What Poisoned Alexei Navalny? And the WSJ Needs A Chemistry Lesson.

By Josh Bloom — August 26, 2020

Navalny, a Russian anti-corruption activist and well-known critic of President Vladimir Putin, is being treated in Germany for an apparent case of poisoning by an "organophosphorus neurotoxin." But which one: the insecticide or the chemical weapon? Here are some clues.

It would seem that Russia lags a bit behind much of the world in the free speech department. Alexei Navalny, a Russian anti-corruption activist and well-known critic of President Vladimir Putin is being treated in Germany for an apparent case of poisoning by an "organophosphorus neurotoxin." (1) But there are organophosphorus neurotoxins and there are organophosphorus neurotoxins; there is a huge range in toxicity depending upon the structure of the chemical in question.

A recent Wall Street Journal article [2] fails to make this distinction in the first sentence:

"German doctors treating Alexei Navalny said Monday that the Russian dissident was poisoned by a substance commonly found in nerve gas and pesticides."

This statement is automatically incorrect. There are pesticides in this class (usually chlorpyrifos)
that kill bugs, and others (VX, Sarin) that kill people even in minuscule doses. It is unwise to get these mixed up. That is, unless it's done intentionally (2).

Here's the problem: there is no chemical that is used to kill both bugs and people within the organophosphorus neurotoxin class (3). The insecticide chloropyrifos has been used as an agricultural pesticide since 1965. While you wouldn't gargle with it, its toxicity is relatively low; the LD$_{50}$ in rats (see Table 1) ranges from 95-270 milligrams per kilogram weight of the rat (mpk). To put this in context, the LD$_{50}$ of caffeine in rats is 367 mpk [3] – not appreciably different from chlorpyrifos. This does not mean you should put it in your coffee. It is a known neurotoxin but far less toxic than those used as chemical weapons.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>LD$_{50}$ rats (mg)</th>
<th>Relative toxicity</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorpyrifos</td>
<td>95-270</td>
<td>1</td>
<td>a</td>
</tr>
<tr>
<td>Sarin</td>
<td>0.1-0.7</td>
<td>385-950</td>
<td>b</td>
</tr>
<tr>
<td>VX</td>
<td>0.008-0.19</td>
<td>1,420-11,875</td>
<td>a</td>
</tr>
</tbody>
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Table 1. The relative acute toxicity of chlorpyrifos, Sarin, and VX in rats. The range of LD$_{50}$ values represents the toxic dose as a function of the method of exposure, for example, given orally, injected, or applied to the skin. References: (a) Drug and Chemical Toxicology [4], (b) EXTOXNET [5]

So what got Navalny? We can't say for sure, but we can probably rule out chlorpyrifos. According to a Washington Post story he "sipped a cup of tea at a cafe in Russia's Tomsk airport. Later, the prominent Kremlin critic was moaning in pain, prompting an emergency landing with an ambulance waiting to race him to intensive care."

Let's do a little math and some quasi-educated suppositions. The solubility of chlorpyrifos in water is very low – 1.4 mg per liter at 25°C (77°F). Now we'll take a wild, unsubstantiated guess that the stuff is three-times more soluble in hot water, like tea, and that Navalny had one 8-ounce cup. If I'm doing the math right (about as common as finding a giraffe in your broom closet) that means that Navalny consumed a total of 1mg of the poison – the maximum amount of chlorpyrifos that would dissolve in a cup of tea. Would this be lethal?

No way. Healthy human volunteers were given a dose [6] of 1 mg (3) of the chemical per day for 28 days and nothing happened.

So, it's a pretty good bet that whatever was in that cup of tea was 50 Shades of Nasty, probably VX or Sarin. And a better bet that if you're a dissatisfied Russian and open your mouth it should not be to sip tea.

**Update - 9/2: Reuters reported [7] that German Chancellor Angela Merkel announced that Navalny was poisoned by a Novichok nerve agent. There are seven known Novichok; while there are differences in chemical structure and potency, they all work by the same mechanism as VX and sarin. Some are even more effective.
NOTES:

(1) Charité hospital in Berlin [8] said that Navalny was poisoned by a "cholinesterase inhibitor" – another term for organophosphorus neurotoxins.

(2) Our dear friends over at NRDC did just this in a phony scare video [9], which I took apart [10]. You can see how they tried to get people to believe that chlorpyrifos is more or less the same as VX or Sarin. Sleazebags.

(3) Just so you don't fling yourself out the nearest window I have avoided using the technically correct but crazymaking terminology of the sub-class of organophosphorus neurotoxins. Nonetheless, if, for some twisted reason here they are if you want 'em: chlorpyrifos is an organophosphate, VX is a thiophosphonate, and Sarin is an organophosphonate. They all act in the same way - by inhibiting the breakdown of acetylcholine in nerve synapses, causing your central nervous system to go nuts. Just like you just did reading this.

(4) Other ACSH work on nerve gases:


VX Nerve Agent Killed Kim Jong-Nam. How Does It Work? [12] (Dr. Alex Berezow)