

Effects of Explosive Type and Form on Contact Trace Sampling Efficiency

John Parmeter

Sandia National Laboratories

(505) 845-0894

jeparme@sandia.gov

Trace Explosive Sensing for Security Applications Workshop

Northeastern University

13 August 2014

Outline

- Contact sampling issues – those covered and not covered in this presentation
- Explosive type: RDX (C-4), TNT, NG
- Form of explosive: RDX vs. C-4; NG in smokeless powder versus NG in dynamite
- Additional comments on
 1. Wet versus dry sampling
 2. How volatile can an explosive be for contact sampling to be effective?
 3. Human factors (variation for one sampler, sampler to sampler variation)

General Comments

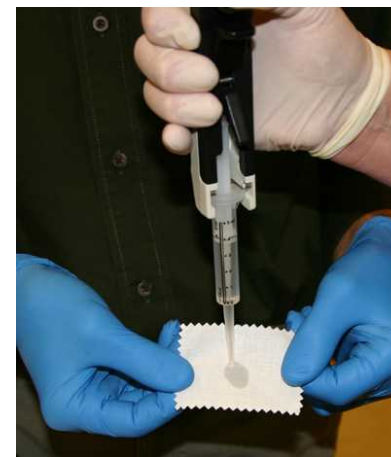
- Most work to be presented is from a DHS study to quantify trace contamination on vehicles loaded with bulk explosives.
- *Approximate* quantification of sampling efficiencies was important, but intent was to estimate sampling efficiencies, not try to maximize them, nor to measure them as accurately as possible.
- I have been out of this business for about five years but main issues seem to be the same.

Factors Affecting Contact Sampling Efficiency

- Type of sampling medium: covered in another talk at this workshop – work presented here used Smiths Ionscan 400B swabs
- Type of surface: covered in another talk at this workshop – work presented here used 4” square coupons cut from a vehicle hood
- Type of explosive and form deposited: main emphasis of this talk
- Human factors: not a primary focus of this workshop but some data presented
- Wet versus dry sampling: limited data presented
- Explosive volatility: limited data on usefulness of contact sampling versus explosive vapor pressure
- Environmental factors – temperature, humidity, etc. – not covered in this talk

Standard Procedure to Quantify Sampling Efficiency in this Study

- Use syringe to deposit known amount of explosive in standard solution onto Bytac dry transfer strip provided by TSL; let solvent evaporate
- Use Bytac strip to perform dry transfer onto 4" square coupon from vehicle hood
 1. Other studies had shown the dry transfer efficiency was typically > 90%
 2. Confirmed in our work by small masses of explosive remaining on used Bytac strips
- Sampler wears clean gloves, deposits 100 μ l isopropanol onto Smiths 400B swab, and swipes the hood coupon; an identical swab is used to swipe the Bytac strip following dry transfer from the Bytac strip to the hood coupon
- Place swabs in vials with 2 ml acetonitrile and refrigerate
- Analyze with GC-ECD



- $$\text{Sampling efficiency} = \frac{\text{Mass on swipe from coupon}}{\text{Initial mass on Bytac strip} - \text{Mass on swipe from used Bytac strip}}$$

Sampling Efficiency Data: TNT

Sampler	Hood Piece Swipes (n=19-20)	Used Bytac Strip (n=19-20)	Direct Swipes of Bytac Strip (n=3)	Direct Deposit onto Swabs (n=3)
Sampler 1	52.7 ± 8.40	2.5 ± 3.5	95 ± 5.0	102 ± 16.1
Sampler 2	54.1 ± 15.5	11.9 ± 14.1	95 ± 15	107 ± 5.77
Sampler 3	67.5 ± 9.10	2.75 ± 4.41	102 ± 7.64	102 ± 7.64
Average	58.1	5.72	97.3	104

- ~104% (100% within experimental error) recovery for direct solution deposit onto swab
- ~97% recovery for direct swipe of Bytac strip with deposited TNT
- ~6% recovery from used Bytac strip
- ~58% sampling efficiency for swipe of hood coupon with TNT deposited via dry transfer

Sampling Efficiency Data: RDX

- 84 ng from solution deposited onto hood coupons
- Two samplers, each swiping one hood coupon with a dry Ionscan 400B swab, an identical swab wetted with isopropyl alcohol (IPA), and a prepackaged commercial IPA wipe
- Dry swabs: first swipe removes 15-20% of RDX; 31-35% total removed with eight consecutive swipes
- Wetted swabs: 40-47% of RDX removed with first swipe; 62-70% total removed with eight consecutive swipes
- Prepackaged IPA wipes: 38-54% of RDX removed with first swipe; 83-115% total removed with eight consecutive swipes. However, a high chromatographic background made quantification difficult.
- This was a quick, semi-quantitative experiment but it suggests that wetting may improve sampling efficiency. However, in real-world applications wetting the swipe adds time and effort, so dry sampling may be preferred.

Sampling Efficiency Data: C-4

- Bytac strips from TSL containing approximately 110 ng C-4, dry transfer to hood coupons
- Laboratory, Sampler 1, $49 \pm 16\%$ sampling efficiency (n=45)
- Laboratory, Sampler 2, $49 \pm 9\%$ sampling efficiency (n=20)
- Validation samples done with vehicle loading experiments, $55 \pm 14\%$, but range of 38-80% (n=10)

Sampling Efficiency Data: NG from Smokeless Powder

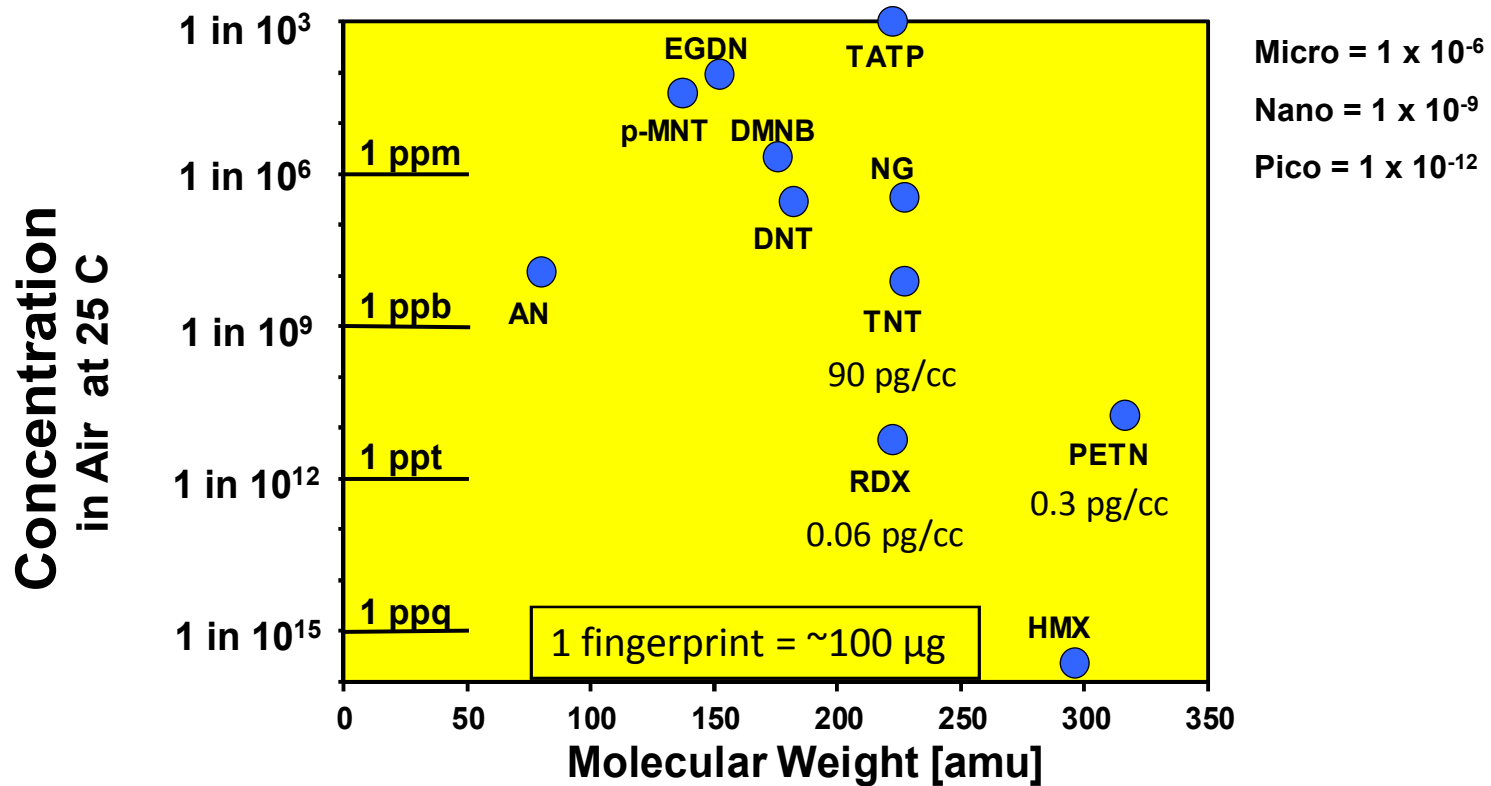
Sampler	Swipes from Hood Pieces (n=20)	Swipes from Used Bytac Strips (n=20)	Swipes from Unused Bytac Strips (n=3)	Direct Deposit onto Swabs (n=3)
Sampler 1	46.7 ± 9.1	3.5 ± 3.6	85.0 ± 0.0	103 ± 5.8
Sampler 2	36.6 ± 9.2	0.9 ± 1.8	69.3 ± 20.5	87.0 ± 10.6
Sampler 3	43.2 ± 9.3	6.0 ± 6.8	65.0 ± 5.0	117 ± 4.6
Sampler 4	53.0 ± 18.7	6.8 ± 7.8	85.0 ± 13.2	103 ± 5.8
Average	44.9	4.3	76.1	102.5

- Smokeless powder 40% NG by weight
- Standard solution of smokeless powder in acetonitrile nominally 100 ng/μl NG
- Solution deposit onto Bytac strip, then dry transfer to hood coupon

Sampling Efficiency Data: NG from Dynamite

- Dynamite is 22% EGDN and 4.4% NG by weight
- Standard dynamite solution in acetonitrile ca. 70 ng/ μ l NG and 300 ng/ μ l EGDN
- Solution deposit onto Bytac strip followed by dry transfer to hood coupon
- Sampler 1, 82 \pm 15% sampling efficiency for NG (n=20)
- Sampler 2, 67 \pm 18% sampling efficiency for NG (n=20)
- Higher efficiencies than for NG from smokeless powder, though for Sampler 2 the standard deviations overlap

Attempts to Measure Contact Sampling Efficiency for EGDN Failed



- Nominal efficiency for both samplers 15-20% using same dynamite solution and same procedure as for NG
- EGDN vaporizes too quickly to obtain meaningful results

Summary

	TNT	C-4	Smokeless Powder	Dynamite
Sampler	TNT	RDX	NG	NG
1	53 ± 8	49 ± 16	47 ± 9	82 ± 15
2	54 ± 16	49 ± 9	37 ± 9	67 ± 18
3	68 ± 9		43 ± 9	
4			53 ± 19	
AVERAGE	58 ± 11%	49 ± 13%	45 ± 12%	75 ± 17%

- Direct contact sampling efficiencies often near 50% (C-4, TNT, NG from smokeless powder)
- Wetting swab appeared to improve efficiency in our study
- Sampling efficiencies appear to differ substantially for NG from smokeless powder solution and NG from dynamite solution
- EGDN is too volatile to quantify using our methods