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The best things in life are free: the chemistry of love and the love of chemistry.

Simulate an important environmental study – is your deck leaching?

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In January of 2004, Canada and the United States started to phase out the manufacture and sale of wood treated with copper, chromium and arsenic (CCA). CCA is used in pressure-treated wood to reduce rotting due to insects and microbial agents.[1] The Healthy Building Network has lobbied government agencies, basing their position partly on research by David Stilwell of the Connecticut Agricultural Experimental Station.[2] His research had demonstrated that after leaching out of CCA-treated wood decks, arsenic, a known carcinogen, was consequently accumulating in nearby garden soil and plants.

Thanks to a bank sponsor, a water-testing kit was freely distributed to Canadian high schools, and I used it to get a taste of Stilwell's work. If teachers obtain class sets of the kit, they could easily create meaningful labs like the one that I'm about to describe. Interested teachers can contact info@safewater.org for more information.

Since the kit is designed to test the amount of arsenic (other tests include manganese, sulphate, chloride, etc.) in water samples, I took about 5 grams of a 5-year old unstained sample of treated wood. Using pliers I cut it into several 1-cm to 2-cm pieces and let soak for 5 minutes in about 100 mL of tap water. After decanting the water into a thin bottle, I successively applied the three reagents of the modified Gutzeit test, which I will describe in detail later.

I also repeated the procedure using 1 mL of vinegar diluted a hundredfold to simulate the approximate average pH of rain samples in Eastern Canada. Of course, to make sure that the arsenic was not coming from the tap water itself, I ran a blank by applying the arsenic test to tap water that had not come into contact with treated wood.

The stunning results are summarized in the following table. The concentration of arsenic in tap water was below the EPA (Environmental Protection Agency) standard limit of 0.01 mg/L. But with only 5 minutes of soaking, the CCA-treated wood created a solution with ten times the EPA limit, and acidified water created 20 times the maximum concentration. Fortunately, newly-purchased treated wood is indeed arsenic free. Our technician brought me a leftover piece from her new deck. Subjected to the same analysis it surrendered no arsenic, aside from what was already in the tap water.

2006 EPA limit for As^{3+}, As^{5+} = 0.01 mg/L	
Sample	**mg/L of arsenic**
4.64 g of treated wood (chopped into 1 to 2 cm pieces) soaked for 5 minutes in 100 mL of tap water. Acidified with three 3 drops of vinegar to simulate acid rain leaching effect.	0.2
4.84 g of treated wood (chopped into 1 to 2 cm pieces) soaked for 5 minutes in 100 mL of tap water. (No vinegar added.)	0.1
5.02 g of wood treated in 2008 (non-CCA formulation)	0.005
Tap water	0.005

Admittedly, chopping the treated wood exaggerated the surface area actually exposed in the field, but a mere 5 minutes of soaking greatly underestimated the actual amount of leaching and physical displacement that occurs over the lifetime of a wooden deck or Hydro pole. For instance, David Stilwell found, next to 8 utility poles in Canada, an average of 262 mg of arsenic per kg of soil.

Here's the chemistry behind the analysis, the so-called modified Gutzeit test.

The first reagent that's added to 100 mL of sample contains tartaric acid with enhancers. In step 3 it will be evident why the acid is needed. Reagent #2, an oxidizer, is then added to remove hydrogen sulfide interference. Finally, with the addition of pure zinc powder reagent, inorganic arsenic ions (As^{3+} and As^{5+}) are reduced to As^{3-}, which, in the presence of acid, forms arsine (AsH_3) gas:

(in the presence of As^{3+})

$$As_2O_3 + 6\ Zn + 12\ HCl \rightarrow 2\ AsH_3 + 6\ ZnCl_2 + 3\ H_2O$$

(in the presence of As^{5+})

$$H_3AsO_4 + 4\ Zn + 8\ HCl \rightarrow AsH_3 + 4\ ZnCl_2 + 4\ H_2O$$

The arsine gas comes out of solution and reacts with a test strip containing mercury (II) bromide ($HgBr_2$), forming mixed arsenic mercury halogenides:

$$x\ AsH_3 + y\ HgBr_2 \rightarrow AsH_2HgBr + As(HgBr)_3 + \text{other variants}$$

Colours ranging from white to shades of yellow or brown depend on the amount of halogenides formed, which are proportional to the amount of arsenic ions in the sample. See back cover for colour photos of the results.

Once the reaction is completed, the test strip is removed and matched to a colour chart to obtain the exact number of ppm (mg/L) of arsenic in the tested sample.

Safety Tips

The reactions should be carried out in a fume hood in case any arsine escapes and the reagent on the mercury strips should not be touched with bare hands. Any readers who are concerned about exposure to arsenic from decks constructed prior to the CCA ban should be relieved to learn that leaching can be greatly diminished by oil-based, semi-transparent wood stains, the kind that soak into the wood. In fact, Stilwell found significantly lower concentrations of arsenic in the soil next to CCA decks that were well maintained.

More tips can be found at Health and Welfare Canada's site listed in the references.

References

1. *http://www.epa.gov/oppad001/reregistration/cca/*

2. Stilwell's Research, D. Stilwell and K.D. Gorny, *Contamination of Soil with Copper, Chromium, and Arsenic Under Decks Built From Pressure Treated Wood*. Bull. Environ. Contam. Toxicol., 58, 22-29 (1997).

3. Legal Issues, *http://www.ct.gov/CAES/cwp/view.asp?a=2815&q=376678, http://www.healthybuilding.net/arsenic/index.html* (accessed July 23, 2008).

4. Health and Welfare Canada's fact sheet on CCA: *http://www.pmra-arla.gc.ca/english/pdf/fact/fs_cca-e.pdf* (accessed July 23, 2008).

5. Chemistry of modified Gutzeit Test *http://inspectusa.com/product_info.php/products_id/833, http://www.patentstorm.us/patents/6576143/description.html* (accessed July 23, 2008). ■

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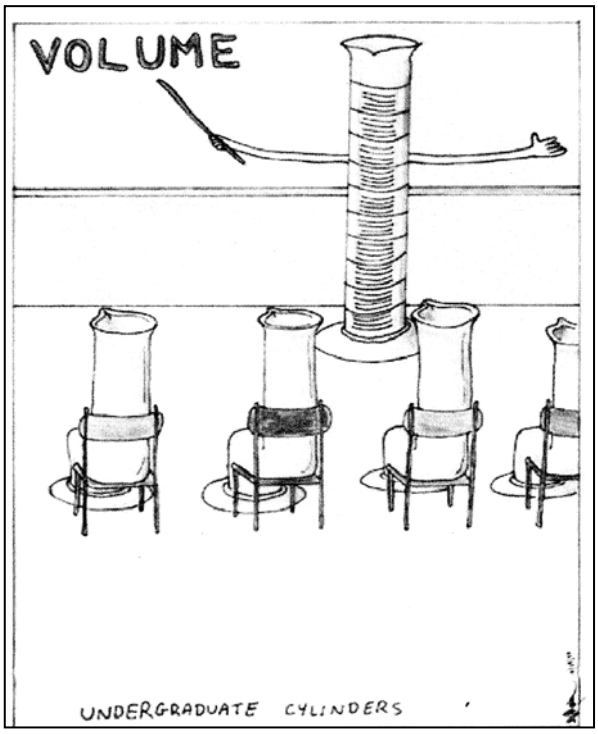
The only thing that stands between you and your dreams is yourself. Have faith in yourself, and there is no limit to what you can accomplish!

Cartoons reprinted from May 2005 and January 2005



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