373.

CORRELATION BETWEEN AIRBORNE TOLUENE DIISOCYANATE AND URINARY TOLUENE DIAMINE. J. Roh, K. Park, C. Kim, H. Kim, H. Kim, Yonsei University College of Medicine, Seoul, Republic of Korea.

Toluene diisocyanate (TDI) is widely used in the production of polyurethane foam, as well as in the formulation of polyurethane paints and coatings. The commercial material is generally a mixture of 2,4-TDI and 2,6-TDI. Studies indicated that exposed workers had elevated levels of urinary toluene diamines (TDAs), but a correlation between levels of TDA in urine and airborne concentration of TDIs in workplace could not be established. This study was conducted to investigate the correlation between levels of urinary TDAs and airborne concentration of TDIs, which are being sampled with open cassette holder (OCH) and the modified 2-piece cassette holder (2-PCH). The sampling was executed on the 22 workers from the factory where operated painting work by using polyurethane paints. This study identified the personal character of workers by using the questionnaire and analyzed TDIs from 44 samples each in the middle of morning and afternoon and TDA from the 17 workers by taking their urine. As a result of analysis, the concentration of TDIs in the air is higher on 2-PCH than OCH. There was no significant difference in the concentration of urinary TDA by general characteristics. The concentration of TDI in the air had significant correlation with the concentration of urinary TDA no matter what kind of sampling method was used, but the sampling technique by 2-PCH had more correlation than OCH. As a result of this experiment, the concentration of TDI by sampling with the each cassette holder has shown a significant relation with the concentration of urinary TDA.

374.

URINARY BROMIDE AND BREATHING ZONE CONCENTRATIONS OF 1-BROMOPROPANE FROM WORKERS EXPOSED TO FLEXIBLE FOAM SPRAY ADHESIVES. K. Hanley, B. Curwin, M. Petersen, NIOSH, Cincinnati, OH; W. Sanderson, University of Iowa, Iowa City, IA.

1-Bromopropane (1-BP) has been marketed as an alternative for ozone depleting solvents and suspect carcinogens and is in aerosols, adhesives, and solvents used for metal, precision, and electronics cleaning. Toxicity of 1-BP is poorly understood, but it may be a neurologic, reproductive, and hematologic toxin. Sparse exposure information prompted NIOSH to conduct an exposure assessment using air sampling, exhaled breath, and urinary metabolites. Mercapturic acid conjugates are excreted in urine from 1-BP metabolism involving removal of bromide from the propyl group. One research objective is to evaluate the utility of urinary bromide analysis for assessing 1-BP exposure using a relatively inexpensive method commercially available. Complete 48-hour urine specimens were obtained from 30 workers on 2 consecutive days at facilities using 1-BP adhesives to construct polyurethane foam seat cushions and from 7 unexposed controls. All of the workers' urine was collected into composite samples representing 3 daily time intervals: at work, after work but before bedtime, and upon wake-up. After collection, urine aliquots were dispensed into acid-rinsed Nalgene® bottles and analyzed for bromide (Br) by inductively coupled plasma-mass spectrometry. Full-shift breathing zone samples were collected for 1-BP on Anasorb-CMS sorbent tubes and analyzed by gas chromatography-flame ionization detection via NIOSH method 1025. Breathing zone concentrations of 1-BP ranged from 45–200 ppm for adhesive sprayers and from 0.8–60 ppm for other jobs. For sprayers, urinary Br concentrations ranged from 77–542 mg/g-creatinine (cr) at work, from 58–308 mg/g-cr after work, and from 43–672 mg/g-cr in wake-up samples. Overall, urinary Br concentrations for sprayers were substantially more than for the nonsprayers and controls, with geometric means of 166, 38, and 3.8 mg/g-cr, respectively. This study demonstrates that urinary elimination is an important excretion pathway for 1-BP metabolism and bromide may be a useful indicator of exposure.

375.

QSAR MODELS OF ALLERGIC CONTACT DERMATITIS. A. Fedorowicz, CDC/NIOSH, Morgantown, WV; H. Singh, E. Demchuk, CDC/NIOSH and West Virginia University, Morgantown, WV.

Allergic contact dermatitis is a common work-related skin disease that often develops after repetitive skin exposures to a sensitizing chemical. A variety of animal and human experimental assays have been suggested to assess the skin sensitization potential. The introduction of the murine local lymph node assay (LLNA) with its quantitative endpoint for skin sensitizing potency has provided continuous scale suitable for developing quantitative structure-activity relationships (QSARs) of skin sensitization, which relate physical-chemical properties of chemical compounds to their sensitization potential. However, at present many LLNA results are mostly reported using a dichotomous scale (+/-), which is consistent with the scale of guinea pig and human tests, which have been widely used in the past. Therefore, in this study only a dichotomous version of the LLNA data was used to develop QSAR models of skin sensitization. Using statistical methods, physical-chemical properties of chemicals, called molecular descriptors, were tested for their ability to predict the skin sensitization potential. A few of the most informative descriptors were subsequently selected to build QSAR models of skin sensitization with high prediction rates.

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376.

ABILITY OF MINOR INCREASES IN INDOOR SHOOTING RANGE AIR VELOCITIES TO REDUCE LEAD CONCENTRATIONS IN THE BREATHING ZONE OF SMALL-ARMS SHOOTERS. D. Lillquist, B. Craig, University of Utah, Salt Lake City, UT.

If the ventilation systems are functioning improperly or are poorly designed in indoor firing ranges, high concentrations of airborne lead are typically present. Low cost temporary ventilation baffle mock-ups can be used to test proposed improvements to reduce airborne lead concentrations. Baffles were installed in an indoor shooting range to increase air velocities and modify airflow patterns in the shooters' breathing zones in an attempt to reduce personal exposures to airborne lead. Ventilation measurements and personal air sampling were conducted prior to and after the baffles were installed. The mean air velocity was increased from 6 to 13.4 feet per minute at the shooting line, and increased to 19.4 feet per minute at the gun position. Airborne lead concentrations were reduced from 645.2 to 30.9 $\mu g/m^3$ (8-hr time-weighted averages 67.2 to 2.3 $\mu g/m^3$, respectively). Although the mean velocities were much lower than the recommended air velocity of 50 feet per minute, significant reductions in airborne lead exposures were achieved. Other necessary improvements to the range were also identified, such as relocating the exhaust ventilation ducting to the bullet trap and improving the distribution of air across all shooting booths; however, the benefits of increased air velocity were observed prior to the additional investments.

377.

DEVELOPMENT OF A NOVEL ROBOTIC WELDING FUME INHALATION AND EXPOSURE SYSTEM. A. Afshari, J. Antonini, S. Stone, G. Fletcher, V. Castranova, D. Frazer, NIOSH, Morgantown, WV.

Epidemiological studies suggest that the long-term inhalation of welding fumes may lead to lung disease, neurotoxicity, and cancer. The fume generated during the welding process has been shown to consist of ultrafine particulates (e.g., chromium and nickel) as well as gases (e.g., ozone, nitrogen oxide, and carbon monoxide). Laboratory studies are needed to further investigate the adverse effects of exposure to welding fume. The objective of this study was to design an inhalation exposure system to be used in the evaluation of the toxicity of welding fume in rats. To ensure continuous delivery of the welding fumes without interruption of exposure, an automated computer-controlled robotic welder has been constructed. The robotic torch is combined with a programmable head stock capable of welding at a con-

tinuous rate of 30 cm/min for 6 hr/day. A flexible exhaust trunk is attached to the robotic arm and is used to collect the generated fume from the welding arc region and transport it to the animal chamber. Initial characterization studies of the fume generated with this system indicate that aerosol size characteristics (less than 1 micron) and ozone levels (0.24 ppm) are comparable with welding fumes formed in the workplace. With the development of this novel robotic welding fume generation system, we will be able to address some of the unanswered questions concerning the heath effects of welding fumes.

378.

MODELING THE INFLUENCE OF FIBER SHAPE ON FILTER PERFORMANCE. P. Raynor, University of Minnesota, Minneapolis, MN.

Fibrous filters collect airborne particles in respiratory protection, air pollution control devices, and HVAC systems. Developing filters that have higher efficiency at the same pressure drop could offer better protection for workers. Currently, most filters are made from fibers with circular cross sections. However, fiber manufacturers can produce synthetic fibers with irregular shapes. The purpose of this research was to use numerical modeling to evaluate the potential for changes in fiber shape to improve filter performance. Airflow around single fibers with circular, elliptical, tri-lobal, and eight-lobed cross sections was modeled in two dimensions using computational fluid dynamics (CFD) software. The simulations included differences in fiber orientation and packing density. In addition, the movement of particles of different sizes was superimposed on the airflow. The modeling suggested that modest improvements in filter performance were possible with changes in fiber shape. Although some fiber shapes and orientations provided higher single fiber efficiency for large particles by the impaction and interception filtration mechanisms, those improvements were generally offset by increases in fiber drag, which is associated with pressure drop. When the simulated fibers collected small particles by diffusion, elliptical fibers exhibited slightly better performance in some orientations than the circular fibers. For example, CFD modeling for fibers with a packing density of 0.05 and particles with a Peclet number of 10,000 showed that an elliptical fiber oriented parallel to the airflow had a single fiber efficiency of 0.00823, whereas a circular fiber had an efficiency of 0.00676. At the same conditions, the drag across the elliptical fiber was 11% lower than the drag across the circular fiber. The tri-lobal and eight-lobed fibers did not show substantial differences from the circular fibers in most cases.

379.

USE OF ENGINEERING CONTROLS TO REDUCE OCCUPATIONAL EXPOSURES DURING INDOOR SUPERFUND SITE REMEDIATION. D. Decker, P. Moore, Shaw E&I, Centennial, CO.

The use of a 3/4-acre movable containment structure to control public exposure to airborne contaminants at a Superfund site created a situation where concentrations of silica, ammonia, and carbon monoxide frequently exceeded the respective PEL/TLV® inside the structure. Workers inside the structure break up and remove a soil, cement, and flyash monolith containing radiological contamination. The structure was designed with an exhaust filtration system to control dust and equipment exhaust emissions created during excavation. Changes in operational techniques resulted in more and different pieces of equipment used for excavation. The fine composition and silica content of the monolith contributed to creating a situation where workers were required to wear respiratory protection and the exhaust system filters were frequently overloading. Engineering control solutions were sought to control the silica generation and vehicle emissions. Initially, a modified fire hose was used to suppress dust. Dust suppression was moderate but the excess water created mud and an opportunity for slips and falls. Alternative dust suppression methods were evaluated. A fog cannon was designed to reduce dust generation and silica exposures. Emission control devices were retrofitted to diesel powered equipment. The fog cannon reduced silica concentrations in the structure by 77%. The fog cannon distributes less water more uniformly reducing slippery surfaces in the excavation and on equipment. Ammonia concentrations were reduced by 50% because there is less water applied to the ammonium salts in the monolith. Containment structure filter replacement was reduced by a factor of 2. Equipment emission controls reduced carbon monoxide concentrations by 83%, to levels below the PEL/TLV®. The combination of the fog cannon and equipment emission controls reduced concentrations of silica, ammonia, and carbon monoxide sufficiently so that respiratory protection was no longer required resulting in better visibility, less heat stress, and cost savings.

380.

ROADMAP TO GAS DETECTION SYSTEMS COMMUNICATIONS—CURRENT AND FUTURE TRENDS. P. Hogan, Zellweger Analytics Inc., Lincolnshire, IL.

Delegates will gain a practical and insightful overview of the current communications protocols, field bus systems, and control networks that can be deployed within industrial environments for life safety sensing, alarm, and controls. An independent, hands-on review of the relative strengths and limitations of analog 4-20mA, HART, ProfiBus, ModBus, LONWorks, Ethernet, DeviceNet, and other protocols will be presented. Issues such as cost of installation, speed of response, ease of configuration, redundancy and connectivity with a broad range of control racks, Fire and Gas systems, PLC, DCS, and SCADA systems will be discussed. Users will gain a clear insight on how to design, cost up, install, commission, and test their communication network for typical industrial safety applications. Actual end user examples will be shared that explain how best to design robust alarm and annunciation scenarios, monitor faults, and develop interactive human machine interfaces that are fit for purpose. A roadmap summary indicating imminent trends in alternative communication systems notably wireless, "less-wire", and Power over Ethernet will equip busy life safety engineers with a fast track awareness of the important benefits to be gained with these emerging technologies.

Mold/IEQ

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381.

DIFFUSIVE SAMPLING AND ANALYSIS OF MICROBIAL VOCS ARISING FROM MOLD. C. Manning, S. Green, J. Hearing, Assay Technology, Pleasanton, CA.

In recent years, molds have been increasingly implicated in indoor air quality complaints ranging from property damage to unpleasant odors and toxic exposures arising from their chemical by-products. Several researchers have conducted studies in which a family of microbial volatile organic compounds (MVOCs) has been identified as the product of mold metabolism in a process similar to fermentation. Although the identities and quantities of specific MVOCs arising from mold metabolism vary somewhat with species and environmental conditions, a strong family resemblance has been found among MVOCs which has led to their characterization by chemical air sampling technologies.

A majority of MVOCs, predominantly oxygenated organics, e.g. saturated and unsaturated aldehydes and alcohols, may be sampled on traditional air sampling media and analyzed by gas chromatography. While several sorbents, desorption methods, and chromatography systems have been recommended for different MVOCs, the goal of this study was to devise a single sampling method capable of collecting and retaining a large number of MVOCs coupled with an analytical method capable of analyzing as many components as possible in a single chromatography scan. In this study, multiple MVOCs were generated in a dynamic chamber and sampled together on a diffusive sampler utilizing activated carbon followed by desorption with a mixture of benzyl alcohol and carbon disulfide. Method evaluations were performed as outlined in ANSI and ASTM protocols. Individual MVOCs were metered via syringe pump into a dynamic flow system gen-

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