles and Pd supported on a variety of oxidic supports - are synthesized, characterized and compared. Bio-synthesized nano-palladium and bio-analogue lipid-vesicle coated Pd are included into this study. The basic catalytic performance has been evaluated by standard protocol batch HDC using common probe molecules such as trichloroethylene, chlorobenzene and chloroform. The catalyst long-term performance and stability have been evaluated by employing long-term set-ups, such as lab-scaled stirred-tank and trickle-bed reactors. The resistance to catalyst deactivation has been tested by standard poisoning stress tests using compounds such as sulfite, humic acids and hydrogen peroxide. Our results showed that long-term protection from such poison is achieved throughout the duration of the experiments (which reached in some cases months). Catalyst incorporation itself leads to a drop in its specific activity of at least one order of magnitude. Deactivation of the catalyst has been ascribed to acid attack at the PDMS network due to the HDC byproduct hydrogen chloride and its accumulation at the catalyst. The findings represent a necessary starting point for improvement and catalyst optimization which may lead to possible implementation of a Pd-PDMS technology in real water treatment devices.

Hildebrand, H., Mackenzie, K., & Kopinke, F.-D. (2009). Highly active Pd-on-magnetite nanocatalysts for aqueous phase hydrodechlorination reactions. *Environmental Science & Technology*, 43(9), 3254-3259.

Fritsch, D., Kuhr, K., Mackenzie, K., & Kopinke, F.-D. (2003). Hydrodechlorination of chloroorganic compounds in ground water by palladium catalysts: Part 1. Development of polymer-based catalysts and membrane reactor tests. *Catalysis Today*, *82*(1), 105-118.

Navon, R., Eldad, S., Mackenzie, K., & Kopinke, F.-D. (2012). Protection of palladium catalysts for hydrodechlorination of chlorinated organic compounds in wastewaters. *Applied Catalysis B: Environmental*, *119*, 241-247.