



**QALTEK**  
INNOVATION | SOLUTIONS

**S4FE-D™ / Bind-It™ Product Testing**

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Qal-Tek Associates

December 18, 2023

3998 Commerce Cir.

Idaho Falls, ID 83401

Test Results for Third-Party Independent Testing: Bind-It™ (also sold as **S4FE-D™**) Decontamination Solutions

This experimental testing was conducted by Qal-Tek Associates (QTA).

**Objective:** The purpose of this study was to explore optimal use conditions and methods of Bind-It™ Decontamination Solution and to evaluate the effectiveness of Bind-It™ against Tc-99m and Glo Germ™ (chemical and biological agent simulant).

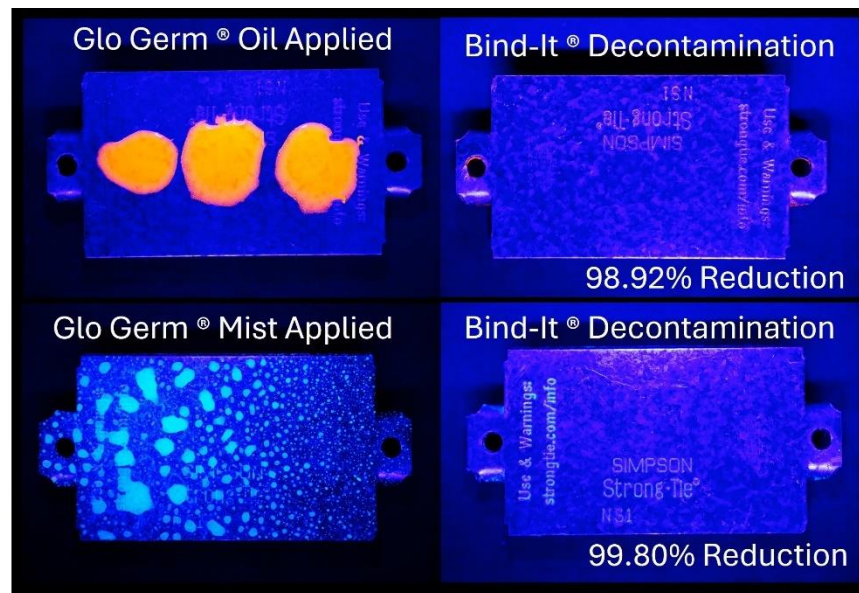
**Dates of Testing:** 11-14 December 2023

**Location of Testing:** Qal-Tek facilities: 3998 Commerce Cir., Idaho Falls, ID 83401

**Executive Summary:** The purpose of this study was to explore optimal use conditions and methods of Bind-It™ and to evaluate the effectiveness of Bind-It™ against Technetium-99m (Tc-99m) and Glo Germ™ (chemical and biological fluorescent simulant).

**Key Findings:**

1. Bind-It™ removed approximately 90% of the Tc-99m contamination from metal surfaces after a single application.
2. Three applications of Bind-It™ reduced Tc-99m contamination to near-background levels (99.2% reduction).
3. Bind-It™ removed 98.6% of the Glo Germ™ Oil and Mist contamination from metal surfaces after a single application. A sample of this fluorescence test is shown below.
4. The effectiveness of Bind-It™ was not highly sensitive to the concentration, water type, method of removal, or contact time. Across all test configurations, approximately 89% of Tc-99m contamination was removed on the first application.
5. Bind-It™ was not observed to have any discoloration or harmful effects on steel, aluminum, Kappler Zytron™ 500 fabric, Kappler Durachem™ 500 fabric, painted concrete, skin, butyl, nitrile, or acrylic materials.



**Conclusion:** Based on our extensive testing, we conclude that Bind-It™ is effective for the decontamination of Tc-99m from a variety of materials using a wide variety of techniques. Bind-It™ was also effective in the removal of simulated chemical and biological agents. At no point during testing was an adverse reaction observed with any test materials. Further testing with real chemical and biological agents is recommended prior to use in real decontamination operations.

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## 1. Introduction

### 1.1. Background

Effective decontamination methods are vital across various industries, from healthcare and defense to manufacturing. Given the critical nature of decontamination, especially in contexts involving radioactive materials, the selection and validation of decontaminating agents are paramount. Bind-It™ is one such agent that has been introduced to the market, purported to facilitate the removal of radioactive iodine from a variety of surfaces. Given the potential applications and implications of such a solution, a rigorous and unbiased evaluation is essential. It is not only prudent but also imperative to assess its performance under controlled conditions, especially when considering the inherent risks associated with radioactive contamination.

In addition to the examination of Bind-It™'s capabilities, this study also aims to compare its effectiveness with that of common household items. Such a comparison is intended to provide a holistic perspective on decontamination methods, from specialized products to everyday items.

This report presents a methodical investigation of Bind-It's™ decontamination properties relative to its stated claims and compared to selected household items. Through a detailed exploration, we aim to provide a comprehensive evaluation, ensuring that stakeholders are equipped with objective insights to make informed decisions in their respective domains.

### 1.2. Bind-It™ Product Claims, from manufacturer website

Bind-It™ Decontamination Fluid is the safe and highly effective way to remove Tc-99m, radioactive iodine and other common nuclear medicine isotopes. For more than 20 years Bind-It™ has been used by major hospitals, nuclear pharmacies, laboratories, and research centers to keep their laboratories, departments, preparation areas and patient rooms clean and free of residual radioactive iodine.

Bind-It™ is different from other radioactive decontaminants. Most radioactive cleaners repel, rather than bind and remove radioiodine. Bind-It™ Decontamination Fluid has a unique affinity for all nuclear medical isotopes. The strong attraction binds radioiodine (I-123 / I-125/ I-131) and suspends it in solution so that when combined with water it becomes a subsidizing cleaner that 'lifts' dirt and residual radioiodine off surfaces so it can be easily wiped away.

Bind-It™ products are ideal for both institutional and patient use after administration of I-131. Bind-It™ Decontamination Fluid is safe for use on delicate well counter detectors, thyroid probes, survey meters and gamma camera heads. For patients going home after thyroid procedures, Bind-It™ can be used for home clean-up as well. In the bathroom there is Bind-It™ Decontaminant for toilet and sink cleaning, as well as Bind-It™ Hand Soap. It is also ideal for showers, floors, tools, bed sheets, etc. The Bind-It™ range consists of concentrated cleaner, ready-to-use-spray and hand soap, all designed specifically for the removal of radioactive iodine (and Tc-99m).

### 1.3. Purpose and Scope of the Study

The purpose of this study was to explore optimal use conditions and methods of Bind-It™ and to evaluate the effectiveness of Bind-It™ Decontamination Solution against Tc-99m and Glo Germ™ (chemical and biological simulants).

## 2. Objectives

- 2.1. Evaluate the effectiveness of Bind-It™ for the removal of Tc-99m from selected surfaces and materials.
- 2.2. Evaluate the effectiveness of Bind-It™ for the removal of Glo Germ™ Oil (chemical simulant) and Glo Germ™ Mist (biological simulant).
- 2.3. Evaluate the effectiveness of Bind-It™ for the removal of simulated nuclear fallout particles.
- 2.4. Test variables that potentially influence the effectiveness of Bind-It™ in order to optimize the application techniques.
- 2.5. Offer discussion from the test results that may be used to inform the effective use and applications of Bind-It™.

### Secondary objectives

- 2.6. Observe for corrosive properties
- 2.7. Observe for discoloration on painted surfaces
- 2.8. Observe for any damage to exposed clothing

## 3. Preparation

### 3.1. Description of the test environment.

All testing took place at the Qal-Tek Associates Headquarters facility in Idaho Falls, ID from 10-14 December, 2023. The test apparatus was constructed so that the contamination and decontamination of the test samples did not influence the direct testing of individual samples.

### 3.2. List of materials and equipment used.

- 3.2.1. Bind-It™ and **S4FE-D™ Spray**, 1 ea.
- 3.2.2. 200 mCi source of Technetium-99m (in solution)
- 3.2.3. Glo Germ™ Oil and Glo Germ™ Mist and fluorescent light kit
- 3.2.4. D-tect Systems Radiological Detection System (RDS) with Sensitive Gamma Probe
- 3.2.5. Lead shielding materials and leaded glass work station
- 3.2.6. Mira Safety™ protective masks, various models
- 3.2.7. Kappler Zytron™ 500, ASTM F1001 Tested
- 3.2.8. Galvanized steel samples, 1"x3", 48ea.
- 3.2.9. Characterized metal-oxide framework (MOF) beads

- 3.2.10. Painted concrete cinder blocks
- 3.2.11. PPE: Tyvek™ suits, butyl booties, nitrile gloves, glasses, face shield, electronic dosimetry
- 3.2.12. Misc: Plastic work tables, stapler, duct tape, plastic sheeting, large trash cans

### 3.3. Preparation of the radiological contaminant

Tc-99m was utilized for all contamination testing. Iodine is more costly and presents a greater hazard for controlled testing situations, such as the current study. Per the QAL-TEK radioactive materials (RAM) license, no more than 200mCi of Tc-99m could be on hand at any time and it had to decay to 150 mCi prior to use (approximately 2.5 hours). Tc-99m was delivered by Advanced Isotopes of Idaho (Pocatello, ID). The RAM was delivered in a 5 mL syringe in liquid form (1 mL) at the start of each testing day, calibrated to 200 mCi at the time of delivery. Standard RAM receipt surveys were conducted to ensure the source had not leaked in shipment. When the RAM was ready for use, it was injected into an applicator that contained 1000 mL of water. With a half-life ( $t_{1/2}$ ) of 6.0067 hours, the radioactive hazard of Tc-99m is considered gone (below background) after 60 hours (~ 3 days).

## 4. Methodology – Radiological Testing

### 4.1. Objectives

4.1.1. Radiological testing was conducted in a variety of conditions to evaluate optimum conditions for use.

Except for material-specific testing, all radiological testing was conducted on galvanized steel samples.

- Solution concentration
- Water type
- Rinse versus wipe
- Contact times
- Applications required to reach background levels

4.2. **Solution concentration** – It is possible that the concentration of Bind-It™ in solution may impact its performance during radiological decontamination. It is desirable to know if an increased concentration of the Bind-It™ active ingredients influences the performance.

4.2.1. Prepare Bind-It™ in concentrations of 1:5, 1:10, and 1:20 using distilled water, as instructed by the manufacturer. Repeat steps 4.2.2 through 4.2.8 for three samples with each concentration preparation.

4.2.2. Apply 1 ounce of Tc-99m and allow it to sit on the samples for 1 minute.

4.2.3. Ensure test apparatus is approximately at background (e.g. not contaminated). Record the background measurement.

4.2.4. Move the contaminated sample to the test apparatus for a pre-decon measurement. Let the

- measurement stabilize for 5 seconds. Record the measurement (kCPM).
- 4.2.5. Return the sample to the decontamination area.
  - 4.2.6. Apply 3 oz of Bind-It™ solution to the center of the sample. Wait 1 minute, as instructed by the manufacturer.
  - 4.2.7. Use a blue shop towel to wipe away all moisture from the sample, folding the towel between each wipe, for 3 total wipes.
  - 4.2.8. Take the decontaminated sample to the test apparatus for post-decon measurement (kCPM).
- 4.3. **Water type** – The manufacturer recommends that distilled water be used to dilute Bind-It™ concentrate but the impact of tap water is not yet characterized. It is desirable to know if the type of water used in preparation of Bind-It™ influences the performance.
- 4.3.1. Using the most effective concentration of Bind-It™ from Procedure 4.2, prepare Bind-It™ in using distilled water and tap water. Repeat steps 4.3.2 through 4.3.8 for three samples with each preparation.
  - 4.3.2. Apply 1 ounce of Tc-99m and allow it to sit on the samples for 1 minute.
  - 4.3.3. Ensure test apparatus is approximately at background (e.g. not contaminated). Record the background measurement.
  - 4.3.4. Move the contaminated sample to the test apparatus for a pre-decon measurement. Let the measurement stabilize for 5 seconds. Record the measurement (kCPM).
  - 4.3.5. Return the sample to the decontamination area.
  - 4.3.6. Apply 3 oz of Bind-It™ solution to the center of the sample. Wait 1 minute, as instructed by the manufacturer.
  - 4.3.7. Use a blue shop towel to wipe away all moisture from the sample, folding the towel between each wipe, for 3 total wipes.
  - 4.3.8. Take the decontaminated sample to the test apparatus for post-decon measurement (kCPM).
- 4.4. **Rinse versus wipe** - It is desirable to know if it is more advantageous to wipe away or thoroughly rise away Bind-It™ after decontamination.
- 4.4.1. Using the most effective concentration and water type from previous tests, conduct steps 4.4.2 through 4.4.8 for three wipe samples and three rinse samples.
  - 4.4.2. Apply 1 ounce of Tc-99m and allow it to sit on the samples for 1 minute.
  - 4.4.3. Ensure test apparatus is approximately at background (e.g. not contaminated). Record the background measurement.
  - 4.4.4. Move the contaminated sample to the test apparatus for a pre-decon measurement. Let the

- measurement stabilize for 5 seconds. Record the measurement (kCPM).
- 4.4.5. Return the sample to the decontamination area.
  - 4.4.6. Apply 3 oz of Bind-It™ solution to the center of the sample. Wait 1 minute, as instructed by the manufacturer.
  - 4.4.7. Choosing either wiping or rinsing: Use a blue shop towel to wipe away all moisture from the sample, folding the towel between each wipe, for 3 total wipes **-OR-** use copious amounts of water to rinse away all Bind-It™ from the sample. Catch the contaminated runoff in an appropriate container.
  - 4.4.8. Take the decontaminated sample to the test apparatus for post-decon measurement (kCPM).
- 4.5. **Contact times** - It is desirable to know if it is advantageous to let Bind-It™ have more contact time with a contaminated area before removal.
- 4.5.1. Using the most effective procedures from previous tests, conduct steps 4.5.2 through 4.5.8 for three samples using 30 seconds, 1 minute, and 5 minute contact times.
  - 4.5.2. Apply 1 ounce of Tc-99m and allow it to sit on the samples for 1 minute.
  - 4.5.3. Ensure test apparatus is approximately at background (e.g. not contaminated). Record the background measurement.
  - 4.5.4. Move the contaminated sample to the test apparatus for a pre-decon measurement. Let the measurement stabilize for 5 seconds. Record the measurement (kCPM).
  - 4.5.5. Return the sample to the decontamination area.
  - 4.5.6. Apply 3 oz of Bind-It™ solution to the center of the sample. Wait 30 seconds, 1 minute, or 5 minutes.
  - 4.5.7. Use a blue shop towel to wipe away all moisture from the sample, folding the towel between each wipe, for 3 total wipes.
  - 4.5.8. Take the decontaminated sample to the test apparatus for post-decon measurement (kCPM).
- 4.6. Application to background levels – It is desirable to know how many applications of Bind-It™ are required to bring a contaminated area to background levels.
- 4.6.1. Conduct steps 4.6.2 through 4.5.8 for a total of five iterations with the same sample so that each sample is decontaminated five times with pre/post measurements with each iteration.
  - 4.6.2. Apply 1 ounce of Tc-99m and allow it to sit on the samples for 1 minute.
  - 4.6.3. Ensure test apparatus is approximately at background (e.g. not contaminated). Record the background measurement.
  - 4.6.4. Move the contaminated sample to the test apparatus for a pre-decon measurement. Let the measurement stabilize for 5 seconds. Record the measurement (kCPM).

4.6.5. Return the sample to the decontamination area.

4.6.6. Apply 3 oz of Bind-It™ solution to the center of the sample. Wait 30 seconds, 1 minute, or 5 minutes.

4.6.7. Use a blue shop towel to wipe away all moisture from the sample, folding the towel between each wipe, for 3 total wipes.

4.6.8. Take the decontaminated sample to the test apparatus for post-decon measurement (kCPM).

#### **4.7. Description of safety precautions taken.**

Tests were performed by two NRC-certified senior source controllers with significant training, qualifications, and experience handling removable contamination. Aseptic techniques were utilized wherever possible, with adherence to the clean-man, dirty-man methodology. One controller performed all the hot zone procedures (contaminating, decontaminating) for all test scenarios. The other controller observed the test apparatus, recorded all data, and observed the procedures of the hot zone controller. The controllers utilized appropriate PPE during the entire testing (Tyvek™ suits, butyl booties, nitrile gloves, glasses, KN95 mask, face shield, electronic dosimetry).

#### **4.8. Variables**

These experiments examine how different decontamination methods (independent variable) affect the radioactivity levels (dependent variable) on various test materials (another independent variable).

4.8.1. **Independent Variables:** These are the variables that you manipulate or classify to study its effect on another variable. In this case, they include:

4.8.1.1. Decontamination method: Different decontamination techniques (Bind-It™ solution, soap solution, and dry blue towel wiping) that are applied to the contaminated surfaces.

4.8.1.2. Test material: Different materials on which the Tc-99m is applied.

4.8.2. **Dependent Variables:** These are the outcomes or results that you measure after manipulating or classifying the independent variable. For this study, the dependent variable is:

4.8.2.1. Radioactivity Level: The net amount of residual radioactivity (measured in thousands of counts per minute, kCPM) remaining on the samples after the decontamination procedure.

4.8.2.2. Fluorescence Level: The net amount of residual fluorescence remaining on the samples after the decontamination procedure.

#### **4.9. Data Collection Methods**

##### **4.9.1. Test apparatus**

The test apparatus was constructed in a way that utilized distance and shielding to reduce the influence of the contamination area (hot zone) on the individual sample measurements. 6-inch diameter lead cylinders were used as a wall between the test instrument and the hot zone. There was approximately 18 feet between the test apparatus and the closest edge of the contamination area. The test instrument (D-tect Systems Radiological Detection System

(RDS) with Sensitive Gamma Probe) was mounted in a fixed position to reduce the variability in measurement distance between samples. The distance from the probe to the sample was held constant for all test scenario.

#### 4.9.2. Frequency and timing of data collection

Data was collected in the same frequency during each method. For each sample of each method and scenario, the recorded measurements include test apparatus background, post-contamination (i.e. pre-decontamination), and post-decontamination.

### 5. Results & Discussion – Radiological Testing

Throughout radiological testing, 104 data points were recorded. No data was rejected as an outlier.

#### Solution concentration

Three concentrations of Bind-It™ or S4FE-D™ Spray were tested.

- Test 1a, Bind-It™ 1:5 with distilled water removed 90.0% of Tc-99m contamination and was the top performing application of this series of three tests.
- Test 1b, Bind-It™ 1:10 with distilled water removed 86.1% of Tc-99m contamination.
- Test 1c, S4FE-D™ Spray 1:10 with distilled water removed 86.2% of Tc-99m contamination.

#### Water type

Two types of water (distilled and tap) were used to prepare 1:5 concentrations of Bind-It.

- Test 2a, Bind-It™ 1:5 with distilled water removed 88.4% of Tc-99m contamination. It should be noted that

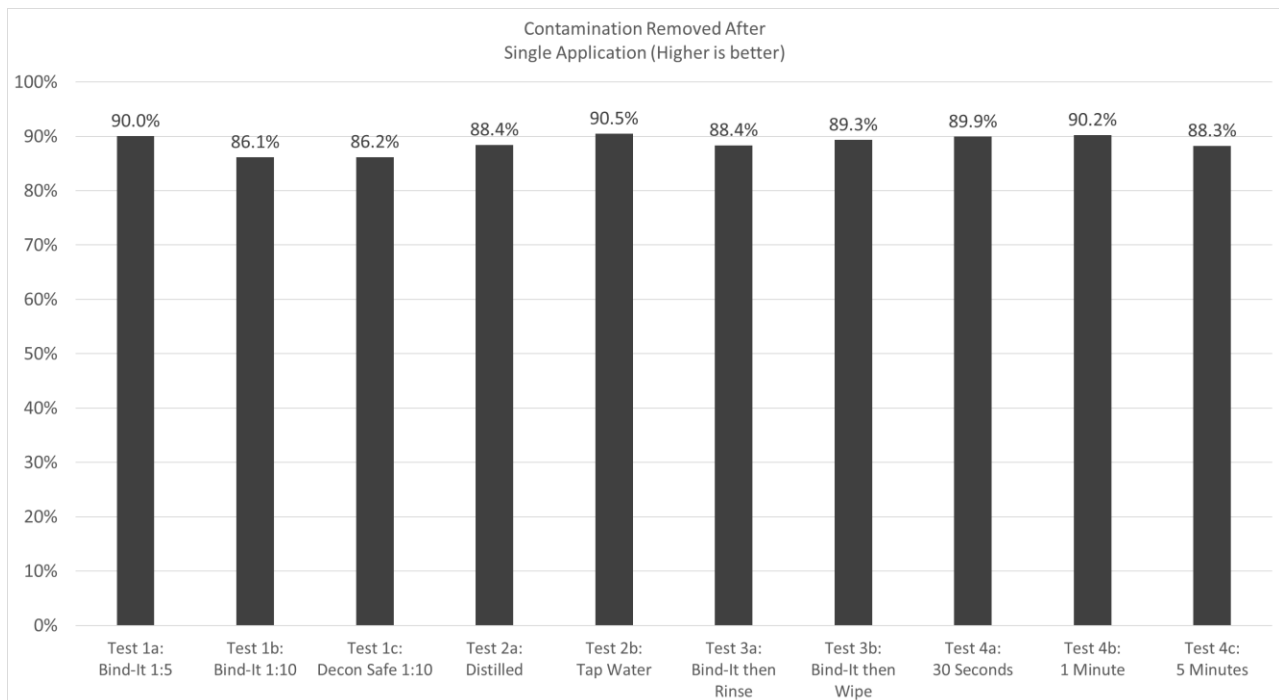


Figure 1. Test results summary

this is essentially a duplicate of Test 1a, but with slightly different results.

- Test 2b, Bind-It™ 1:5 with tap water removed 90.5% of Tc-99m contamination.

### Rinse versus wipe

Two techniques (rinsing and wiping) were used to remove 1:5 concentrations of Bind-It™ after application to TC-99m contamination.

- Test 3a, Bind-It™ 1:5 with copious rinsing removed 88.4% of Tc-99m contamination.
- Test 3b, Bind-It™ 1:5 with wiping (3x) removed 89.3% of Tc-99m contamination.

### Contact times

Three contact times (30 seconds, 1 minute, and 5 minutes) were used to allow physical interaction with 1:5 concentrations of Bind-It™ after application to TC-99m contamination.

- Test 4a, Bind-It™ 1:5 with 30 seconds of contact time removed 89.9% of Tc-99m contamination.
- Test 4b, Bind-It™ 1:5 with 1 minute of contact time removed 90.2% of Tc-99m contamination.
- Test 4c, Bind-It™ 1:5 with 5 minutes of contact time removed 88.3% of Tc-99m contamination.

### Applications required to reach background radioactivity levels

Multiple applications of Bind-It™ were applied to the same sample. The ideal endpoint would be removal of radioactivity such that a sample measurement was at background levels. Measurements of sample radioactivity were taken before and after each application of Bind-It. The first application of Bind-It™ removed over 93% of the initial contamination. Subsequent applications continued to remove additional radioactivity but with diminishing returns as there was less available Tc-99m available for removal. After 5 applications, the sample was not quite at

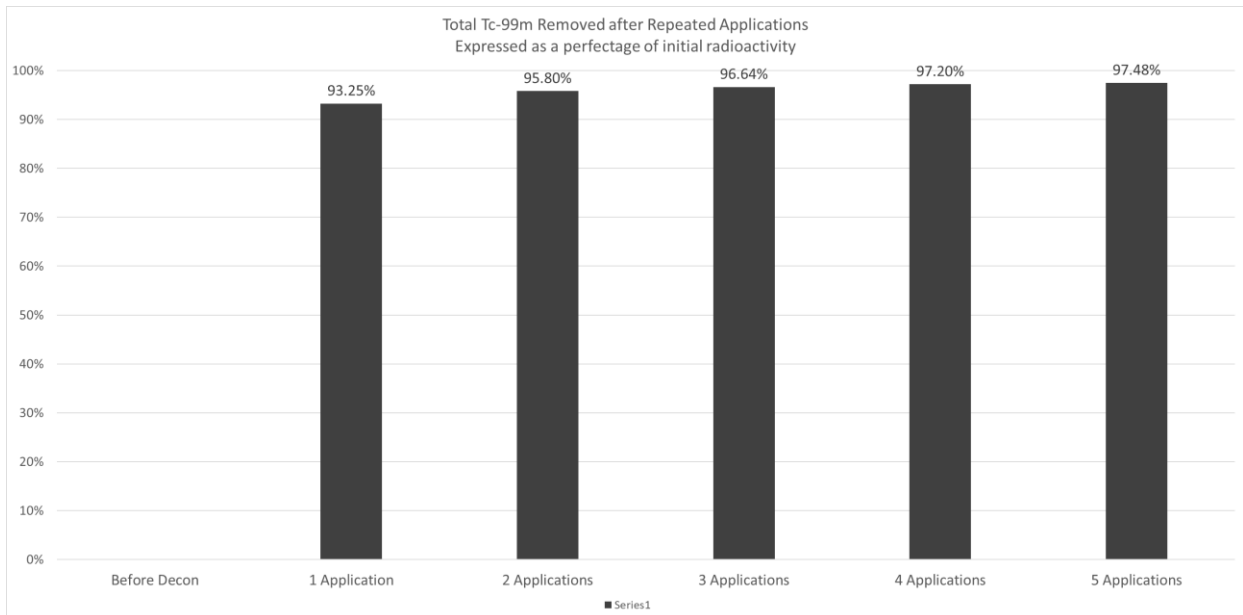


Figure 2. Removal of Tc-99m with repeated applications of Bind-It™

background levels, but was below “twice background” (20k CPM versus 11kCPM background).

### Simulating nuclear fallout simulation

Shortly after a nuclear weapon detonation, nuclear fallout is residual radioactive material that is propelled into the upper atmosphere that "falls out" of the sky over a period of hours to months. If the fireball from a nuclear detonation touches or is near the ground, dirt and other particulate will aggregate with the residual radioactive material and form fallout particles due to the intense heat. Fallout particles contain a wide range of radioisotopes and fission products (actinides) but Tc-99m was used in these tests for safety.

Simulated nuclear fallout was created by adsorbing Tc-99m onto small beads. The beads were made of metal-organic frameworks (MOFs) in two different sizes 10-20 micrometer ( $\mu\text{m}$ ) and 100-300 $\mu\text{m}$ . These sizes are consistent with potential fallout particle sizes. The beads were procured from a leading MOF vendor but are not currently available outside the RDT&E space.

The small and large MOF beads were added to Tc-99m and mixed until the consistency of wet sand was achieved (Figure 4). The contaminated MOF was set out to dry for 3 hours. After drying, the two preparations were highly radioactive and appeared and behaved like sand or dirt (Figure 5). These preparations were used to simulate nuclear fallout and dispersed onto aluminum sheeting and left for one hour. After one hour, the surface contamination was removed by sweeping, followed by one application of ready-to-use Bind-It™. Sweeping removed over 77% of the removable contamination but there was still a significant amount of residual contamination. One application of Bind-It™ removed all residual contamination (99.49%) and brought the radioactivity to background.

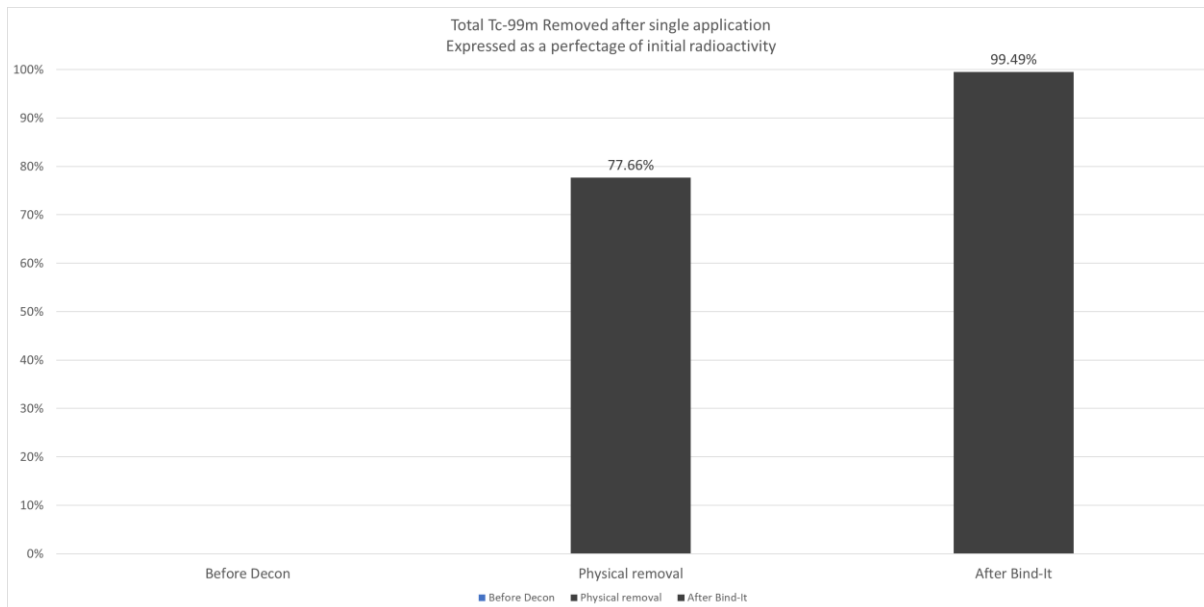


Figure 3. Bind-It removed 99.49% of particulate contamination.

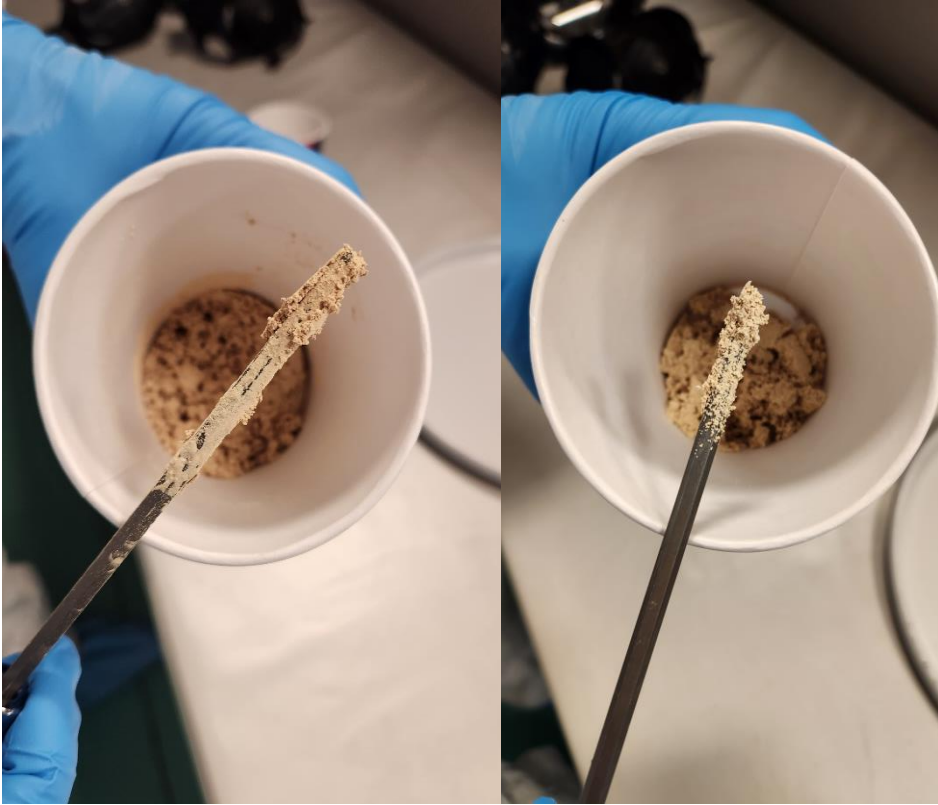


Figure 4. Preparation of Tc-99m contaminated MOF



Figure 5. Contaminated MOF before (top) and after (bottom) drying.

## **Materials testing**

### **Aluminum**

Bind-It™ removed 98.75% of Tc-99m contamination from aluminum after one application. During testing and over 72 hours after testing, no discoloration, peeling, or other damage was indicated on the samples that were tested with Bind-It™.

### **Zytron 500 Fabric**

Bind-It™ removed 85.6% of Tc-99m contamination after one application from Z500 fabric. Z500 is essentially an impermeable fabric and the Tc-99m contamination was permitted 10 minutes of contact time before decontamination. During testing and over 72 hours after testing, no discoloration, peeling, or other damage was indicated on the samples that were tested with Bind-It™. Since the Z500 samples were cut (4" x 4") from a Level-A ensemble suit made of Z500 fabric, it is highly likely that some of the Tc-99m absorbed into the inner fabric layer where it was not easily accessible to Bind-It™ for decontamination, leading to slightly lower initial removal levels.

### **CBRN Protective Gas Mask**

**CBRN Protective** Tactical Gas Masks were contaminated on the face shield, solid shield seal, and rubber surround material with 10 minutes of contact with Tc-99m. This was a challenging test for any decontamination method since there are many areas that the contamination can settle where rinsing or wiping may not remove the residual contamination. Decontamination by submersion may be preferred in real-world applications. However, Bind-It™, 1:5 with distilled water and wiping removed approximately 82% of contamination after one application. During testing and over 48 hours after testing, no discoloration, peeling, or other damage was indicated on the masks that were tested with Bind-It™.

### **Painted Concrete**

Bind-It™, 1:5 with distilled water and wiping removed approximately 82% of contamination after one application on painted concrete (cinder blocks). This was a challenging test for any decontamination method since there are many porous areas that the contamination can settle where rinsing or wiping may not remove the residual contamination. During testing and over 48 hours after testing the concrete blocks, no discoloration, peeling, or other damage was indicated on the samples that were tested with Bind-It™.

## **6. Methodology – Chem/Bio Simulant Testing**

### **6.1. Objectives**

The objective of this series of tests was to determine the decontamination effectiveness of Bind-It™ against simulants for chemical and biological agents. These tests were designed to measure the visible reduction in contamination using UV fluorescence and modern image processing software. These tests only account for physical removal of contamination and do not account for potential neutralization, denaturing, or other destructive means

of decontamination.

Glo Germ™ products are common in the Combating Weapons of Mass Destruction (CWMD) fields of study to visualize contamination and the spread of contamination during operational and decontamination processes. Glo Germ™ markets several variations of its products, one being an oil form, and another in a pressurized mist (wet aerosol) form. Glo Germ™ is colored to the naked eye but also visible under UV light.

## 6.2. Variables

These experiments examine how decontamination with Bind-It™ (independent variable) affects the measured fluorescence levels (dependent variable) on the test material.

## 6.3. Data Collection Methods

### 6.3.1. Test apparatus

Testing that utilizes radioactivity permits direct measurements with a calibrated device. Testing that uses a method such as fluorescence commonly utilizes fluorescence imaging and image processing software techniques. For these tests, a dark box was constructed for UV imaging and photography. The apparatus was designed to:

- reduce image glare by being painted flat black on the inside
- prevent aberrant light from affecting the photos by sealing seams/cracks
- permit stable photographs by mounting a high resolution mirrorless digital camera (36MP)
- consistently illuminate the sample with UV light with fixed UV strips



Figure 6. UV Light Box interior



Figure 7. UV Light Box exterior

### 6.3.2. Test Validation

The techniques performed in these tests are widely used in fluorescence microscopy to analyze cellular mechanisms with fluorescent-tagged antibodies. These tests took a macro approach with relatively large samples without the need for microscopes. Apparatus validation and characterization steps included:

- 6.3.2.1. Observe illuminated test apparatus without a sample present. No conflicting fluorescence was observed (Figure 8- left).
- 6.3.2.2. Observe illuminated test apparatus with an uncontaminated sample present (Figure 8 - right).
- 6.3.2.3. Observe illuminated test apparatus with a contaminated sample (either Glo Germ™ Oil™ and Mist™) (Figure 9).

### 6.3.3. Test Procedures

- 6.3.3.1. Contaminate each sample with either 3 drops of Glo Germ™ Oil or 1 spray of Glo Germ™ Mist.
- 6.3.3.2. Observe and photograph the contaminated sample in the test apparatus.
- 6.3.3.3. Apply Bind-It™ to the samples, wait 1 minute, remove the Bind-It™ with a blue towel in three wipes, folding between each wipe.
- 6.3.3.4. Observe and photograph the decontaminated sample in the test apparatus.
- 6.3.3.5. Perform image processing procedure to measure reduction in contamination.

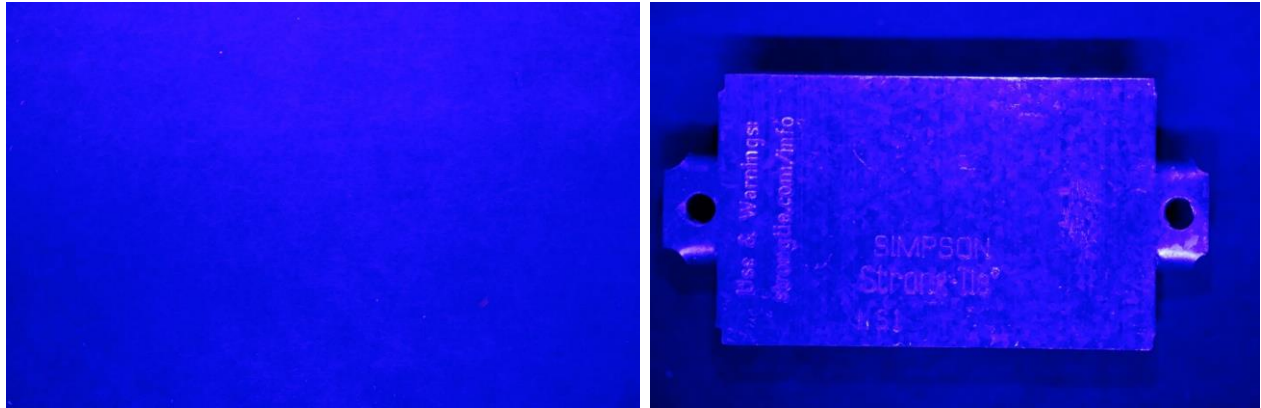


Figure 8. Illuminated apparatus image without a sample (left) and with an uncontaminated sample (right)

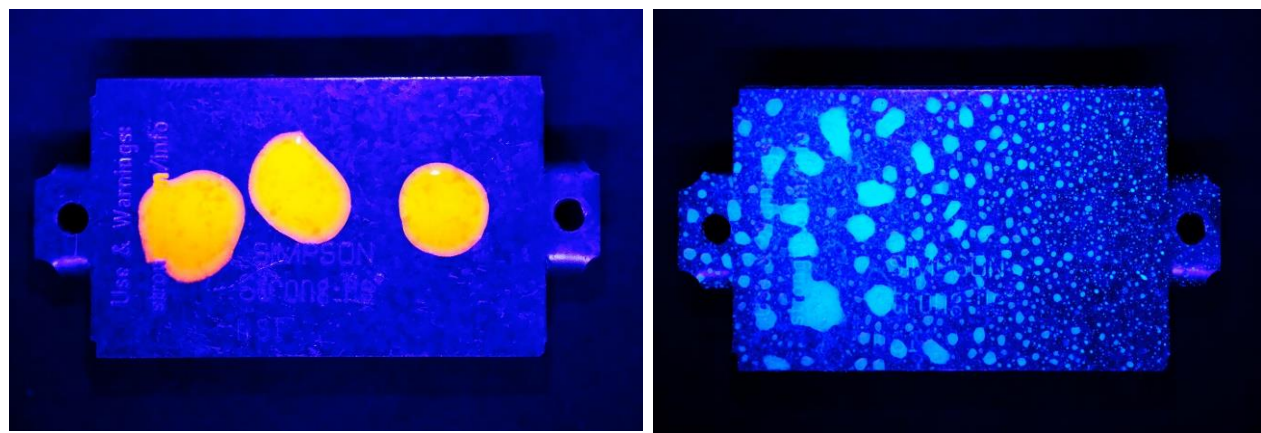


Figure 9. Samples contaminated with Glo Germ® Mist (above) and Glo Germ® Oil (below)

#### 6.3.4. Fluorescence Image Processing Procedure

Image processing was performed on the open-source program called ImageJ (v1.54h, released 12/15/23). The fluorescence image processing procedure was based on the procedure published by J. Ramirez-Franco (2020). This process isolates specific regions of interest (ROIs) which encompass the fluorescing areas of Glo Germ™ contamination. The same values are used in each image to establish consistency between samples. The steps in ImageJ follow:

- 6.3.4.1. Open image in ImageJ
- 6.3.4.2. Convert image to an 8-bit grayscale image
- 6.3.4.3. Image>Adjust>Threshold
- 6.3.4.4. Click Auto\*1 (isolates fluorescing areas of the image)
- 6.3.4.5. Click Apply (creates a binary image of white and black pixels only)
- 6.3.4.6. Process>Binary>Watershed (This will split in two cells that are too close and were processed as a single particle)

6.3.4.7. Analyze>Analyze Particles

6.3.4.8. Size: 0-Infinity

6.3.4.9. Circularity: 0.00-1.00

6.3.4.10. Check the checkbox: Add to manager

6.3.4.11. Save the ROI manager (it's saved by default as a \*.zip file)

6.3.4.12. Click over ("activate") your original image.

6.3.4.13. In analyze>Set measurements... Click on the parameters you want to analyze (Area)

6.3.4.14. In the ROI manager click "Measure"

6.3.4.15. Record the total ROI area

6.3.4.16. Repeat for the different images

6.3.4.17. A visual representation of these steps is shown in Figure 10.

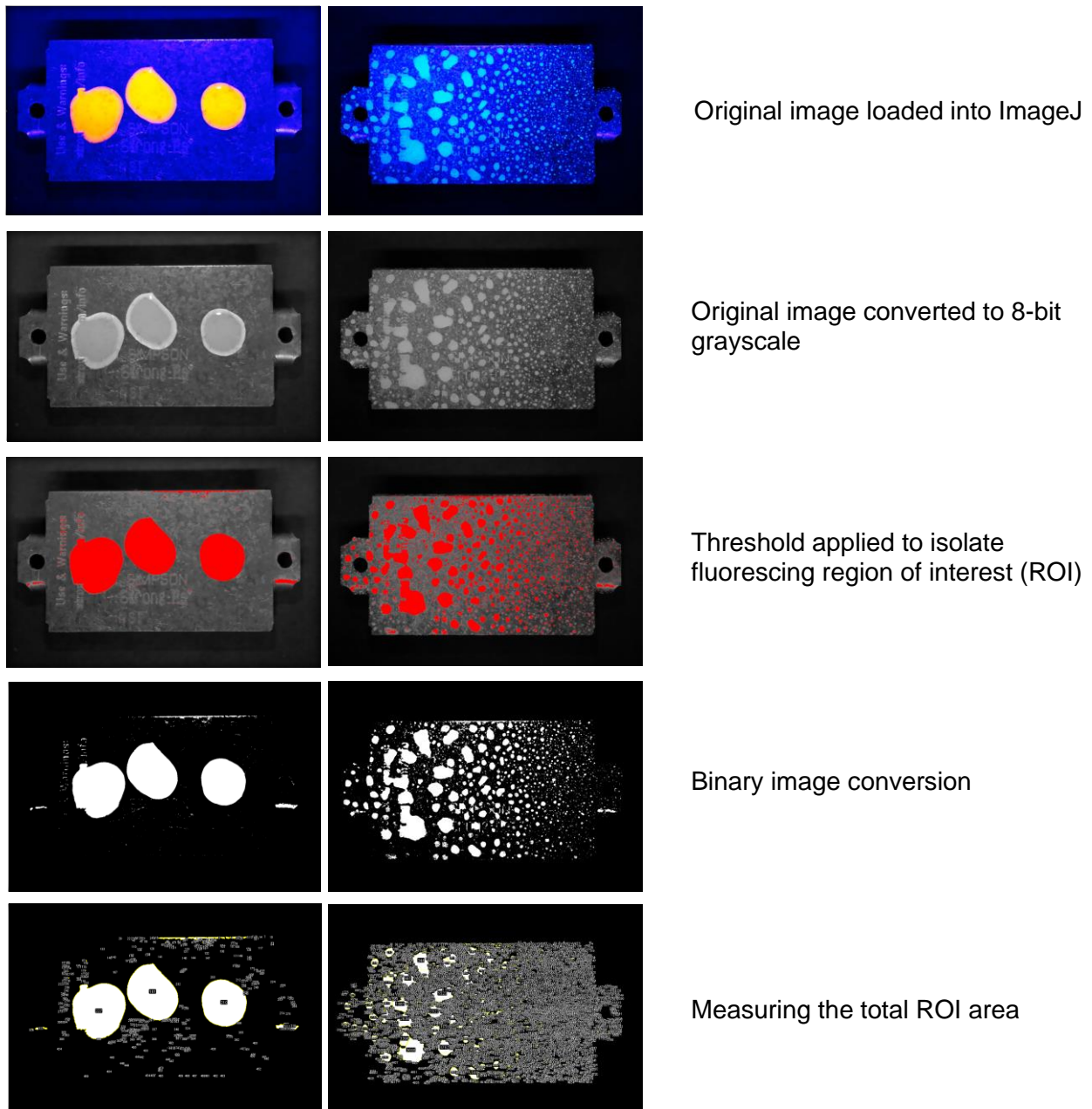


Figure 10. Image processing procedure summary in ImageJ

## 7. Results & Discussion – Chem/Bio Simulant Testing

7.1 Bind-It™ performed very well in the Glo Germ™ Oil and Mist tests for all samples. The average reduction in fluorescent contamination was 98.6% for both Oil and Mist samples (Figure 11).

7.2 These tests do not imply chemical or biological neutralization or inactivation of actual chemical or biological agents. However, the physical removal of the simulants is a promising indicator.

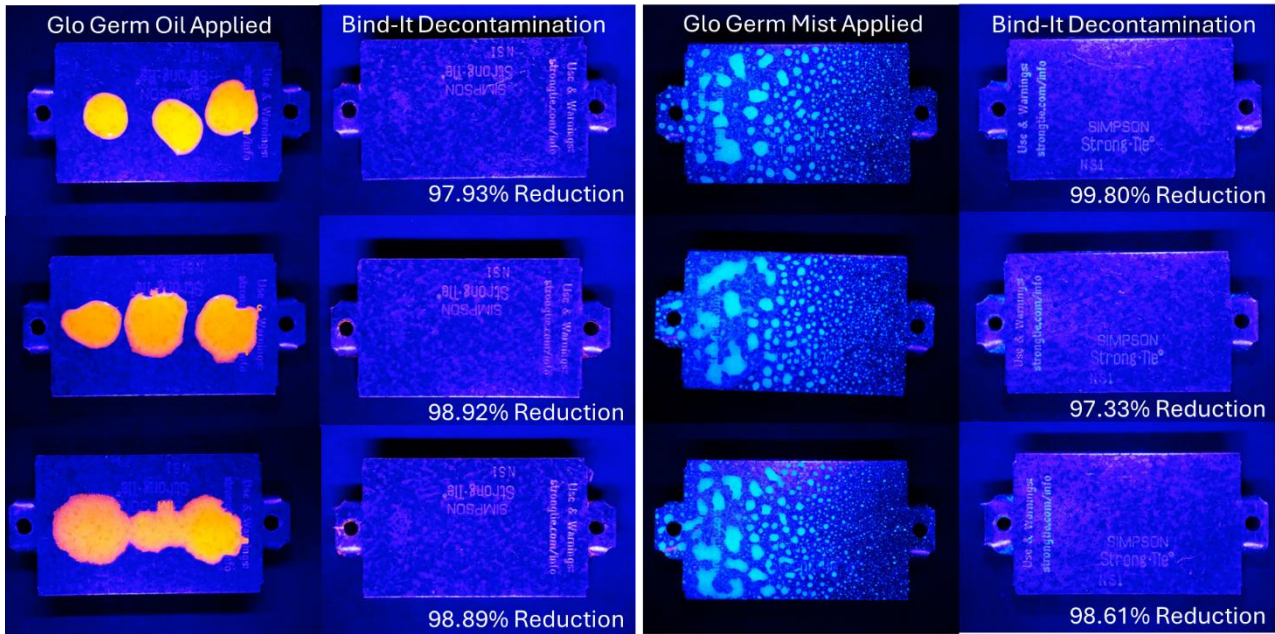


Figure 11. Fluorescent images from Glo Germ® testing

## 8. Conclusions

- 8.1. Bind-It™ was overall very effective for the removal of Tc-99m from selected surfaces and materials.
- 8.2. Bind-It™ is not very sensitive to the concentration, preparation, method of removal, or contact time with contamination. This is a desirable characteristic since the manufacturer does not have complete control over how the product is utilized once purchased by the end user. The average contamination reduction across all variations of usage testing was 88.7% on the first application.
- 8.3. While the use procedures were not very sensitive, the data indicate that a 1:5 preparation of Bind-It™ with (soft) tap water, left in contact with Tc-99m contamination for 1 minute then wiped away is an optimal procedure. However, since the quality of tap water is highly inconsistent, distilled water is recommended for consistent results.
- 8.4. Multiple applications of Bind-It™ continue to remove additional Tc-99m contamination, but with expected diminishing returns.
- 8.5. Bind-It™ was very effective for the removal of Glo Germ™ Oil (chemical simulant) and Glo Germ™ Mist (biological simulant), averaging 98.6% removal on the first application for both challenges.
- 8.6. In a nuclear fallout simulation, Bind-It™ brought surface-contaminated aluminum to background levels after one application.
- 8.7. Bind-It™ did not demonstrate any observable corrosive properties
- 8.8. Bind-It™ did not demonstrate any observable discoloration on painted surfaces

- 8.9. Bind-It™ did not demonstrate any observable damage to exposed clothing or other materials (aluminum, steel, Z500, protective masks, painted concrete, nitrile).
- 8.10. Bind-It™ did not demonstrate any undesirable effects or reactions in addition to those specifically requested by the manufacturer.

## 9. Recommendations

- 9.1. Research the reported mechanism of action that Bind-It™ uses to “bind” and create an “affinity” for radioisotopes. This could reveal use cases that could maximize the effectiveness of Bind-It™.
- 9.2. Explore the potential for Bind-It™ to decontaminate biological and chemical agents. Many common CWA/BWA decontamination solutions are not shelf-stable over long periods, are highly caustic, and damage most materials. Bind-It™ could provide an easily-accessible and shelf-stable CWA/BWA decon solution that is an improvement to common household methods but easier to use and remediate than military-grade decontamination solutions.

## 10. References

- [https://lablogic.com/nuclear-medicine-and-pet/consumables/Bind-It™ -tm](https://lablogic.com/nuclear-medicine-and-pet/consumables/Bind-It™-tm)
- Ramirez-Franco, J.. (2020). Re: How to quantify the fluorescence intensity of an image using ImageJ software?. Retrieved from: [https://www.researchgate.net/post/How\\_to\\_quantify\\_the\\_fluorescence\\_intensity\\_of\\_an\\_image\\_using\\_ImageJ\\_software](https://www.researchgate.net/post/How_to_quantify_the_fluorescence_intensity_of_an_image_using_ImageJ_software)

## Appendix A: Safety Procedures

The guiding principle for safe conduct of this testing is ALARA – exposures were kept as low as reasonably achievable within the guidelines of radioactive material licenses and QTA operational procedures.

1. Personal Protective Equipment (PPE):
  - Wear full Tyvek suits.
  - Use safety goggles or face shields to protect eyes.
  - Wear two layers of nitrile gloves.
  - If the risk of inhalation exists, utilize appropriate respiratory protection, such as masks with proper filters.
2. Workspace Precautions:
  - Conduct tests within designated radiation areas to prevent exposure from non-test participants during and after testing.
  - Ensure contaminated aerosols do not leave the control areas.
  - Keep emergency spill kits ready in the event the source material is spilled.
  - Employ physical controls to ensure non-test personnel cannot access the contaminated test area until at least 10 half lives have elapsed (~60 hours for Tc-99m).
3. Limit Exposure:
  - Limit the time spent in areas where radioactive materials are handled. Understand the test methods before beginning to reduce the time required to complete the tests.
  - Maintain a safe distance from radioactive sources when not directly working with them. For example, test personnel should not stand near the contaminated test materials while waiting for the water to evaporate.
  - Use shielding to protect against radiation when appropriate.
4. Handling and Storage:
  - Store radioactive materials in shielded containers, clearly labeled with the radionuclide, activity, date, and hazard symbol.
  - Use tools (tongs or forceps) to handle sources, reducing direct hand exposure.
  - Segregate radioactive waste from regular waste. Use specific containers for radioactive waste collection.
5. Monitor Radiation Levels:
  - Regularly use radiation survey meters to check areas, surfaces, and personnel for contamination.
  - Wear personal dosimeters (Rad-Eye) to monitor radiation exposure IAW QTA OP-PRO-153.
  - Wear personal dosimeters (TLD/OSL) to record cumulative radiation exposure IAW QTA dosimetry program.
6. Minimize Contamination:
  - Work on easily cleanable, absorbent, and disposable surfaces to contain spills and prevent the spread of

contamination.

- Do not eat, drink, smoke, or apply cosmetics in areas where radioactive materials are handled.
7. Waste Management:
- Dispose of radioactive waste according to local regulations and guidelines.
  - Segregate waste based on half-life, type of radiation, and activity.
  - Perform clearance surveys after the allotted decay time has passed before releasing the test area, test materials, and waste.
8. Training and Knowledge:
- Ensure all personnel are trained in radiation safety principles and understand the nature and risks of the radioactive materials they're handling.
  - Conduct regular safety drills for possible emergencies, like spills or exposure incidents.
9. Emergency Procedures:
- Have a clear plan for handling spills or accidents, including immediate containment, notification of safety personnel, and cleanup procedures.
  - Ensure easy access to emergency equipment, such as eye wash stations, first aid kits, and spill kits.
10. Post-Test Decontamination:
- Thoroughly decontaminate the testing area after tests, checking with radiation meters to ensure no residual contamination.
  - Change and safely dispose of gloves and other PPE after handling radioactive materials.
11. Notification and Signage:
- Clearly mark areas where radioactive materials are stored or used with appropriate signage.
  - Inform all personnel working in the vicinity about the ongoing tests and associated risks.