Colorimetric Sensors for Rapid Reliable Threat Identification

Sara Paalhar

Background

Colorimetric testing is a key tool for real time detection or indication of the presence of a target chemical. These tools are key to the safety of first responders and military personnel. The evaluation of colorimetric detection products for toxic chemicals is approached by taking into considering multiple factors, such as target chemical application method to the product, resonance time, and variation of color changes. MRIGlobal performs a variety of colorimetric detection studies for toxic chemicals, that include chemical agents and substances of abuse. Application of the target chemical can be liquid exposure or vapor exposure. Quality controls are imperative to ensure testing results are accurate. Negative controls such as environmental matrices or water (humidified air if a vapor exposure is tested) are used to ensure false positives do not trigger a response to the colorimetric detection product. Positive controls such as a certified standard must be used when applicable. Determining the target chemical purity should be considered, laboratory grade vs “street grade” target chemicals each have their appropriate uses.

Toxic Chemical Testing

At MRIGlobal many toxic chemicals have been evaluated by colorimetric detection. Direct liquid spikes onto colorimetric detection paper, substrate spiking with colorimetric test article evaluation of the spiked surface, and toxic vapor sampling using colorimetric sensor detection to list a few.

Drug Detection: Strengths and weaknesses for primary targets such as GHB (Gamma Hydroxybutyrate), Ketamine, and benzodiazepines have been evaluated against many colorimetric kits. Control testing included a variety of alcoholic beverages.

Chemical Warfare Agents (CWA): MRIGlobal has evaluated a multitude of various products for manufactures and interested parties against many CWAs. Sarin, Soman, VX, Lewisite, Mustard Agents and new immerging threats such as A-230 "Novichok" and many more have and can be tested. The difficulty in developing a single use colorimetric product is finding one material that will react and differentiate between the many different classes or categories of CWA compounds. A one stop shop product as a goal is difficult to achieve.

Pharmaceutical based agents (PBA): Variations of fentanyl compounds and other PBA have been tested in solid and liquid form. Solids cut with another compound like caffeine can be used to determine the detection limit of the various products.

Vapor Chambers: Colorimetric sensor testing for toxic chemical including CWA vapors can be disseminated into an enclosed chamber where sensor/device testing can occur. Devices can sample from the chamber or be directly exposed internally to allow colorimetric detection for evaluation. The chambers can be controlled to various temperatures and humidities to mimic a variety of environmental conditions.

Colorimetric Testing Advantages VS Disadvantages

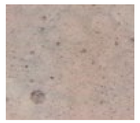
Advantages	Disadvantages
Ease of Use (swab test, paper application,	Selectivity (Typically Single Threat Use)
Speed of Use (Seconds to minutes)	False Positives
Low Cost Detection	Often Qualitative Results
Off the shelf products	Single Threat Use
Portable/Field ready	Single Test Use

Each colorimetric test is unique and not all advantages/disadvantages apply to all products.

Considerations

There are many variables to consider when determining a colorimetric test design, mimicking each product's end use is ideal but isn't always practical for the laboratory. Target chemical application can be completed as a liquid or a vapor, and total mass to area needed for color change should be noted. Target chemical purity (including impurities) can have a significant impact to the color change and should be evaluated when applicable. Color changes can be due to impurities instead of target compound itself and should be evaluated.

Once application is complete resonance time for color change is important to determine the speed of use of the product, also note if the color changes over the duration of the test. Color change may intensify or fade overtime.



Starting material (right image) is not uniform in color. This can make detection of the color change (left image) difficult to confirm.

Target chemical application can be completed as a liquid or a vapor. Products can be dipped into the target compound, or have the target spiked onto the surface. Total mass to area determined for color change should be noted. Lower concentrations typically result in less color change. Color changes determined by visual recorded results may add to the variability. Use of an RBG score can reduce the variability of the results.

Controls

Test for false positives; e.g. M-8 paper (used for chemical agent detection) has many non-agent materials (solvents, bases) that will produce a color change.

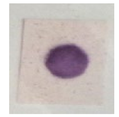
Environmental matrices; e.g. humidified air as a negative control for vapor testing or solvent as a liquid control.

Positive controls; e.g. a certified standard such as M8 paper for liquid chemical warfare agents, or Dräger Tubes for various hazardous chemicals

Evaluating Color change

Color changes should be strong enough to differentiate between the test article and the positive color change. Other variables such as lighting (warm vs cool) and shadows can make the color changes difficult to standardize. Evaluation with the use of an RGB score or RGB device measurement can help standardize the reported results

There are hundreds of available color wheels and color standard cards available for purchase to evaluate color. The selection of the color wheel is important.



How would you evaluate the color change for the two samples above based on the color wheel to the right vs the color wheel on the left?

External Support

CBRNE TECH INDEX: Website supported by MRIGlobal staff where available colorimetric products can be found and compared. A good resource for finding historical and commercially available products for comparator testing.

Contact Information

Sara Paalhar
T.#816-326-5788
E. spaalhar@mriglobal.org

MRIGlobal
425 Dr. Martin Luther King Jr. Blvd
Kansas City, Missouri 64110-2241