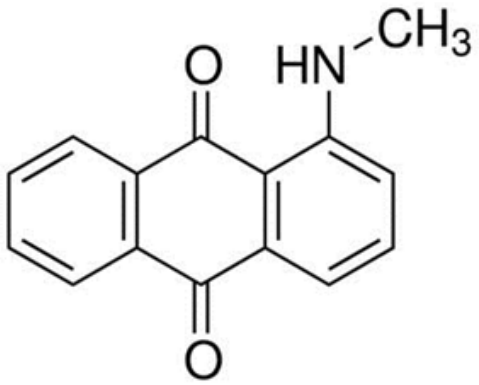
10.3 Bank Dye Analysis

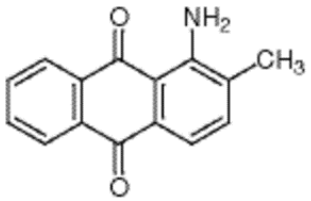
10.3.1 Overview

Dye-packs are security devices used by banks/financial institutions for the purpose of visibly staining stolen money in the event of a robbery. A dye-pack device looks like a stack of real currency, however after being improperly removed from the premises it is designed to activate and emit a cloud of the red dye 1-methylaminoanthraquinone (MAAQ), staining the currency. Other objects such as clothing, footwear, bags and car seats may also become stained when the device is activated. Depending on the amount of MAAQ deposited, the staining may appear pink to red in color. MAAQ is not easily removed through regular washing, thus it may be present on items such as clothing even after washing.

1-Methylaminoanthraquinone ($C_{15}H_{11}NO_2$) MW = 237.26 - CAS #82-38-2



Note: There is also a positional isomer to be aware of: 1-amino-2-methylanthraquinone (1-A-2-MAQ) - C15H11NO2 - CAS Number: 82-28-0 which is an orange-red color and not the dye used in bank security packs. Synonym = Disperse Orange 11



Exploding bank dye packs often contain the red dye, 1-methylaminoanthraquinone (MAAQ), and at times the lachrymator, o-chlorobenzylidenemalononitrile (CS). This procedure describes a means of extracting and identifying the red dye MAAQ component.

If there is a suspected lachrymator component to the evidence, please consult with an analyst who performs that analysis to make a plan of examination.

MAAQ is a disperse dye also found in a limited number of items/products. Besides its use in dye-packs, MAAQ is used in certain pyrotechnic devices, in some devices containing red smoke mixtures, and in the manufacture of some plastics and other dyes. It can also be found in the red plastic of vehicle tail lights and possibly in magazines/posters (glossy). But in each case, the dye is locked up (chemically bonded) and not likely to be separated/isolated (for transfer) out of (or off of) those surfaces. Further, it is practically insoluble in water. Additional uses of MAAQ as colorant for other materials and products have been mentioned in publications and on websites. However, the availability of MAAQ to the general public is limited.

Safety/Caution:

- Care should be taken as MAAQ is a prolific dye that does not wash off with water.
- Lachrymators, such as CS, are compounds that irritate the eyes and mucous membranes and should be handled accordingly.

10.3.2 Collection

10.3.2.1

Treat the questioned samples and any control/standard samples in the same manner.

When performing extractions also analyze a blank of the extraction liquid and an extracted unstained portion of the substrate, if possible. If an unstained portion of the substrate is not possible, analyze the extraction solvent as the negative control. Use the same approximate size of unstained material, if available, for the substrate control or analyze the extraction solvent of unstained swabs wetted with extraction solvent.

Visually examine the evidence for any red, red-orange or pink stains. Document the physical appearance and location of the stain(s).

To collect a suspected dye sample, saturate a cotton swab with methyl alcohol (MeOH) or other appropriate solvent such as isopropyl alcohol, chloroform or acetone and swab the area of suspected dye. The MeOH will aggressively absorb the dye and is relatively stable.

A portion or cutting of the stained area can also be rinsed with MeOH, collecting the extracted stain. This can then be concentrated down as needed prior to analysis. There are times it is more advisable to rinse a stain area rather than collect it onto a swab.

A very dark red stain is much more suited to the swab technique, however for a weak, broad stain, rinsing/extraction/concentration might be preferred. In either case, it might be necessary to concentrate the stain prior to analysis. If necessary, concentrate the extract to as dark a red color as possible. Concentrate the blank a like amount.

If the stained area is dark and powdery, scrape the material into a sample vial and add solvent.

If stained areas do not extract into methanol or other solvent used, **no further testing is necessary**.

If the substrate is dark in color and no stains are visible, rub cotton swabs wetted with solvent over a small area of the item at a time. Observe any red, red-orange or pink color transferred to the swab and cut out these areas for extraction. If no color is transferred to the swab, continue swabbing additional areas as appropriate. **If no color is transferred to any of the swabs, no further testing is necessary.**

10.3.2.2

The swab with the suspected dye can be stored in a test tube immediately or the dye can be rinsed into a test tube with additional MeOH. Care should be taken to use only enough MeOH to remove the dye from the collection swab.

10.3.2.2.1

Note: For relatively short length of time between collection and analysis (up to 3 days) the dye/MeOH solution can be stored at room temperature. For any length of time between collection and analysis longer than 3 days, the dye/MeOH solution can be capped and stored in cold storage for several days.

10.3.3 GC-MS Analysis

Use appropriate QA/QC procedures. An instrument function verification check will be run each day that the instrument is used for casework. This run will use the same conditions as those run for the samples. Blanks will be run between samples. An internal standard can be added to the samples and blanks if desired.

1-Methylaminoanthraquinone requires column temperatures of 100 - 280°C.

Example GC-MS parameters: Initial temp 80°C; 0.0 min hold; 15°/min to 280°; 7.5 min hold

Run a known MAAQ sample with the case (and included in the case record).
It is recommended to include this sample at the end of the GC-MS runs. This sample can be prepared by placing a very small amount of known MAAQ into approximately 1ml of solvent.

10.3.4 Identification

Retention time and mass spectra are used for for identification.

10.3.5 Report Wording

Include a description of the physical appearance of the evidence/staining.

Example wording:

The stain(s) observed on Item XX was analyzed using Gas Chromatography-Mass Spectrometry (GC-MS) and 1-Methylaminoanthraquinone (MAAQ) was identified. MAAQ is the red dye component of some types of security dye packs.

10.3.6 References

Egan, James M. et. al. "Bank Security Dye Packs: Synthesis, Isolation, and Characterization of Chlorinated Products of Bleached 1-(methylamino)anthraquinone", Journal of Forensic Sciences, November 2006, pgs 1276-1283

Analysis of Bank Dye Evidence and the Challenges of Daubert Hearings - FBI Lab, Pamela C. Reynolds - Forensic Science Communications January 2008 - Volume 10 - Number 1

AAFS workshop notebook - Workshop #16 FBI Bank Security Device Workshop, New Orleans AAFS meeting, February 22, 2005. (located at the Grand Rapids Lab)

Martz, R.M., Reutter, D.J., and Lasswell, III, L.D., “A Comparison of Ionization Techniques for Gas Chromatography/Mass Spectroscopy Analysis of Dye and Lachrymator Residues from Exploding Bank Security Devices”, Journal of Forensic Sciences, Vol. 28, No. 1, January 1983, pp. 200-207.