

Youth Views on Sustainability



Chemical Waste Management at Clinical Laboratories

From lab curiosity to suitable environment—healthcare for the world and human beings.

by David Yafté Díaz-Sánchez

Waste, a very popular word these days, commonly refers to a human-made product with no significant value, which must be eliminated. When I was younger, I studied at a technical college in the south of Mexico City. I used to ask my teachers what happens to chemical waste generated at the clinical laboratory. Today, I study metallurgical chemical engineering, but I cannot forget my old questions about chemical waste, because some chemical waste has properties that make it hazardous to health and the environment.

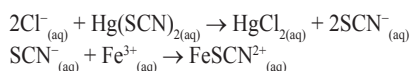
When working in a clinical laboratory, hazardous waste is often produced. It must be reduced and, where it cannot be, its potential risk or impact to the environment and our health should be minimized. There are, principally, two kinds of dangerous waste at clinical laboratories: chemical waste and biological waste. This article focuses on chemical waste.

Chemical waste may be hazardous in several different ways [1,2]. It could be corrosive, like HNO_3 , or toxic, like NaCN , or could be hazardous to the environment, like CuSO_4 . There are different types of chemical waste, and we must learn how to treat them properly. Sometimes a neutralization reaction is enough to make waste less dangerous, but at times more is necessary.

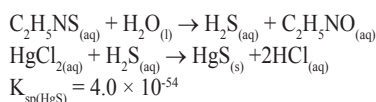
Some examples:

Example 1: Spectrophotometric determination of chloride ion in blood

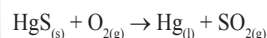
The principle of this method is the quantitative displacement of thiocyanate by chloride from mercuric thiocyanate. The subsequent formation of a red ferric thiocyanate complex is measured colorimetrically. Here the intensity of the colour formed is proportional to the chloride ion concentration in the sample:



In this case the reagent used to measure the chloride ion in blood contains mercury compounds, which are highly toxic and can be accumulated in the human body. The mercury concentration in this reagent is 6 mmol L^{-1} , and usually about 0.250 L is used. This makes treating this waste properly a necessity. One possible treatment is to add thioacetamide, which releases hydrogen sulfide while heating in aqueous solution, permitting the precipitation of the very insoluble mercury (II) sulfide without noxious odors.



Although both thioacetamide and hydrogen sulfide are toxic, only small quantities, in the order of micrograms, are needed, and mercury (II) sulfide can be recycled to obtain mercury, just like a metallurgical engineer does with the mineral cinnabar.

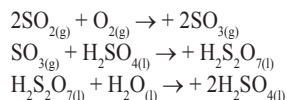


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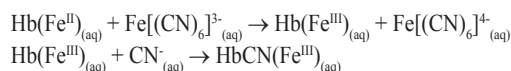
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Going beyond mercury, in an industrial scale, this can be used to obtain the always useful H_2SO_4 from the SO_2 .

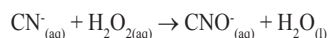


Example 2: Hemoglobin determination by Drabkin's reagent

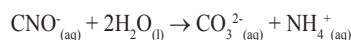
Hemoglobin, the oxygen-carrying protein of erythrocytes (red blood cells), is oxidized by hexacyanoferrate (III) ion to methemoglobin and cyanide complex to get cyanmethemoglobin:



Drabkin's reagent contains cyanide ions, which are extremely poisonous. This time, cyanide concentration in the reagent is 77 mmol L^{-1} . As in the first example, usually about 0.250 L is used. Fortunately, we can find a few different ways to treat this waste. One of them is the destruction of cyanide by oxidation with H_2O_2 using CuSO_4 as a catalyst [3]:



The cyanate produced reacts with water at $\text{pH} < 7$ to produce ammonium and carbonate ions:



It is essential to make this treatment "one step at a time". If we attempt to make these reactions in just one step, adding H_2O_2 and CuSO_4 to cyanide and immediately adding an acid to push down the pH, we could die, because cyanide reacts with acids to produce the even more poisonous gas hydrogen cyanide.

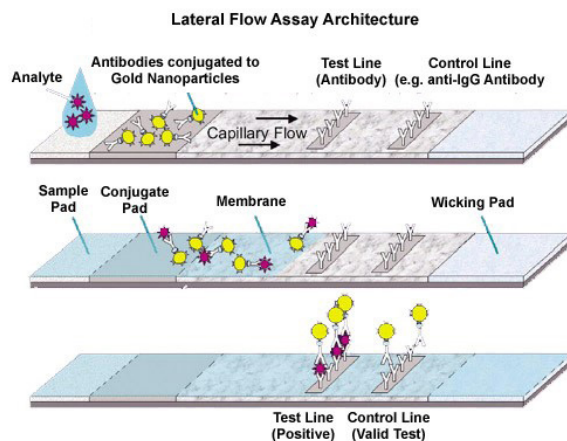
However, not all is bad news—we can even find gold if we know where to look....

Example 3: Pregnancy tests and the rainbow's end

Most pregnancy tests are based on the detection of the human chorionic gonadotropin (hCG) in urine and serum. Because hCG is a hormone produced by the placenta and other tissues when a woman is pregnant, its presence in urine and serum is an early indicator

of pregnancy. Commonly, a pregnancy test is a one-step lateral flow chromatographic immunoassay. The test strip in the device consists of a conjugate pad containing mouse monoclonal anti-hCG antibodies conjugated to colloidal gold and a nitrocellulose membrane strip containing two lines, a test line and a control line.

The magic word here is gold. Like with "e-waste", this is an example of urban mining, where we can find gold in higher concentrations than in the mined ores [4]. Contrary to e-waste, a pregnancy test only contains gold, and its extraction process can be hydrometallurgical or pyrometallurgical. In the hydrometallurgical method we could try to use an alternative lixiviant, such as amino acid- [5] or thiosulfate- [6] based solutions. Recently, these last systems have been identified as potential industrial competitors to cyanide based systems.



But pregnancy tests are just an example. We can find gold and other precious metals in a large number of clinical tests and studies. A well-established source of silver ($3\text{--}6 \text{ g m}^{-2}$) is X-ray radiographs. Approximately 2 billion radiographs are taken around the world per year [7]. These are now collected to recover silver, which has an insufficient world production. Other tests contain precious metals, as well. For example, plasmonic ELISA tests contain colloidal gold, and surface plasmon resonance uses thin layers of gold or silver and is often used in immunology. We need only search in these and other tests to find the pot at the rainbow's end.

Technical and economic studies need to be done to determine the most inexpensive and least toxic methods to get precious metals from these sources efficiently and economically. This last example revolutionizes the way we see what we call "waste". Each day we can find that more and more things contain silver,

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gold, palladium, and other useful materials.

Some reflections about waste management and treatment

I have been writing a Standard Operating Procedure (SOP) manual where I clearly record, step by step, the reactions needed to reduce the potential risk of chemical waste. My technical college has recently improved that manual, and together we are working to evaluate the document. While few people are interested in these types of projects, they are important in changing the way people think about waste. At school, in industry, or in research laboratories, everyone who produces chemical waste must know why and how to treat them. This is not just an issue for teachers, auxiliary laboratory workers and students have to learn about chemical waste management as well. Each action plan needs a person to supervise and ensure that everything is being done correctly. This person must know about chemistry, chemical waste, and health care and must be qualified to evaluate any method to minimize chemical waste, assisted in this by chemists, medical professionals, and biologists.

Safety data sheets are good resources to get information about the chemical wastes of chemical substances. Generally, a small number of substances of daily use have properties comparable to cyanide or mercury (II), but remember, waste can be reactive, corrosive, explosive, oxidant, toxic, poisonous, flammable and/or hazardous to the environment. Personnel must be constantly vigilant, taking discussion sessions with experts and caring about themselves and their safety.

Only if we are concerned about treating chemical clinical waste can we guarantee the well-being of every person who visits a clinical laboratory. Otherwise, we quickly shall see how the green hills around our technical college become grey, and the sown fields

near to us turn into sterile loads of soil. I am sure this is not only happening here in Mexico. 🌍

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David Yafté Díaz-Sánchez <david.dadfat@gmail.com> is an engineering student at UNAM, Mexico. His interest focuses on the recycling of valuable metals from medical and clinical sources. He finds that this leads directly towards a proper chemical waste management, and believes it is necessary to change the way we think about waste and resources to make a more sustainable future.

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