POTENTIAL HEALTH EFFECTS RELATED TO WORKER EXPOSURE TO PU SPRAY FOAM

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Potential Health Effects Related to Exposure to PU Spray Foam

- What’s in it
- Major health effects
- Major challenges
- Biomonitoring - Isocyanate-specific IgG (MDI-IgG
- NIOSH / CPWR study – preliminary data
- Homeowner observations
- Questions
Chemical Composition of SPF

Part A – Isocyanates
Methylene diphenyl diisocyanate (MDI) /pMDI

Part B – Polyol blend ??? (variable / proprietary)
Polyols (petroleum or soy based)
Amine catalysts
Flame retardants
Blowing agents
Surfactants

Mix A + B = POLYURETHANE FOAM
(exothermic reaction)
Major Commercial Isocyanates

**HDI**
- hexamethylene

**TDI**
- toluene

**MDI** *
- diphenylmethane or methylene diphenyl

*Less volatile, considered “safer”

- Paints, coatings, light resistant
- Foams – soft, hard
- Adhesives
- Coatings
- Elastomers
Isocyanates (in PU products) are Everywhere
Expanding and innovative markets

Building and construction
Automobiles, plains, ships
Clothing, foot wear and sporting goods
Paints / coatings industry
Foundry, casting and machining
Furniture, home furnishings
Medical care
Health Effects Isocyanates

- Potent sensitizer / allergen
- **Occupational asthma**
- Rash / skin irritation - less common, but occurs
- One of the most common reported causes of occupational asthma
- Minimal odor, warning signs, especially MDI
Health Effects from Exposure to other Components PU Foam ???

- **Amine catalysts**
  - Sensitizers, irritants – asthma, rash
  - **Blurry vision (halo vision)**
- Flame retardants
- Blowing agents
- VOCs
- Polyols
- Thermal combustion products
Case PU Spray foam worker

Healthy 38 y/old construction worker / insulator
2 yrs ago started use PU spray foam
Past 6 months - cough after work / evening – wife concerned
Exercising less, chest tightness, SOB
Better on weekends

Initial Medical evaluation
No prior h/o asthma, allergies
Diagnosis “bronchitis” - treated with inhalers / antibiotics
Initially improved, continues to work
Worsening cough, SOB. Goes to ER
Diagnosis – asthma – no discussion of work
Isocyanate Asthma – Key features

First reported in 1950s
Clinically similar to “ordinary” asthma
Timing- onset months to years after onset isocyanate exposure - delayed symptoms 6-8 hours after exposure common
Once sensitized, exposures to very low levels (below OELs, OSHA PEL) trigger asthma symptoms
Diagnosis is frequently missed – (by patient and doctor)
Asthma commonly persists away from exposure - permanent
Early diagnosis – better outcomes (health and economic)
Remains one of the most commonly reported causes OA
Over time – looks more like “ordinary asthma”, multiple triggers
Who gets isocyanate asthma (IA) ?

- Smoking, seasonal allergies, prior asthma does **NOT** increase risk
- Most important risk factor is **EXPOSURE to isocyanates** (MDI, uncured foam)
  - Inhalalational exposure
  - Skin exposure
- Only some workers (5–25%?) are at risk to develop IA, but don’t know which ones
Preventing Asthma by Recognizing and Reducing Exposures

2 Main Routes Exposure

- **Inhalation** - airborne exposure
- **Skin** – likely contributes to sensitization and asthma

- PU foam complex exposure – not just MDI vapor
  - Liquid, aerosol, vapor
  - Application - exothermic reaction
  - Cut / shave foam → dust / particulates
Qualitative SWYPEs* can detect MDI on surfaces

*CLI Colorometric Laboratories, Inc.
Who gets isocyanate asthma?

- Smoking, seasonal allergies, prior asthma does **NOT** increase risk
- Most important risk factor is **EXPOSURE to isocyanates** (MDI, uncured foam)
  - Inhalational exposure
  - Skin exposure
- IH air monitoring is **NOT** adequate, does not monitor skin exposure, and once sensitized can react to very low airborne levels (well below OELs)
- **Need a good biomarker of isocyanate exposure** – as have for lead
Why does isocyanate asthma still occur?
(especially with “minimal” detected exposures?)

Limitations of airborne IH sampling and regulation
  - Need for exposure biomarkers and medical surveillance

Diagnosis isocyanate asthma is easily missed
  - No single practical diagnostic test

Despite better IH practices, PPE, safer products
  - End-user settings are challenging to monitor and control
  - Stuff happens - hoses blow, PPE not perfect

Sensitizers in general are hard to control
  - Human allergic responses are not predictable
  - Once sensitized, miniscule exposures trigger responses – e.g. peanut allergy
MDI-IgG blood test

- MDI-IgG is a potential useful marker of MDI exposure
- Only present if exposed to MDI (but not everyone with exposure makes it)
- Indicates exposure – not disease (asthma)
- Reflects past weeks to months of exposure
- Can help target industrial hygiene efforts, identify sources exposure, similar to use of blood lead levels
  - Identify exposure sources (skin as well as air)
  - Use to evaluate the effectiveness of control strategies (engineering controls, PPE)
Case: PU spray foam worker

MDI-IgG over time

Worse asthma, leaves PU spray foam work

Needs a job, returns to PU spray foam work

Away from PU foam

MDI-IgG ng/ml

4/1  6/1  8/1  10/1  12/1  2/1  4/1  6/1  8/1  10/1  12/1  2/1
HDI-IgG identifies exposure
Hill AFB (US Airforce) – Aircraft Maintenance

Wisnewski, Redlich et al. Biomonitoring HDI Exposure Based on Serum Levels of HDI-IgG. Annals Occup Hygiene 2012: 10; 1-20
Study of Construction Workers in CT who use PU Products*
(in progress; n = 103 workers recruited)

Aim 1) Evaluate the health of the construction workers (symptoms, lung function)

Aim 2) Assess exposures to MDI using MDI-IgG and questionnaire data

Aim 3) Improve approaches to reduce worker exposures

*Funded by NIOSH / CPWR Construction Center Grant 153322
Construction workers: work-related symptoms
(preliminary data n=94)

- **Wheeze**: 27% (Spray), 6% (Others)
- **Short breath**: 23% (Spray), 9% (Others)
- **Chest tight**: 23% (Spray), 4% (Others)
- **Cough**: 15% (Spray), 7% (Others)
- **Nasal / eye**: 4% (Spray), 7% (Others)
- **Blue Haze**: 54% (Spray), *P < 0.05*
- **Skin rash**: 27% (Spray), 9% (Others)

(*) Indicates statistical significance.
Prevalence of MDI specific-IgG (% positive) in workers who spray PU foam often vs others

* P < 0.05
Study of Construction Workers in CT who use PU Products in CT

1) Evaluate the health of the construction workers (symptoms, lung function)

2) Assess exposures to MDI using MDI-IgG and questionnaire data

3) Improve approaches to reduce work exposures
   - Recognize exposure opportunities
   - Reduce exposures
Key Elements of an Exposure Reduction Program

1) Training

2) Work Practice Changes
   - Engineering controls
   - PPE – Respirators and skin protection

3) Evaluate the Effectiveness of H&S Programs
   - Questionnaire
   - Spirometry
   - MDI-IgG Blood test
Reducing Inhalation Exposure
(www.spraypolyurethane.org)

• Active spraying – A NIOSH-approved full face or hood-type supplied air respirator

• Other tasks such as trimming/cleaning – Organic Vapor and P100 cartridges

• Use local exhaust ventilation & containment or
• Restrict areas for other tradesmen – typically 25 feet as requiring proper PPE
SPFA Recommendations to reduce skin exposure
(www.spraypolyurethane.org)

- MDI-resistant chemical gloves (e.g., nitrile), or fabric gloves coated in nitrile, neoprene, butyl, or PVC
- Chemically resistant long-sleeve coveralls or full body suit with hood
- MDI-resistant fitted boots/booties
Evaluate Program Effectiveness: Medical Monitoring of Workers*

- Pre-employment and periodic (yearly)
  - Questionnaire
  - Spirometry
  - Biomonitoring (MDI-IgG)

- Assess individual worker AND company-wide data
  - New or worse symptoms, changes in spirometry, MDI-IgG
  - Evaluate jobs, tasks with highest risks (assess symptoms, lung function, exposures, PPE)
  - Evaluate trends over time (exposures, lung function, symptoms)
  - Use this data to further improve Program Effectiveness

*Recommended by many guidelines but not routine practice in USA
Selected Resources

• American Chemistry Council Center for Polyurethanes Industry (CPI)
  http://www.spraypolyurethane.org/

• Spray Polyurethane Foam Alliance
  http://www.sprayfoam.org/

• NIOSH Poster (and other NIOSH resources)

• CLI Colormetric Laboratories, Inc.
  http://www.clilabs.com/
PU Spray Foam: Potential Health Effects
Many Unanswered Questions

• Extent of health risk to PU spray foam workers?
  – Studies / data on PU spray foam workers is very limited
  – Incidence / prevalence isocyanate asthma is unknown
  – Exposure settings highly variable / complex
    ▪ Small / large jobs, new, old construction, variable weather
      conditions (heat, humidity), small spaces, variable ventilation
    ▪ Exothermic reaction ? thermal degradation products
    ▪ Manipulation applied PU foam - dust, particulates

• How effective are current controls in the “real world”?
  – PPE in the “real world” is different than in a “lab”
  – Preventing skin exposure is challenging
  – Medical surveillance of workers is very limited
IF / When Things Go Wrong: Personal Experiences with PU Foam Homeowners

- Properly applied PU foam is a great product
- Improperly applied “bad” PU foam can happen (how often ???)
- Such foam can off-gas multiple chemicals (amine catalysts, blowing agents, surfactants) and smell for a long time (months to years)
- Home owners can note odors, develop symptoms after spray PU foam is applied, (but highly unlikely will get isocyanate asthma)
- Inadequate ventilation can exacerbate the problem, but is NOT the only issue
- The problem is NOT airborne MDI
- **Measuring MDI** or other selected chemical (and finding none) does NOT solve the problem
- Denying there is a problem does NOT solve the problem
- Home remediation can be expensive
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THANK YOU

QUESTIONS ????