

TECHNICAL NOTE

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Surface Contamination by TNT

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ABSTRACT: We have performed experiments that indicate TNT contamination is present on surfaces exposed to TNT vapor, and that TNT contamination is transferred rapidly between proximate surfaces. Contaminated surfaces continue to be nearly constant sources of TNT vapor for some time after removal of the primary source.

KEYWORDS: forensic science, TNT, explosive detection, vapor, sorption, desorption

Considerable attention has been given to measurement of vapor emitted from solid explosives during the past 20 years (see for example Ref 1 for a compendium of recent research). Little research has been directed toward the secondary sources of these vapors, which can result from proximity to explosives or other contaminated surfaces. Of immediate interest are wooden boxes or metal containers that may have been used to transport explosives, varnished or painted surfaces on which explosives may have rested, or soil with which explosives may have been in contact.

If these secondary sources release substantial amounts of vapor from residue left by the primary explosive, they may provide a traceable path to concealed explosives or to recent concealments. This note addresses the durability of several materials as sources of explosive vapors after contact, and the magnitude of surface-to-surface transfer of explosive contamination during handling.

Technique

Common building materials, including pine, cedar, spruce, fir plywood, and birch plywood, were placed in a 10 L glass desiccator jar, that also contained about 150 mg of

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TNT particles. Several aluminum plates (15 by 15 by 0.5 cm), prepared as painted surface standards by the Environmental Institute of Michigan (ERIM) using a variety of alkyd paints, were similarly exposed. There was no contact among specimens and the TNT particles. The vapor diffusion from TNT to specimen was the only available source of TNT to the specimen surfaces. The specimens remained in the jars from 20 to 90 days at ambient temperatures of about 24 to 27°C before removal for analysis. The concentration of TNT vapor in the jar under these conditions was calculated to be approximately 10 ppb by volume or 9.3×10^{-8} g/L [2].

The specimens were removed from the vapor jars (located at the Cold Regions Research and Engineering Laboratory in Hanover, N.H.), placed in plastic wrap, and hand carried to Quantico, Virginia, or Woburn, Massachusetts for analysis. About 24 h elapsed between removal from the exposure jar and the beginning of analysis in these cases. On one occasion, the painted standards were transported to Woburn within the exposure jar, and only a few minutes elapsed between removal and measurement. The ambient temperatures during transport were in the 5 to 20°C range.

The specimens were placed in the center of a large drawing paper pad about five times as large as the specimens for analysis. Air was drawn over a defined area of the specimen at 120 LPM and then passed through a preconcentrating collector. The concentration of TNT in the air sample was determined by desorbing the collected vapor into a chromatographic column, and finally into the chemiluminescence detector of an EGIS (registered trademark of Thermedics, Inc.) test instrument.

The detector response was determined by injecting a 1 ng/ μ l solution of TNT in acetone directly into the chromatograph inlet. A chromatogram showing the separation of TNT from its common contaminant 2,4-dinitrotoluene, and the calibration signal amplitude is provided in Fig. 1. Since the collector/detector suite was not specifically standardized using ambient air-TNT vapor mixtures in these experiments, the results reported in this note should be considered preliminary until verified with calibration standards of TNT in air [3].

TNT and other explosives are frequently analyzed at both laboratories where these experiments were conducted and some background contamination may be present. Ambient air samples collected 1 m above and adjacent to the experiments were analyzed several times during each experiment session, and were consistently less than .01 of signals measured near the specimen surfaces. A background air chromatogram is also shown in Fig. 1.

Collected volumes (and sampling times) were varied by a factor of four to determine if the degassing rate was constant. Several of the specimens were stored in ambient laboratory air, and remeasured a few hours to a few days later to determine the persistence of the contamination.

Results of Experiments

Initial measurements at Quantico showed contaminated common pine lumber to be a persistent source of TNT vapor. The mass of TNT vapor collected above a pine surface for several sampling times, over a 2-day period is shown in Fig. 2. The mass of TNT collected varies linearly with sampling time, indicating the source is relatively constant. Following these measurements, one of the 15 by 15 by 2 cm common pine samples was split with the grain into two approximately equal slabs. The degassing rate of the interior surface was just slightly less than that of the original exterior surface, indicating the TNT vapor had thoroughly penetrated the porous structure of the pine. A cube of approximately 1 cm on a side was cut from a remaining pine specimen. Extraction with benzene followed by GC-ECD analysis [4] indicated a concentration of at least 1 μ g/cm³ of TNT in the pine specimen.

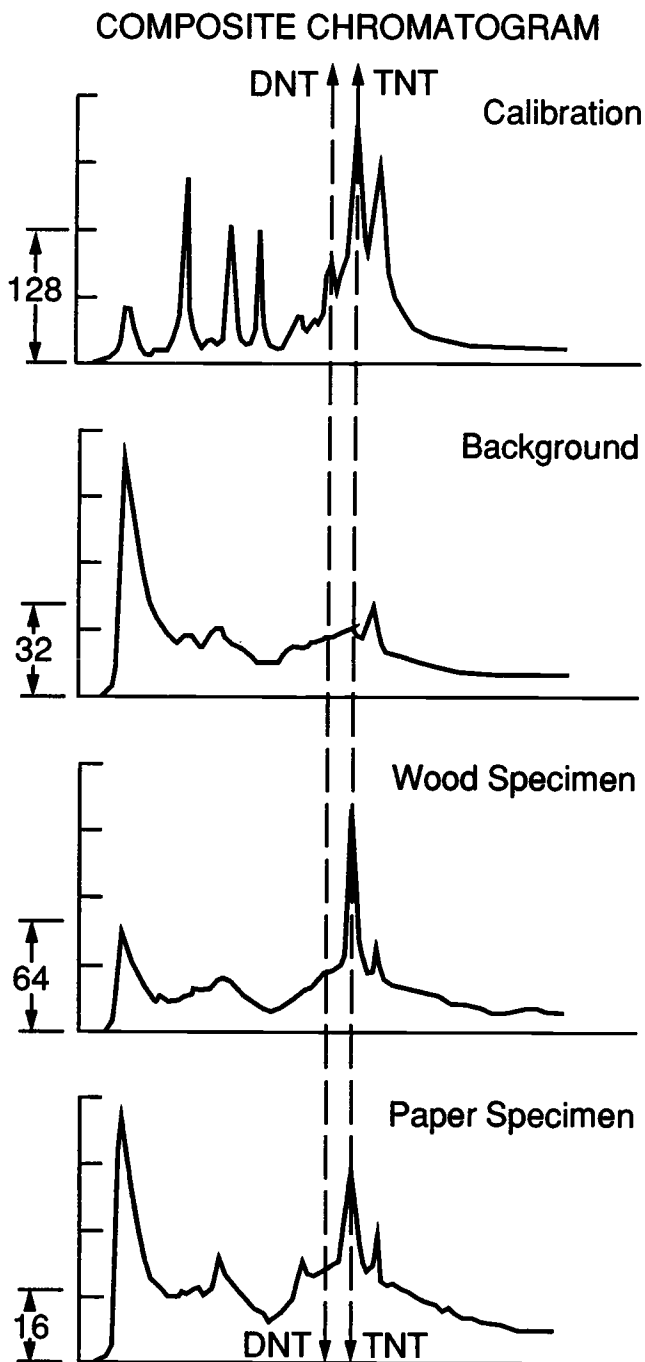


FIG. 1—Upper chromatogram shows separation of DNT(D) and TNT(T) in a multi-explosive standard solution in acetone at 128× relative attenuation. Lower chromatogram shows laboratory air background at 32× relative attenuation.

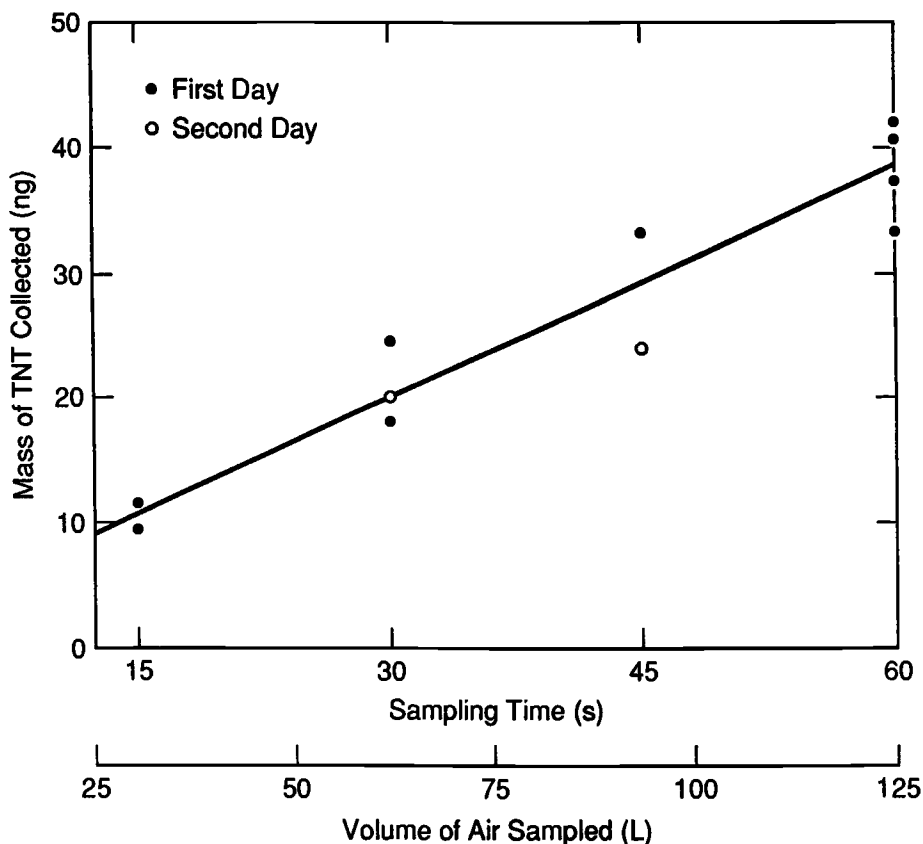


FIG. 2.—Mass of TNT vapor collected over surface versus time and volume sampled.

Domestic fir plywood, European-style hardward core birch plywood, spruce lumber and cedar lumber were also examined in the initial experiment. Splitting the fir plywood along the glue joint and measuring the new surface showed TNT vapor had permeated the entire outside ply. The cedar, which had been coated with three coats of urethane varnish, had a slightly lower desorption rate than pine or fir plywood. The degassing rates of these and subsequently measured materials are given in Table 1. Remeasuring a pine specimen 45 days after the initial experiment showed the degassing rate to have diminished to one-third the original value.

An additional series of experiments at Woburn measured the desorption rates from the alkyd painted metal surfaces after 30 days exposure to TNT vapor. The degassing rates from these surfaces are slightly less than those of the porous wood, and are also shown in Table 1. Several times during these experiments the specimen being analyzed was removed from the drawing pad and the rate of desorption of TNT vapor from the paper measured. Chromatograms representing donor and collector are shown at the bottom of Fig. 1. The desorption rate of the plastic bubble wrap used to enclose the specimens in transport was also measured. In addition, a transfer experiment was performed, in which a contaminated surface was placed in contact with another surface for from 1 to 10 min at ambient room temperature. The originally contaminated surface was

TABLE 1—Source strength of contaminated surfaces (TNT vapor at room temperature).

Material	Lab	Source Strength [g/cm ² /s]
Common Pine (2 cm)	Q	5.44×10^{-13}
Fir Plywood (1 cm)	W	8.0×10^{-14}
Birch Plywood (2 cm)	Q	1.44×10^{-12}
Rubber (≈ 2 mm)	Q	1.1×10^{-12}
Aluminum, CARC Brown Paint	W	$2.0\text{--}3.0 \times 10^{-14}$
Aluminum, Alkyd Paint	W	1.6×10^{-14}
Aluminum, Alkyd Paint	W	1.4×10^{-14}

TABLE 2—Transfer of TNT contamination among surfaces in proximity.

Source/Receptor	Receptor Source Strength [g/cm ² /s]
From Primed Aluminum to Paper	1.3×10^{-13}
From Alkyd Painted Aluminum to Paper	1.1×10^{-13}
From Alkyd Painted Aluminum to Sand	9.5×10^{-14}
From Primed & Painted Aluminum (both sides) to Plastic Bubble Wrap	1.5×10^{-14}
From Wood (several species) to Paper (middle of range of several measurements)	5×10^{-14}

removed and the degassing rate of TNT vapor from the contacted surface was measured. The fluxes from the receptor surfaces are shown in Table 2.

Summary and Conclusions

These experiments indicate that wood and painted metal exposed to TNT vapor sorb TNT, and then desorb the TNT into the air for several days after removal of the source. Surface-to-surface transfer of TNT is very rapid even for rough surfaces, when the surfaces are in close proximity. Further experiments are necessary to determine the change of degassing rate with time and the specific mass of TNT that can be stored on the surfaces of various materials. The nature of surface-to-surface transfer must also be investigated.

Acknowledgment

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References

- [1] *Journal of Energetic Materials*, Vol. 4, Nos. 1–4, 1986, pp. 1–548.
- [2] Dionne, B. C., Rounbehler, D. P., Achter, E. K., Hobbs, J. R., and Fine, D. H., "Vapor Pressure of Explosives," *Journal of Energetic Materials*, 1986, pp. 447–472.

- [3] Pella, P. A., "Generator for Producing Trace Vapor Concentrations of 2,4,6-Trinitrotoluene, 2,4-Dinitrotoluene, and Ethylene Glycol Dinitrate for Calibrating Explosives Vapor Detectors," *Analytical Chemistry*, Vol. 48, No. 11, 1976, pp. 1632-1637.
- [4] Palazzo, A. J. and Leggett, D. C. "Effect and Disposition of TNT in a Terrestrial Plant," *Journal of Environmental Quality*, Vol. 15, No. 1, Jan. 1986, pp. 49-52.

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