

Effects of Groundwater Constituents on the Activity of Supported Palladium Catalysts for Water-Phase Hydrodechlorination

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Abstract

In a laboratory setting, supported palladium catalyst is known to exhibit excellent catalytic activities for the hydrodechlorination (HDC) of hazardous chlorinated compounds, such as chloroform and trichloroethylene, to benign gas products at room temperature and pressure. When tested under realistic conditions, significant reduction in catalytic activity is observed, potentially due to chloride and sulfide poisoning and possibly other groundwater constituents. Through this research, we aimed to verify the possible causes of this problem by carrying out systematic HDC study under isolated groundwater solutes with comparable concentrations. Although numerous components are detected in groundwater, we only tested our HDC reaction against specific chloride and sulfate salts which exhibit high concentrations; namely sodium, potassium, magnesium, calcium, iron (II), and aluminum salts.

HDC results showed about 72% reduction in catalytic activity when using groundwater instead of purified lab water. With sulfate salts, a small effect in the range of 13.3-25.5% reduction in catalytic activity was observed suggesting that, since the effect was minimal, sulfate salts interfered with the reaction site instead of decomposing to sulfide. Furthermore, chloride salts reduced catalyst activity in a larger range of 24.8-47.6%, suggesting a more complex interaction between the cations and anions that enhance the deactivation rate. Iron (II) and aluminum chloride had the most significant changes in reaction rates compared to all salts studied, which suggests that a further study could examine the intrinsic properties of these salts in order to determine the exact nature of the increased reductions in their respective reaction rates. On a broader scale, two salts (chloride and sulfate salts) could, considering the possibility of combined effects, potentially account for 80% of the reduction in groundwater. At the same reaction conditions, bimetallic Pd/Au catalyst exhibited more resistance to deactivation than Pd-based catalyst, indicating a better material for future groundwater remediation.

Acknowledgement: This work was supported by an NSF award from the Division of Biological Infrastructure No. 1004856.