Dr Christina Baxter, of EmergencyResponseTIPS.com and Hazard3.com, offers helpful advice for first responders

Keeping you safe!

This column aims to provide operational guidance to the hazmat/CBRNE community regarding the selection and performance of equipment and tactics. In this issue we focus on colorimetric chemistry. While it is one of the oldest forms of chemical detection for solids, liquids and gases, colorimetric chemistry is still relevant today and is applicable to most threat materials including explosives, pharmaceutical based agents (PBAs), toxics and corrosives. When used in combination, these tools can quickly classify many threat materials without engaging electronic devices. This is particularly important in flammable and/or corrosive atmospheres where many electronic tools can either ignite the flammable atmosphere or be destroyed by the corrosive atmosphere. This edition focusses primarily on the detection of solids and liquids using traditional chemical papers and test strips. Later columns will delve into further possibilities.

pH paper

The most ubiquitous colorimetric chemistry for hazmat/CBRNE response is the measurement of corrosivity of aqueous solutions using pH paper. The paper is saturated with a pH indicator dye or mixture of dyes and the colorimetric response indicates acid (pH < 7), basic (pH >7) or neutral (pH=7) ranges. A colour chart is used for visual comparison to determine the corrosivity of the solution.
Corrosive gases can also be evaluated using wetted pH paper.

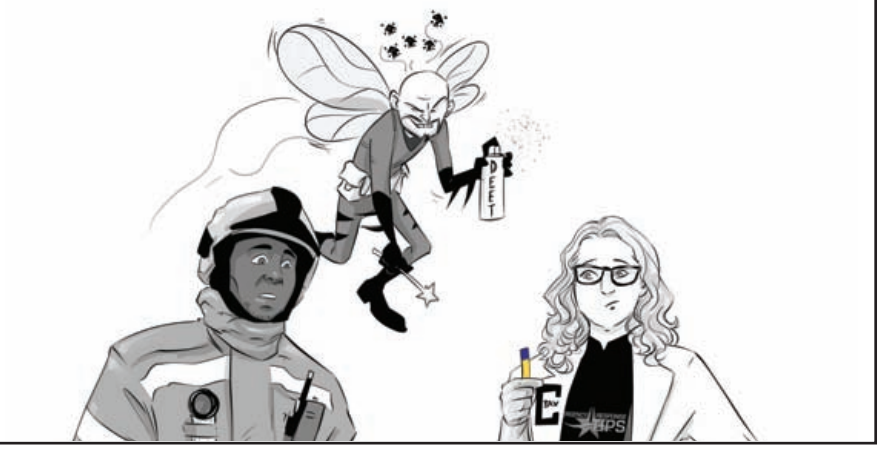
Further useful information can be gleaned from pH paper. For instance oxidiser solutions like hypochlorite ions bleach the paper white, or bleaching in gas phase indicates the presence of chlorine. pH at extremes is helpful as pH <2 indicates strong inorganic acids which typically are non-flammable, pH >12 indicates free alkali or alkaline earth hydroxides which also tend to be non-flammable, however ammonia can indicate in this pH range and is flammable. It is also important to remember that not all materials have a pH measurement, for instance those in organic solutions.

KI paper

Potassium iodide (KI) paper is also frequently used by emergency responders to determine the presence of some oxidising agents. The paper turns a blue/violet colour in the presence of halogens (chlorine, bromine, fluorine), inorganic peroxides and iodine, but misses other oxidisers like nitrates, perchlorates, and many organic peroxides. KI paper dampened with water may be used to evaluate oxidising gases. Like pH paper, the dye used in KI paper 'bleaches out' when bleach/hypochlorite or chlorine gas is present.

M8 paper
Chemical agent detector paper, aka M8 paper, turns gold in the presence of G-series nerve agents, green/blue in the presence of V-series nerve agents, and red/pink when blister agents are present. Clearly, this paper has many more applications than originally intended! For example, water-based solutions will 'bead up' on M8 paper while organic materials tend to soak into it. Most amines larger than ammonia turn the paper green blue while most alcohols, ethers and nitroalkanes turn the paper gold. Esters, furans, hydrocarbons, ketones and organic peroxides generally turn the paper a pink/red colour. While there are many other cross-sensitivities, these examples are very helpful in classifying chemical threats.

Water finding paper
Used to determine if water is present in an organic liquid like gasoline this paper turns either pink or blue, depending on the manufacturer. It is very helpful when used in parallel with pH paper to ensure that neutral readings are neutral versus no pH. Important cross-sensitivities to keep in mind include methanol, dimethyl sulphoxide (DMSO), and dimethylformamide (DMF).



Peroxide test strips
These are used to detect hydrogen peroxide in solutions. The intensity of the resultant blue colour reflects the peroxide concentration. Strips can be used in combination with KI paper to capture the detection of some organic peroxides and common peroxide-forming chemicals such as diethyl ether, isopropyl ether, tetrahydrofuran (THF) and dioxane. Adding ethanol to the solution can sometimes aid recognising organic peroxides. Other strong oxidisers, such as nitrates and hypochlorites, can also cause colour changes (silver/gray for silver nitrate and orange for nitric acid and hypochlorite solutions).

Fluoride (F) paper
This pinkish-red paper is often used to identify the presence of hydrofluoric acid or hydrogen fluoride, which is indicated when it turns yellow. F paper can also measure non-acidic fluoride ions of interest when wetted with 0.5N hydrochloric acid. Substantial amounts of chlorates, bromates, or sulphates can cause a white discolouration of F paper which may be confused with a positive result.

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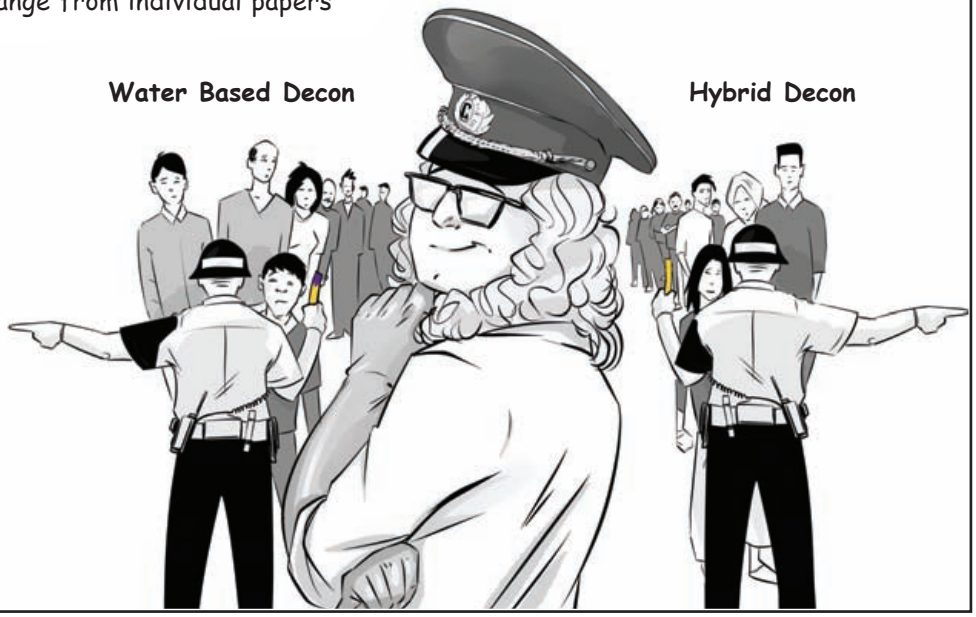
Marquis and Scott reagents
PBAs, specifically fentanyl related substances, can be detected using a combination of the Marquis reagent and the Scott reagent. The Marquis reagent turns brown in the presence of methamphetamine or fentanyl and violet in the presence of heroin or morphine while the Scott reagent turns blue in the presence of fentanyl and cocaine but remains pink for heroin, morphine and methamphetamine. In this way, known cross-sensitivities are used to identify the threat.

This small subset of colorimetric tools is well suited to providing initial directions in the first few minutes after an event. For example, materials at the pH extremes or positive on KI paper generally require high flow, water-based decontamination, whereas materials that are positive on M8 paper generally require hybrid decon. For medical countermeasures, it is important to provide the initial treatment for organophosphate and opioid exposures before initiating decontamination due to the fast onset of life-threatening symptoms. These materials can quickly be identified using M8 paper along with the Marquis/Scott reagents. In addition, low pH in combination with a positive detection on F paper indicates the presence of hydrofluoric acid which requires the immediate application of calcium gluconate gel following water-based decontamination.

To enhance your readiness to manage incidents it is essential to engage with your partner agencies to identify the likely threats in your response area and assess whether your current detection tools are appropriate; if not, identify the capability gaps. These gaps can often be filled cheaply via colorimetric detection, which can frequently quantify as well as detect the threat material. Ensure that the products are integrated into your agency approaches and operators are trained.

While several colorimetric chemistry options are described above, these only represent a small proportion of what is available. Products range from individual papers and strips to kits containing a wide variety of these tools along with flow charts to help identify threat materials. New concepts are underway that incorporate multiplexed arrays of colorimetric responses to answer operational questions. Entire systems exist for the identification of illicit drugs and explosive threats. In addition, many tools are available, and others are under development, for the detection of gas-phase threats.



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