



## Electrochemical Disposal of Hydrazines in Water

This method offers advantages of safety, economy, and scalability.

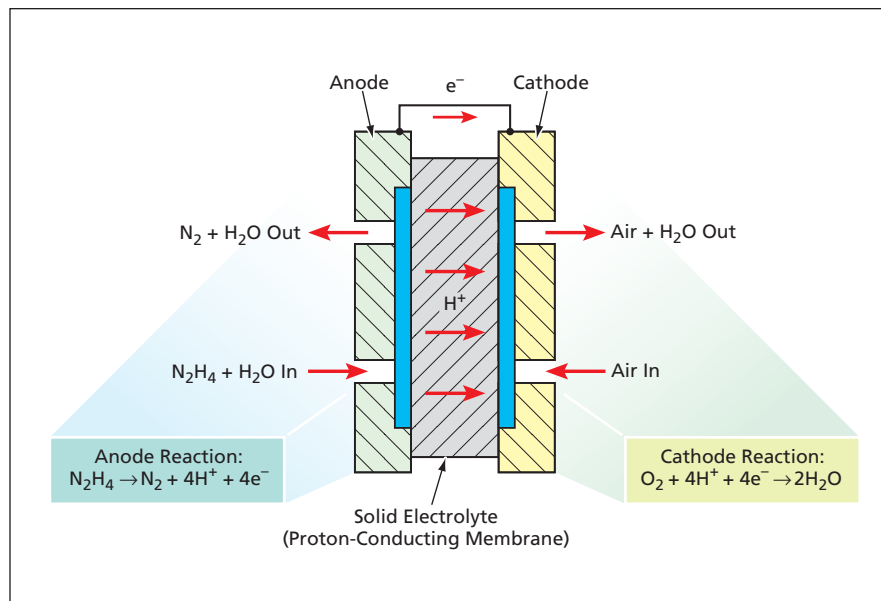
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An electrochemical method of disposal of hydrazines dissolved in water has been devised. The method is applicable to hydrazine ( $N_2H_4$ ), to monomethyl hydrazine [also denoted by MMH or by its chemical formula,  $(CH_3)HNNH_2$ ], and to unsymmetrical dimethyl hydrazine [also denoted UDMH or by its chemical formula,  $(CH_3)_2NNH_2$ ]. The method involves a room-temperature process that converts the hydrazine to the harmless products  $N_2$ ,  $H_2O$ , and, in some cases,  $CO_2$ . In comparison with prior methods of disposing of hydrazines, the present method is safer and less expensive.

Hydrazines are probably best known as hypergolic fuels used in rocket engines. In addition, hydrazines have some industrial uses. The need for safe disposal of hydrazines dissolved in water arises because water is used (1) to clean up spills of these chemicals; (2) to rinse equipment used in storing and transferring them; and (3) as a solvent in gas scrubbers that are typically included in such equipment.

In the present method, one uses an electrochemical cell, which can be operated in either of two modes, depending on the nature of the rinse-water solution(s) to be treated: if the concentration of hydrazine is sufficiently high, the cell can be operated as a fuel cell; otherwise, the cell can be operated as an electrolyzer. The cell (see figure) includes a solid polymer electrolyte sandwiched between electrodes that have three-dimensionally complex, high-surface-area structures and contain appropriate electrocatalysts. The solid polymer electrolyte separates the anodic compartment from the cathodic compartment. Thus, there is no mixing of rinse-water containing hydrazine with any oxidant and, therefore, the undesired formation of nitrogen oxides or nitrate is prevented.

In the anodic compartment, hydrazine is oxidized. Hydrogen ions that are generated in the oxidation of hydrazine travel through the solid electrolyte into the cathodic compartment,



An **Electrochemical Cell** oxidizes highly toxic  $N_2H_4$  to the harmless products  $N_2$  and  $H_2O$ . The cell can be operated in an electrolyzer or fuel-cell mode; in either mode, the oxygen needed for oxidation is obtained from the air. The thickness of the proton-conducting membrane is greatly exaggerated here.

where they are converted to hydrogen atoms, which are then oxidized to water, using oxygen from the air. The three-dimensionally complex, high-surface-area electrocatalytic nature of the electrodes promotes the desired chemical reactions, thereby reducing the amount of time needed for treatment, thereby, further, reducing the cost of treatment.

The electrocatalytic materials for the anodic compartment are selected so as to suppress electrochemical reactions (e.g., evolution of oxygen) that are undesired there while promoting the selective oxidation of hydrazine to nitrogen and water (or the selective oxidation of monomethyl hydrazine or unsymmetrical dimethyl hydrazine to nitrogen and carbon dioxide). The electrocatalytic materials for the cathodic compartment are selected to favor the desired oxidation of hydrogen to water. A key feature — essential for successful operation in either the fuel-cell or the electrolyzer mode — is close control of each reaction step through control of the cell current or potential and of the duration of the treatment.

A system for treating hydrazine-contaminated water can easily be scaled up from a single cell to a stack of cells. The system can easily be automated, requires little maintenance, and can be operated without much training. If the concentration of hydrazine is sufficient to enable operation in the fuel-cell mode, then the power generated by the system could offset some or all of the cost of treatment. Even at low concentrations, the cost of treatment — about \$0.03/gallon (about \$0.008/liter) at the time of this report in 2003 — is of the order of a hundredth of the cost of treatment by prior methods.

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*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Kennedy Innovative Partnerships Office at (321) 867-8130. Refer to KSC-12133/492.*