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New University Study Proves Superiority of CPVC Relative to Taste, Odor and Leaching Concerns

Copper and Five Different Polymer Pipe Materials Tested to Compare Performance Using Multiple Water Treatment Disinfectants

Executive Summary

Water quality – both from a health and safety standpoint, as well as a taste and smell perspective – should be a primary concern whether you're installing hot and cold water distribution piping into a consumer's home or a commercial food or beverage processing plant. The boom in the bottled water industry is proof that consumers are sensitive to noticeable tastes and odors in the water they drink, and they're willing to go to extra efforts and even pay more for more aesthetically-pleasing water.

The Civil and Environmental Engineering Department of Virginia Tech recently conducted a sensory impact study on various piping materials in regard to the possible leaching of polymer additives, organic compounds and oxidation of the surface of the pipe during extrusion – all of which can affect the taste and smell of the water.

This study leaves no doubt that CPVC is the preferred choice from a taste and smell viewpoint, as well the absorption of disinfectants used in the water treatment process. Whether you're a contractor working in new construction or remodeling, or the engineer or specifier for a major commercial or industrial project, it's important to understand water quality changes imparted by pipe materials in order to make smart decisions relative to the products you use.

Study Details

There are many considerations when choosing a piping material – cost, reliability, safety, long-term maintenance requirements, to name just a few. In recent years, polymer pipes have gained market share particularly in residential but also in commercial applications because of their superior performance in all of these areas.

One questionable area regarding the use of polymer materials, however, has been the possible introduction of perceptible tastes and odors that either occur during the extrusion process or during the pipe's interaction with various water treatment disinfectants. The study confirmed that not all plastics produce the same results with regard to the possible leaching of polymer additives, organic compounds and oxidation of the surface of the pipe during extrusion.

Specifically, CPVC performed consistently higher when compared to copper, high-density polyethylene (HDPE), epoxy lining and the PEX piping selected for the study. In fact according to the report:

“Results indicate that copper pipe consumed nearly all the residual disinfectants... results for the polymer materials indicated that CPVC imparted the fewest organic compounds to the water, consumed the least amount of disinfectants, and produced no noticeable odors. All other polymer materials imparted distinct odors and organic chemicals to water and consumed residual disinfectant.”

The Virginia Tech study is not the first to examine the sensory impacts from polymer pipes interacting with drinking water oxidants. What makes the study unique, however, was that both chemical and consumer-assessed sensory characteristics of water in contact with the materials were compared. A trained human panel used Flavor Profile Analysis to assess odors. A chemical process commonly referred to as SPME-GC-MS (or more formally known as solid phase microextraction-gas chromatography-mass spectrometry), which utilizes various fiber elements to extract compounds in the water, was used to detect and identify organic components. And total organic carbon was determined using an automated Sievers® 800 Portable TOC Analyzer.

The study further took into account recent changes in water treatment in the U.S., including the increased use of monochloramines to disinfect water instead of chlorine. Both chlorine and monochloramine levels were determined using the DPD (diethyl-p-phenylenediamine) method, which is a popular testing technique used to monitor water quality in both pools and spas across the globe. Through this test, a tablet interacts with the water to turn it a shade of pink, depending on the intensity of the chlorine concentration in the water.

The test was designed to accomplish two objectives: (1) to investigate the sensory properties of water with either chlorine or chloramines when it came into contact with different piping materials; (2) to investigate changes in residual disinfectant and leaching of organic chemicals from pipe when in contact with drinking water.

All testing was conducted under “typical” drinking water quality conditions. The Utility Quick Test, a standard leaching protocol for new materials, was conducted at room temperature using a low alkalinity water of pH 7.8-8 with no disinfectant, 2 mg/L chlorine, or 4 mg/L monochloramine. This test consisted of three consecutive 72-96 hour leaching/flushing periods and included triplicate testing of all pipe types.

Results comparing the polymer materials indicated that CPVC imparted the fewest organic compounds to the water, consumed the least amount of disinfectants, and produced no noticeable odors. All other polymer materials imparted distinct odors and organic chemicals into the water and were shown to consume residual disinfectant. Of all the materials tested, epoxy lining had the most dramatic effect on water quality, imparting a moderate “plastic-putty-glue” odor, leaching 0.4–0.6 mg/L organic carbon including the compounds bisphenol A, styrene, toluene, nonylphenol and benzaldehyde. It also consumed nearly all the residual chlorine and chloramines.



As for copper, the results indicate that it consumed nearly all the residual disinfectant but released few organic compounds or odors.

The below table summarizes the impacts of the various polymer piping materials on both the sensory (taste and smell) and chemical quality of drinking water. It is interesting to note that while some materials performed well in certain categories, they under-performed in others. The best-performing PEX pipe, for example, leached the greatest amount of organic carbon, as well as the greatest number of volatile organic compounds, but did not contribute the most intense odors (although it did contribute a variety of odors). HDPE leached only a minor

amount of organic carbon (but many specific organics) yet imparted the greatest odor intensity.

In contrast, HDPE consumed a low amount of residual disinfectant and released only about 0.1 mg/L organic carbon to the water including phenol, bisphenol-A, tetradecane, cyclohexadiene, cyclohexanone, and cyclopentanone. The overall odor imparted to the water from HDPE had a moderate intensity and was described as “waxy/plastic/citrus.” Panelists described the HDPE odor as “chemical/plastic” in the presence of chlorine and “waxy-crayon/plastic” in water with chloramines. The presence of disinfectants did not appear to alter the intensity of the odors. Despite their overall similarities, various PEX piping products performed differently in the tests, with some pipe producing more odors than others. Water in contact with the best performing PEX product possessed weak to moderate intensity odors, leached about 1 mg/L organic carbon, and consumed up to 0.5 mg/L free chlorine. Ethyl-t-butyl ether (EtBE) was found to contribute significantly to the characteristic “burning-solvent/plastic” odor of the better performing PEX pipe.

Only CPVC performed consistently well across the categories. Not only did it leach the least amount of Total Organic Compounds (TOC) and have the fewest number of compounds identified by SPME-GC-MS, but it also had the least impact on water aesthetics, which meant there was no offensive taste or smell to water flowing through CPVC piping. Not only does this conclusion support the selection of CPVC but it suggests that it is the specific organic chemicals and not the concentration of organic carbon present in the water that determines odor intensity and aesthetic impact. Additionally, there did not appear to be any correlation between the type of disinfectant and amount of organic carbon leached. Both chlorine and monochloramine had minimal effect on the intensity of the odors associated with the polymer.

Impact on Drinking Water Quality

Parameter (short-term testing)						
	CPVC	HDPE	Best Performing PEX	Worst Performing PEX	Epoxy	Copper
Increased Odors – sensory annoyance	1	5	2	4	5	3
Organic Carbon Release	1	1	2	5	3	1
Chlorine Consumption	1	2	1	1	5	5
Chloramine Consumption	1	2	1	1	5	5
(1 indicates least impact to water quality; 5 indicates greatest impact)						