FEATURE

Chemical concentrations and contamination associated with clandestine methamphetamine laboratories

We conducted a study to determine the chemical exposures associated with the clandestine manufacture of methamphetamine. Two scenarios were utilized, sampling at actual clandestine laboratories as they were being raided by law enforcement (Scenario 1) and sampling at controlled "cooks" conducted in houses to be destroyed (Scenario 2). Sampling during Scenario 1 revealed that most suspected laboratories had significant amounts of methamphetamine surface contamination throughout the suspected "cook" area. Levels of hydrocarbons, phosphine, iodine, and inorganic acids were unremarkable in these inactive laboratories. Sampling during the controlled cooks (Scenario 2) revealed high concentrations of phosphine, iodine, anhydrous ammonia, and hydrogen chloride during the "cooking" process. Anhydrous ammonia and hydrogen chloride were detected at levels that exceed NIOSH Immediately Dangerous to Life and Health (IDLH) levels. An aerosol of methamphetamine was also created during the process resulting in surface contamination within the structure as well as contamination on the clothing of the individuals participating in the "cooking" process. Based on our study, individuals entering a suspected clandestine methamphetamine laboratory should wear chemically resistant protective clothing and use a self-contained breathing apparatus. Individuals entering the suspected laboratory should also assume that items and persons associated with the "cook" area are chemically contaminated and need to be decontaminated.

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INTRODUCTION

The Nation continues to face an epidemic of clandestine methamphetamine drug manufacturing. Illegal laboratory seizures have increased nationwide from 7,438 in 1999 to 12,484 laboratories in 2005.[1] These clandestine labs continue to put police, fire, and other first responders at risk for a variety of hazards. In addition, susceptible third parties, such as children, are at risk for exposures to the chemical hazards as well as the fire, explosion, and safety hazards inherent with the clandestine manufacture of methamphetamine.

The Centers for Disease Control reported a number of public health injuries and illnesses in first responders and medical personnel associated with clandestine methamphetamine laboratories between 1996 and 1999.[2] One hundred and twelve methamphetamine-associated events were reported by five state health departments. These events resulted in injury to 155 persons, of which 79 were first responders and 7 were hospital personnel. Predominant complaints in first responders were respiratory irritation and eye irritation, while hospital personnel complained primarily of nausea/vomiting and dizziness.

The State of Washington reported on 91 methamphetamine-related incidents, of which 35 (38%) resulted in injuries to a total of 66 people.[3] Twenty-two (33%) of the individuals injured were classified as members of the general public, but most were either methamphetamine "cookers" or individuals living in homes where methamphetamine was produced. Nineteen individuals were employees of businesses (hotels, refuse pickup, transfer facilities, etc.) where methamphetamine had been produced or byproducts were illegally dumped. Thirty-two (48%) of the 66 total people were hospitalized or taken to the hospital and released. The rest of the individuals were either treated at the scene, by their personal physician, or did not need treatment.

Studies conducted by Dr. Jefferey Burgess[4,5] investigated symptoms reported by emergency responders during illegal methamphetamine laboratory seizures. Responders predominately reported general irritant symptoms, but at least one case of phosphine gas exposure was reported. In the questionnaire study of emergency responders, 53.8% reported at least one illness while conducting laboratory seizures with most symptoms appearing to be related to chemi-

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cal exposure at the laboratory site. The primary symptoms reported were headache and mucous membrane irritation.

Upon repeat pulmonary function testing, a number of responders were found to have an accelerated drop in 1 second forced expiratory volume (FEV_1) that may have been related to work in drug laboratories.[5] The majority of symptoms reported by officers occurred during the processing phase of the laboratory seizures which is also the phase in which the most time was spent in the laboratory area dismantling the laboratory and collecting evidence. The use of respiratory protection did seem to reduce the incidence of symptoms while investigating these laboratories. While there has also been anecdotal evidence of exposure to methamphetamine or methamphetamine laboratory byproducts causing permanent lung damage, actual cases have not been reported in the literature.

Due to these potential health effects, many law enforcement and social services agencies have developed policies for medical surveillance, personal protective equipment, and personal decontamination. These policies have been implemented based on limited evidence for chemical exposure in clandestine laboratory environments. This is the first systematic effort to assess potential chemical exposures associated with these environments and to provide recommendations based on quantitative chemical sampling results.

MANUFACTURING METHODS

Methamphetamine was first commercially synthesized in the 1930s and was used in many prescription and over-the-counter medicines until its long-term addictive effects were known. Prior to the 1990s, the clandestine production of methamphetamine was mostly confined to the Pacific coast states and was controlled by motorcycle gangs. The predominate early production method utilized phenyl-2-propanone (P2P) as the precursor. This manufacturing process can be very malodorous, difficult to conduct and requires some knowledge of chemistry. In addition, it produces a lower quality drug with less addictive properties as compared to the current production methods. In the 1988 the Federal Chemical Diversion and Trafficking Act of 1988 placed P2P and other chemicals on the controlled substances list, which increased the difficulty of obtaining the precursor chemicals for the P2P method.[6,7]

As P2P manufacturing method precursors became harder to obtain, clandestine chemists began to utilize production methods using ephedrine or pseudoephedrine as precursors in the production process. These compounds are structurally very similar to methamphetamine with ephedrine differing only by a single hydroxyl group (Figure 1). In addition, this method of production yields a higher purity of d-methamphetamine, which is more physiologically active. Clandestine laboratories using the ephedrine/pseudoephedrine method of production are the most common laboratories found by law enforcement in recent years.[6–8]

The ephedrine/pseudoephedrine manufacturing processes have frequently been classified as three separate methodologies: the red phosphorous or "red P" method, the hypophosphorous acid method, and the Birch reduction method. The "red P" method and the hypophosphorous acid method are very similar with the only difference being the source of phosphorous used in the

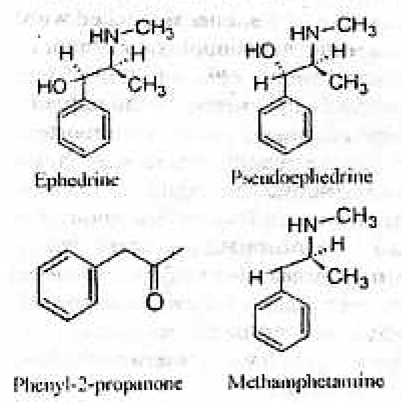

Figure 1. Illustration of the structural similarities between the ephedrine, pseudoephedrine, and methamphetamine. Phenyl-2-propanone was also utilized in the production of methamphetamine at one time.

reaction. The Red "P" method typically uses red phosphorous, while the hypophosphorous method uses hypophosphorous acid. Both methods involve the addition of ephedrine/pseudoephedrine, iodine, water, and phosphorous in order to produce the methamphetamine. Both production methods utilize a strong base, a solvent, and hydrochloric acid to remove the methamphetamine from solution and both methodologies can produce large quantities of relatively high purity methamphetamine.[4,8]

The Birch reduction method has become very popular since the late 1990s due to the low cost and high availability of the necessary chemicals. This method combines ephedrine/pseudoephedrine with a reactive metal (sodium or lithium) in the presence of anhydrous ammonia. The need for a strong base for extraction is not necessary but the use of a solvent and hydrochloric acid is still necessary. Anhydrous ammonia is easily obtained, especially in rural areas where it is used as a fertilizer. Lithium is a reactive metal present within many photographic batteries. The nationwide incidence of clandestine methamphetamine production laboratories using this method rose from 439/3015 (14.5%) laboratories in 1998 to 2912/6426 (45.3%) laboratories in 2000, just a two-year period.[9]

As pure ephedrine and pseudoephedrine became more and more difficult to obtain, individuals interested in the clandestine manufacture of methamphetamine switched to extracting these compounds from cold tablets purchased or stolen from drug stores. This ephedrine/pseudoephedrine extraction method involves mixing the crushed pills with a light solvent (water or alcohol) in order to obtain the necessary compounds. The use of alcohol is faster since it evaporates faster, but it is much more flammable and can result in fires.[7]

We prioritized our exposure sampling based on information from law enforcement intelligence sources describing the precursor chemicals and anticipated production methods. Based on this information, the primary exposures of interest consisted of red phosphorous, hydrogen chloride, iodine, anhydrous ammonia, lithium,

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