Urine Pretreatment Development

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Recovery of potable water from wastewater is a critical requirement for long-duration space missions. For many hardware systems used to recover potable water from wastewater, the most efficient operation requires wastewater that is stabilized to prevent deterioration of the contaminants. This is referred to as "pretreatment" of wastewater, since a chemical is typically added to the wastewater prior to storage.

The current pretreatment method used on space shuttle adds potassium peroxymonosulfate (Oxone®, DuPont), an acidic oxidizing biocide that must be replaced daily by crew. Potassium peroxymonosulfate is a highly reactive compound that is hazardous to human health. Our exploration life support team is working to develop alternate pretreatment techniques that have a lower toxicity than the current space shuttle urine pretreatment method.

Our urine pretreatment efforts focused on identifying and testing low-toxicity chemicals to stabilize urine and prevent the biological and chemical changes that cause precipitates and fouling of plumbing surfaces. We also experimentally determined the lowest effective concentration of the chemicals.

The team conducted a series of laboratory experiments to test urine pretreatment chemicals that are less toxic than potassium peroxymonosulfate. The Crew Exploration Vehicle is expected to require urine pretreatment to prevent microbial contamination and the formation of alkaline precipitates that interfere with urine dumps to space vacuum. We performed this investigation to identify biocide pretreatment chemicals that are less toxic than potassium peroxymonosulfate and to suppress and prevent microbial contamination that aids in preventing the subsequent production of alkaline precipitates during urine storage. Team members examined a number of low-toxicity chemical compounds commonly used to stabilize personal hygiene products for their effectiveness at preventing microorganism contamination and growth in wastewater.

We based urine pretreatment development on 13 experiments assessing the effectiveness of low-toxicity urine pretreatment chemicals to stabilize urine during storage. In the first set of three experiments, maleic and malonic acid were shown to prevent urea hydrolysis in urine for 3 weeks even with the addition of urease-producing bacteria. In the second group of five experiments, 13 different, low-toxicity biocides were tested. The team determined the required mass concentration of these alternative biocides to stabilize urine. In the final set of five experiments, we tested 20 combinations of biocides and organic acids. We conducted toxicological hazard assessments on the biocides that were effective at killing bacteria and preventing precipitates in stored urine, and identified two effective, nonoxidizing pretreatment liquid pretreatment alternatives to potassium peroxymonosulfate. One low-solubility dry chemical was an effective biocide at 1 gram per liter urine. These formulations have some advantages over potassium peroxymonosulfate in that they are less toxic, add less dissolved solids to urine, and do not produce toxic volatile organics compounds. Development of an in-tank delivery system is in work to study methods of delivering the dry chemical pellets by slow release within the wastewater tank.

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