# Evaluating Methods for Removing Radioactive Contamination from Traditional Forensic Evidence: Moths

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MARSHALL FORENSIC SCIENCE

## Abstract:

In 2009, police found 300 grams of a uranium oxide compound in a storage property. During analysis of this material, the head and body of a moth were found. In order for an entomological study to be performed, the moth would have to be decontaminated. The purpose of this study was to determine an effective and nondestructive method for the decontamination of the evidence moth. Sample moths were gathered ultrasonicated in 1 of 11 different solvents. Mass difference and analysis by Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) were used to determine the amount of contamination remaining on the sample moths for comparison to the U.S. NRC regulations. The use of mass difference proved to be imprecise and difficult to interpret. These results were used instead to indicate the most promising solvents for ICP-MS analysis. According to the ICP-MS results, 5% Radiacwash™, 5% Decon® 90, acetone, and 1% nitric acid were found to be the most promising decontamination solvents; however, none of the solvents were able to remove enough contamination to allow for unlicensed handling.

## Introduction:

### 1 April 2009 – Victoria, Australia

Police carried out a drug raid of an alleged amphetamine laboratory. They unexpectedly found 300 grams of uranium oxide in a storage property. After initial analysis by the Australian Science & Technology Organization (ANSTO), aliquots of the material were sent to Lawrence Livermore National Laboratory (LLNL) for further analysis. While aliquoting the sample for chemical analysis, researchers at LLNL found the body and head of a moth (Figure 1).

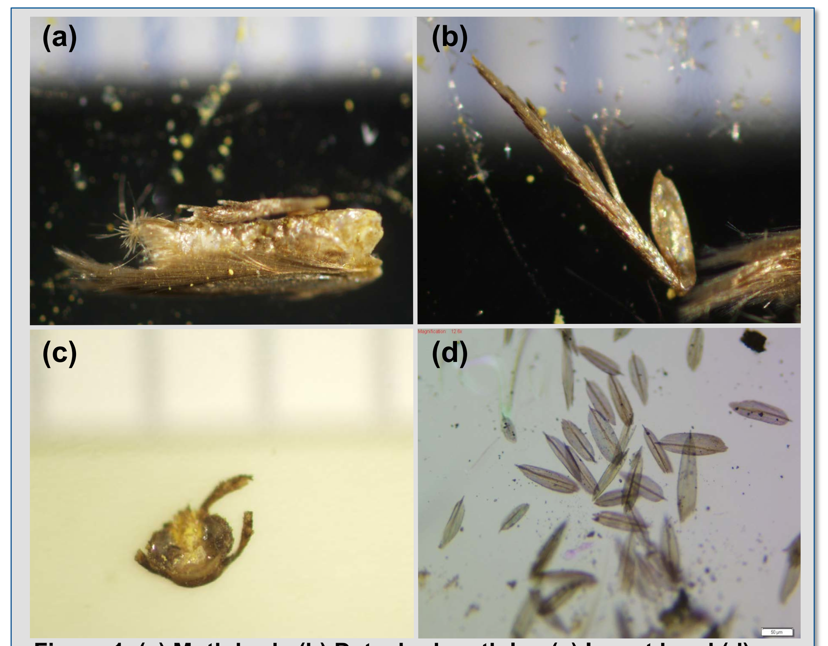


Figure 1. (a) Moth body (b) Detached moth leg (c) Insect head (d) Moth scales (with mm scales in background)

Entomological study of the moth could prove useful for understanding the history of the material from production to interdiction within Australia. However, entomology labs are unequipped to handle dispersible radioactivity. According to U.S. NRC regulations, contamination by a radioactive source must be below 0.05% of the evidence's weight in order to be handled without a license. **The decontamination process must remove enough nuclear material to render the evidence safe without destroying the evidentiary value.** Previous research suggests that a chemical removal of the contamination will be the most successful method.

## Method:

- Exemplar moths were gathered from northern Colorado. These moths are much larger (possibly more durable) than the evidence moth.
- CUP-2, a uranium ore concentrate (UOC), was used to contaminate the moths.
- Decontamination method: ultrasonication in 1 of 11 different decontamination solvents (five moths per solvent system).
- Determine decontamination efficacy by mass difference and microscopic examination.
- Ash moths decontaminated with the most promising solvents and perform ICP-MS to determine mass of uranium remaining.


http://www.freundcontainer.com/push-top-glass-vials/p/v7014B21/, http://whmcuratorscorner.blogspot.com/2012/04/miller-moths.html, http://img2-2.timeinc.net/toh/i/a/tools/wood-ashes-00.jpg

## Results:

### Microscopic Examination

To be successful, the decontamination procedure must remove the contamination and maintain the value of the forensic evidence.

Figures 2 and 3 demonstrate a partially successful decontamination.

- Figure 2 shows the furry thorax on a moth after contamination. The visible dusty, green particles are UOC. After decontamination with water, some small particles are still visible but the forensic value of the moth is retained.

Figure 4 demonstrates an unsuccessful decontamination.

- The solvent, a solution of 10% RBS™-25 (percentage recommended by the manufacturer), might have left a residue on the moth that resulted in the charred appearance after desiccation at 120 °C. The mass difference data (Table 1) suggests that RBS™-25 could be a viable option; however, the moth lost its forensic value when it became charred.

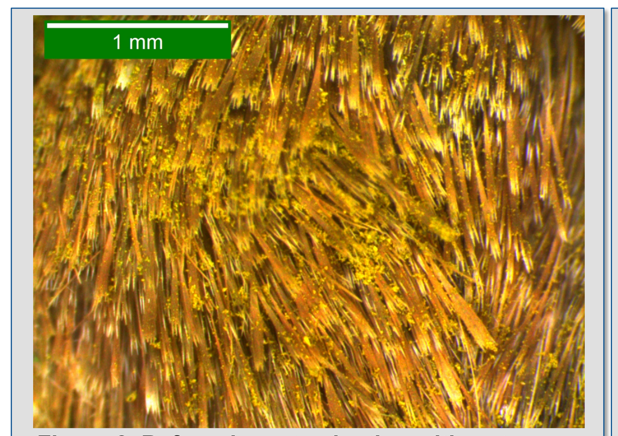


Figure 2. Before decontamination with water.

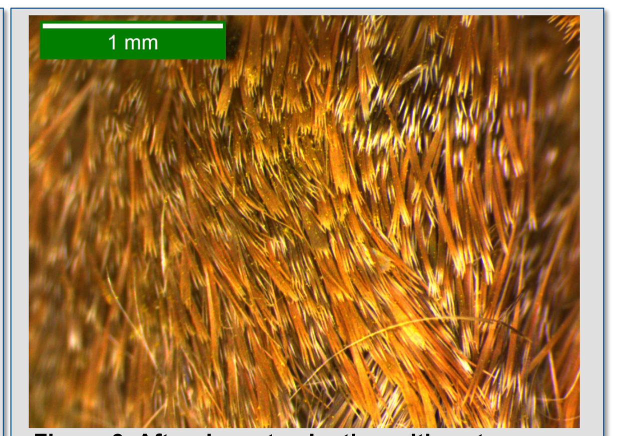


Figure 3. After decontamination with water.

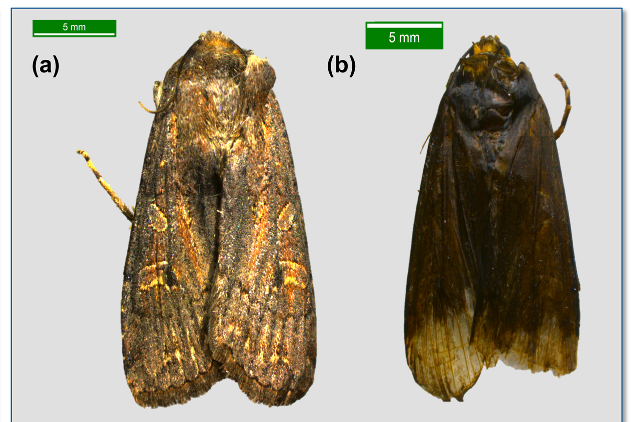


Figure 4. (a) Before and (b) After 10% RBS-25

Figures 5 and 6 demonstrates a successful decontamination.

- Figure 5 shows the moth after contamination with UOC. A solution of 5% Radiacwash™ was used to remove the UOC particles. Figure 6, taken after the decontamination process shows no significant changes to the appearance of the moth.

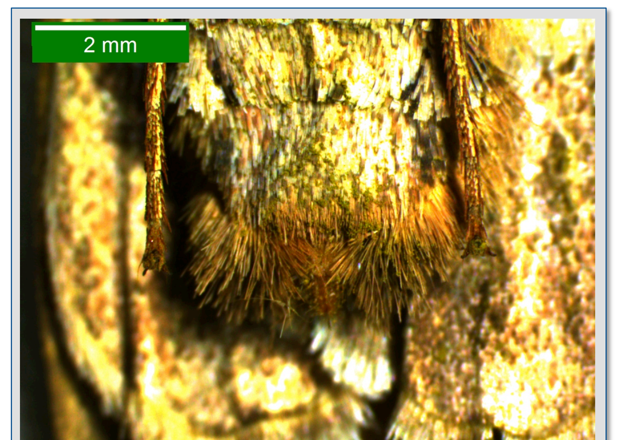


Figure 5. Moth body after contamination.


Figure 6. Moth body after decontamination with 5% Radiacwash™.

### Mass difference

The masses of each moth before and after the decontamination process was used to determine the percentage of UOC removed.

Table 1. The mean percentage of UOC removed from the treated moths for each solvent is presented along with the standard error of the mean.

| Solvent | Mean % UOC Removed | Standard Error of the Mean |
|---|---|---|
| Water | 18.7 | 12.2 |
| 3% Citric Acid** | -15.2 | 15.2 |
| 1.4% Sodium Bicarbonate** | 62.0 | 4.6 |
| 0.25 M EDTA** | 50.2 | 10.5 |
| 1% DTPA* | 64.9 | 13.1 |
| 5% Radiacwash™ | 158.5 | 32.6 |
| 10% RBS™-25 | 106.7 | 5.2 |
| 5% Decon® 90 | 170.9 | 50.1 |
| Acetone | 147.4 | 15.5 |
| 1% Nitric Acid^ | 119.3 | 3.9 |
| 1M Nitric Acid^ | 99.0 | 6.6 |

*Chosen from Ref 12. **Chosen from Ref 12 and 13. ^Chosen from Ref 14.

- Moths treated with citric acid gained mass during decontamination:
  - These were coated with a white residue (possibly a citrate salt) that could account for the extra mass.
- Several solvents results appear to have lost more UOC than they were originally contaminated with.
  - Explainable by a high initial "dry" mass due to incomplete desiccation during first step.
- Some loss of body parts (legs and antennae) occurred, however, when possible, they were gathered and continued on in the process with the moth.
- All moths, unavoidably, lost some mass from scales that were washed off during ultrasonication. Further experiments will need to be performed to see if this mass is significant.

## Results:

Table 2. Mean percent decontamination and the standard error of the mean for each solvent determined by ICP-MS.

| Solvent | Mean % Decon | Standard Error of the Mean |
|---|---|---|
| Water | 70.87 | 4.56 |
| 1.4% Sodium Bicarbonate* | 86.53 | 6.16 |
| 5% Radiacwash™ | 93.85 | 0.21 |
| 10% RBS™-25 | 93.05 | 1.24 |
| 5% Decon® 90 | 91.85 | 1.16 |
| Acetone | 84.13 | 1.88 |
| 1% Nitric Acid | 63.31 | 4.03 |

Table 3. Mean UOC mass remaining based on ICP-MS results compared to the mean allowable mass of UOC according to the U.S. NRC regulation.

| Solvent | Mean UOC Mass Remaining (mg) | Mean Allowable Mass of UOC (mg) |
|---|---|---|
| Water | 0.910 | 0.042 |
| 1.4% Sodium Bicarbonate* | 0.493 | 0.033 |
| 5% Radiacwash™ | 0.114 | 0.024 |
| 10% RBS™-25 | 0.502 | 0.042 |
| 5% Decon® 90 | 0.216 | 0.044 |
| Acetone | 2.50 | 0.044 |
| 1% Nitric Acid | 1.08 | 0.036 |

## Conclusions:

- Mass difference measurements are imprecise due to:
  - Incomplete desiccation – water left in the moth from an incomplete initial desiccation can result in an artificially high mass when compared to the final desiccated mass. An average of 37% of the total body mass was lost during initial desiccation, this may not be a complete desiccation.
  - Loss of body parts during ultrasonication – lost legs and antennae were collected; however, scales were unavoidably lost and might have a significant mass contribution.
- Solvents found to be promising for decontamination include:
  - 5% Radiacwash™, 5% Decon® 90, Acetone, and 1% Nitric Acid.
  - These solvents removed the most mass without damaging the moth.
- None of the solvents were able to remove enough radioactive contamination to allow for transfer to a traditional forensic science laboratory without further processing.

## Future Steps:

- Optimization of study parameters:
  - Complete desiccation of moths for more reliable data – may require the use of isopropanol and/or longer desiccation time with storage in a desiccator.
  - Use of exemplar moths that are closer to the evidence moth in size.
  - Cost and benefits should be considered of running the moths through a second round of the decontamination procedure.
- Spike samples with known amounts of gamma emitters and determine the amount of decontamination with gamma counting.
- DNA extraction – can DNA be extracted and separated from the radioactive material for analysis in a traditional forensic science laboratory.

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