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Desorption of a methamphetamine surrogate from wallboard under remediation conditions

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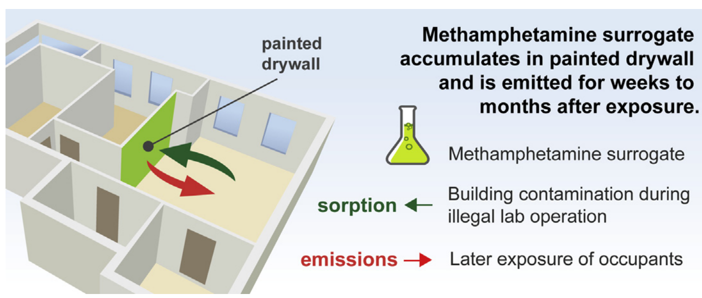
HIGHLIGHTS

- Painted drywall can readily sorb and reemit a methamphetamine surrogate.
- Less than 22% of the surrogate was emitted at elevated temperature in 20 days.
- Increasing humidity only modestly increases the emission rate.
- Latex paint encapsulation did not significantly reduce emission rates.

GRAPHICAL ABSTRACT



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ABSTRACT

Thousands of homes in the United States are found to be contaminated with methamphetamine each year. Buildings used to produce illicit methamphetamine are typically remediated by removing soft furnishings and stained materials, cleaning and sometimes encapsulating surfaces using paint. Methamphetamine that has penetrated into paint films, wood and other permanent materials can be slowly released back into the building air over time, exposing future occupants and re-contaminating furnishings. The objective of this study was to determine the efficacy of two wallboard remediation techniques for homes contaminated with methamphetamine: 1) enhancing desorption by elevating temperature and relative humidity while ventilating the interior space, and 2) painting over affected wallboard to seal the methamphetamine in place. The emission of a methamphetamine surrogate, *N*-isopropylbenzylamine (NIBA), from pre-dosed wallboard chambers over 20 days at 32 °C and two values of relative humidity were studied. Emission rates from wallboard after 15 days at 32 °C ranged from 35 to 1400 $\mu g\ h^{-1}\ m^{-2}$. Less than 22% of the NIBA was removed from the chambers over three weeks. Results indicate that elevating temperatures during remediation and latex painting of impacted wallboard will not significantly reduce freebase methamphetamine emissions from wallboard. Raising the relative humidity from 27% to 49% increased the emission rates by a factor of 1.4. A steady-state model of a typical home using the emission rates from this study and typical residential building parameters and conditions shows that adult inhalation reference doses for methamphetamine will be reached when approximately 1 g of methamphetamine is present in the wallboard of a house.

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1. Introduction

Methamphetamine is inexpensive, potent, and a highly-addictive stimulant that can be manufactured using common

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household items and easily accessible ingredients such as cold remedies and fertilizers (Marris, 2005; USEPA, 2013). The United States Substance Abuse and Mental Health Services Administration concluded that 5.3% of the United States population (over 12 million people) had used methamphetamine at some time (SAMHSA, 2007). The availability of methamphetamine in the United States has increased since 2007, due to production increases in both Mexico and the United Sates (UNDOC, 2011). In 2009, North America accounted for 44% of global seizures of methamphetamine with 7.5 metric tons seized in the United States (UNDOC, 2011). From 2010 to 2012 nearly 40,000 illegal methamphetamine laboratory incidents were recorded in the United States (DEA, 2013).

Many of the chemicals used for manufacturing methamphetamine are volatile organic compounds and will volatilize prior to cleanup of methamphetamine labs (USEPA, 2013). However, due to its low vapor pressure methamphetamine can remain on indoor surfaces long after the termination of illicit activities (Patrick et al., 2009; Van Dyke et al., 2009). Methamphetamine can contaminate surfaces in its freebase or protonated salt form and interconvert between the two forms depending on local chemical conditions (e.g. pH). Freebase methamphetamine can penetrate into materials such as paint films (Serrano et al., 2012). Freebase residue accumulated on surfaces or sorbed within materials can slowly re-emit back into the air and contaminate other surfaces. Surfaces and materials can also be contaminated with a range of synthesis by-products, intermediates, or impurities, including amphetamine and N,*N*-dimethylamphetamine (Stojanovska et al., 2013). Anyone occupying a building after the termination of illegal activities can be exposed to methamphetamine and related chemicals through inhalation of the contaminated air and dermal or oral contact with the contaminated indoor surfaces. The exposure of young children to residual (or re-emitted) methamphetamine is of particular concern.

The cost of methamphetamine lab remediation in the United States is highly variable, depending on the severity of contamination and individual state standards. The estimated average cost is $2,200, but can be as low as $500 for smaller labs (USDOJ, 2010) or as high as $60,000 (Hammon and Griffin, 2007). Importantly, current remediation techniques are based on practical experience and lack strong scientific background (USEPA, 2013). There is a need to better understand the nature of methamphetamine remediation techniques through research, so that policy makers can establish effective remediation guidelines.

Current remediation practice typically involves two approaches to reduce exposure to methamphetamine contaminated wallboard that is not removed from a home: 1) washing the wallboard with a detergent-water solution, and/or 2) painting over affected wallboard in an attempt to encapsulate the methamphetamine in place (USEPA, 2013). Oil-based paint can effectively prevent methamphetamine from penetrating back to the surface (Serrano et al., 2012), but it is not clear oil-based paints are the dominant encapsulation method, especially if remediation is performed by homeowners. Some state remediation guidance documents have also recommended enhancing the desorption (emission) of methamphetamine from wallboard during remediation by elevating indoor temperatures (MDHSS, 2000). However the effectiveness of this method has never been documented (USEPA, 2013).

We investigated the efficacy of heating and encapsulation for reducing emissions of a free-base methamphetamine surrogate from wallboard. The potential for enhanced desorption during remediation by increased relative humidity was also explored. Wallboard was chosen as it is a material with a large indoor surface area that is often not removed during remediation activities. *n*-Isopropylbenzylamine (NIBA, Aldrich 136964-25G) was used as a surrogate for methamphetamine. NIBA is a close chemical isomer and has physical properties similar to methamphetamine (see supplementary information Table S.1). This approach reveals specific, fundamental interactions between a methamphetamine surrogate and painted drywall and is not intended to precisely simulate contamination from methamphetamine lab operations.

The specific objectives of this research were to 1) quantify dynamic gas phase, freebase, emission rates of NIBA from gas-phase contaminated painted wallboard at an elevated temperature (32 °C) and at two different relative humidity conditions, and 2) quantify dynamic emission rates of NIBA from gas-phase contaminated wallboard after encapsulating with latex paint.

2. Methodology

Chambers constructed entirely of painted wallboard were exposed to vapor phase NIBA for 10 days to simulate exposure during illicit manufacturing operations. The chambers were then ventilated and NIBA emission rates and total emitted NIBA were quantified by periodically collecting exhaust samples.

Three sets of experiments were completed to:

1. Quantify NIBA emissions during elevated temperature remediation conditions. Liquid NIBA was allowed to evaporate (or volatilize) into four sealed painted wallboard chambers for ten days. After the dosing phase, clean air was injected into the chambers for 20 days at 32 °C and 49% relative humidity (RH). Airborne NIBA concentrations were measured daily. These experiments are listed as Standard in Table 1 (chambers 1A-1D).
2. Quantify emissions at a different relative humidity condition. Experiment 1 was repeated at 27% RH. These experiments are listed as Low RH in Table 1 (chambers 2A-2D).
3. Determine the impact of encapsulating with latex paint on NIBA emissions. Two of the chambers from the first experiment (with a substantial amount of NIBA still sorbed) were repainted and allowed to dry for 20 days. After 20 days, the two repainted chambers (1A & 1D) and the two remaining non-painted chambers (1B & 1C) from the first experiment that had not been repainted were ventilated again at 32 °C and 49% relative humidity for seven days. These experiments are listed as Paint in Table 1.

2.1. Chambers

Preliminary experiments involved NIBA desorption from painted wallboard placed in stainless steel chambers. However, the low vapor pressure of NIBA (44 Pa at 25 °C, boiling point of 200 °C (ChemSpider, 2014)) made it difficult to separate the direct NIBA emissions from the wallboard and emissions of NIBA that adsorbed to stainless steel chamber walls during the experiments. To ensure that emissions were solely from the painted wallboard, two sets of new chambers were fabricated entirely of gypsum wallboard (Georgia Pacific Toughrock® TE, 1.3 cm × 1.2 m × 2.4 m).

Prior to construction of the chambers the wallboard was primed (Kilz 2® Latex Primer) and painted (one coat of Behr Premium Plus® Eggshell Enamel) according to manufacturer's directions. The paint was allowed to dry under ambient indoor conditions for 48 days prior to construction of the chambers for the first experiment and 63 days for the second experiment. The painted wallboard was cut to produce six sides for each cubic chamber (25.4 cm inside length per side, volume of 16.4 L, Supplemental Information Figure S.2). Each chamber was wrapped in Tedlar® and sealed with foil tape.

Chambers were prepared with three holes (inlet, outlet and sampling port). Air was injected into the chambers through a 0.64 cm diameter stainless steel bulkhead fitting located in one of

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