UV & EB Safety And Handling

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UV/EB CURABLE COATINGS, INKS AND ADHESIVES ARE WELL ESTABLISHED

- First commercial applications in the 1960's
- UV/EB has been widely adopted due to productivity and environmental advantages...

Graphic Arts, Folding Cartons, Labels, Food and Pharmaceutical Packaging, Publications, Plastics, Vinyl Flooring, Hardwood Flooring, Wood Parts and Furniture, Metal, Fiber Optics, CDs/DVDs, Plastic Lenses, RTA Furniture, Automotive Headlamps, Automotive Coatings, Photoresists, Window Film, Decorative Films and Foils, Photopolymer Printing Plates, MDF and Particleboard Fillers, Electronic Assembly, Dental Adhesives, Release Coatings, Composites, 3D Modeling

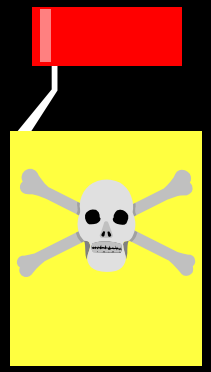
HEALTH AND SAFETY HAZARDS IN TYPICAL INDUSTRIAL OPERATIONS

- Potential for chemical exposure
- Potential for explosion and/or fire due to flammable vapors
- Physical injuries caused by equipment
- Unsafe confined spaces
- Ergonomic injuries

UV/EB SAFETY CONSIDERATIONS

- Chemical hazards and safe handling of UV/EB curing materials
- Non-ionizing (Ultraviolet) and Ionizing Radiation (Electron Beam)
- Equipment Safety
- Ozone
- Inerting Gas
- Waste Management

SAFETY MYTHS AND MISCONCEPTIONS



UV/EB materials are much more hazardous than conventional materials

FACT

Unlike many solvents, acrylates have:

- Low acute systemic toxicity
- Low chronic toxicity
- Low toxicity by ingestion
- No fetal or reproductive toxicity at doses that do not cause maternal toxicity
- Low mutagenic and carcinogenic activity

FACT

- UV and EB curing materials can cause skin and/or eye irritation
- The most severe irritants can cause skin blisters on prolonged direct contact

SKIN AND EYE IRRITATION

PRIMARY IRRITATION INDEX (PII) AND DRAIZE TESTING

- PII and Draize scores are only rough estimates of irritation potential
  - Skin range is 0 (none) to 8 (severe)
  - Eye range is 0 to 110
- Scores are primarily a qualitative indication of irritation potential
- Tests for the same material often yield significantly different results

ACRYLATE IRRITATION

- Acrylate irritation is a warning signal of industrial hygiene problems in the work environment
- If it occurs, take immediate action to correct poor practices that can result in skin contact

SENSITIZATION

- A few individuals who are exposed repeatedly to acrylates can become chemically “sensitized”
- Indications of sensitization are:
  - Immediate onset of a skin itching sensation when entering a work space with ppb traces of acrylates in the air
  - Quick disappearance of the sensation after leaving the work environment
  - There are no other significant physiological symptoms

ACRYLATE OLIGOMER TOXICITY

- The substantially higher molecular weight and lower net acrylate functionality of oligomers results in very low acute toxicity
- Skin and eye irritation normally are mild to minimal

ACRYLATE TOXICITY STUDIES

- EPA/industry co-sponsored long-term skin painting tests (ACC SAM Panel) showed:
  - Skin irritation, but
  - No systemic toxicity
  - No carcinogenic activity
- No excess cancer reported in EPA sponsored NIOSH plant surveys

ACRYLATE CHRONIC TOXICITY STUDIES

A review published in 2008 of over 200 in vitro and live animal mutagenicity studies confirmed:

- Acrylates as a class demonstrate mixed results in *in vitro* mammalian cell assays, but they consistently show no evidence of mutagenicity when tested in *in vivo* studies

- A series of chronic rodent bioassays further support the conclusion that acrylates are not genotoxic in live animals

ORAL STUDIES SHOW NO MUTAGENIC EFFECTS

- Both the SAM Panel and the RadTech Food Contact Notification Alliance determined that acrylate monomers are not mutagenic via oral exposure

- In 2008 FDA cleared a group of UV and EB cured acrylates for direct food contact (FCN 772)
  - Allows up to 1 ppm of FCN 772 acrylates in food

CYCLOALIPHATIC EPOXY TOXICITY

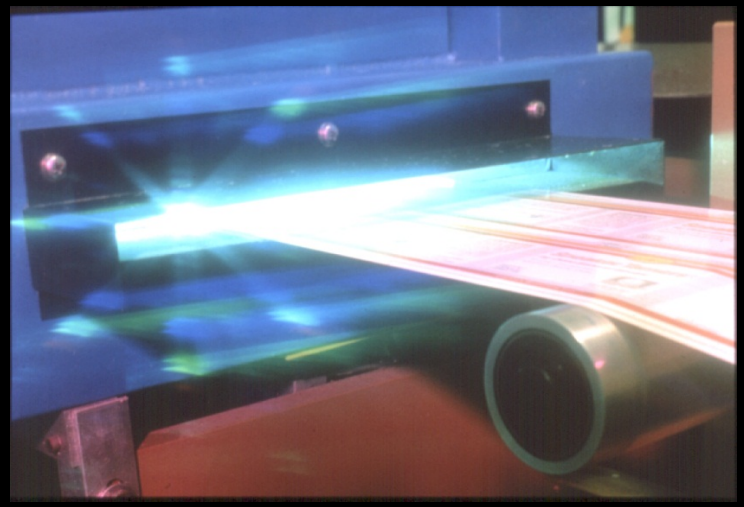
- Low acute ingestion toxicity
- Vapor pressure <0.1 mm Hg
- Low skin absorption
- Mild skin irritation
- Mild to moderate eye Irritation
- Limited evidence of carcinogenicity

CYCLOALIPHATIC EPOXY TOXICITY

- Cationic curing agents can contain arsenate, phosphonium, sulfonium and iodonium salts
- Cationic curing agents have been reported to release small amounts of benzene
- Ensure good ventilation

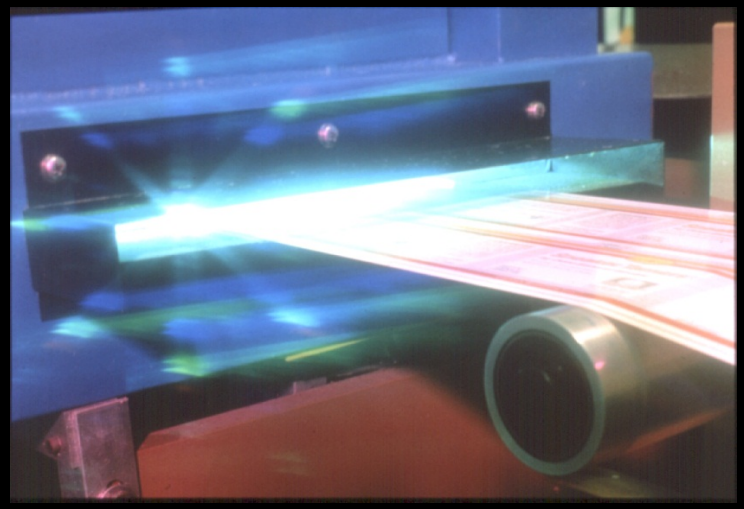
UV/EB SAFETY ADVANTAGES

- Little to no volatile organic compounds (VOC)
- Acrylates are not hazardous air pollutants (HAPs)
- Much lower vapor pressures than conventional solvents
- Not flammable, high flash point, reduced risk of explosive vapors



UV/EB CHEMICAL SAFETY ADVANTAGES

- Lower fire risk = lower insurance rates
- Reduced inhalation hazards
- Little to no coating air drying or evaporation =
- Easier to clean up with less aggressive solvents and water



SAFETY MYTHS AND MISCONCEPTIONS

UV and EB curing exposes workers to hazardous “Radiation”

UV/EB CURING EQUIPMENT HAZARDS

- Ultraviolet: non-ionizing radiation
- Electron Beam: ionizing radiation
- Contact with electrically energized equipment
- Contact with hot equipment
- Ozone
- Inerting gas

UV RADIATION

BIOLOGICAL EFFECTS

Mostly from wavelengths below 325 nm

- Skin: reddening, dryness, wrinkling, darkening
- Eyes: inflammation, pain, photophobia, tearing, photokeratitis (inflammation of the cornea) photoconjunctivitis (inflammation of the conjunctiva: “snow blindness” or “welder’s flash”), cataracts

UV RADIATION

- Sensitized individuals may exhibit UV light reactions even at low exposures
- Certain prescription drugs may increase sensitivity

UV RADIATION

ENGINEERING, HYGIENE AND ADMINISTRATIVE CONTROLS

- Ensure that the UV light source is properly shielded
- Avoid line of sight to the UV source
- Avoid UV reflections from metallic surfaces
- Monitor UV light released into the workplace
- Adherence to ACGIH / NIOSH UV exposure limits prevents skin and eye effects in most workers

UV RADIATION

- National Institute for Occupational Safety and Health (NIOSH) *Criteria for Occupational Exposure to Ultraviolet Radiation* (PB214 268)
- American Council of Governmental Industrial Hygienists (ACGIH) *Threshold Limit Values*
- Different wavelengths have different levels of allowable exposure
- Generally, a lower threshold limit is allowed for longer exposure
- For example, 0.1 μW/cm² at 270 nm is the limit level for 8-hour continuous exposure

UV EXPOSURE METERS

- Typically hand-held meters
- Measure the UV field to which workers will be exposed
- Calibrated responsivity in the UVB range in μW/cm², or
- May be calibrated in units of minimal erythemal dose (MED), or
- In hours (allowable exposure time)

UV PROCESS EQUIPMENT

ENGINEERING, HYGIENE AND ADMINISTRATIVE CONTROLS

- Ensure that lamp cooling systems are operating properly
- Ventilate UV lamps and curing areas to prevent ozone from entering the workplace
- Install interlocks to shut down unsafe conditions
- Allow lamps to cool and disconnect power before cleaning

UV PROCESS EQUIPMENT

- Medium-pressure and low-pressure mercury vapor lamps contain small amounts of mercury
- See “Ultraviolet Curing Lamp Safety & Handling” at www.radtech.org

EB CURING EQUIPMENT HAZARDS

- EB Radiation = High Velocity Electrons And X-rays
- Potential for unintentional release of inert gas into the work environment

EB PROCESS EQUIPMENT

ENGINEERING, HYGIENE AND ADMINISTRATIVE CONTROLS

- Equipment design and shielding
- Installation under manufacturer supervision
- Interlocks shut down unsafe conditions (equipment misconfigured, low atmospheric oxygen)
- Federal permissible radiation exposure levels

STATE AND LOCAL REGULATIONS/ LICENSING

- State and local regulations and permits are similar to medical/dental X-ray equipment
- The manufacturer will provide documentation (radiation map, and verification of the radiation monitors) to ensure safe use of the equipment
- The manufacturer can provide assistance in verifying safe installation and use

EB PROCESS EQUIPMENT

MONITOR OPERATIONS

- Equipment radiation monitors
- Employee radiation exposure monitoring (film badges and electronic systems available)
- Internal and external oxygen sensors

ELECTRICAL HAZARDS

Electrical

- Electrical equipment should be labeled to meet NFPA, NEC, UL, CSA, or CE codes or standards
- Service to the power supply should be conducted only by a trained technician

ELECTRICAL HAZARDS

High voltage

- Most UV equipment operates at high voltages up to 5,000 volts dc
- EB curing equipment operates at even higher voltages
- Interlocks and EPO (Emergency Power Off) controls never should be over-ridden or disabled

ELECTRICAL HAZARDS

RF (Microwave)

- Microwave-powered lamps operate on the same frequency as microwave ovens
- RF screens and gaskets must remain intact
- Any damage such as rips or holes in the screen may cause leakage of microwave radiation
- The power to the lamp is interlocked to an RF detector and will shut down the system if microwave leakage is detected

FACT

With appropriate engineering controls and training, UV and EB curing presents minimal to negligible potential for worker exposure to radiation

OZONE

- Atmospheric oxygen + high energy electric field $\Rightarrow$ Ozone
- Pungent, irritating gas
- Respiratory irritation, fatigue, headache
- Proper ventilation prevents ozone from entering the workplace

Ozone Exposure Regulations or Guidelines (ACGIH)

- The United States Occupational Safety and Health Administration (OSHA) 8-hour permissible exposure limit (PEL) for ozone is 0.1 parts per million (ppm)
- This is also the ACGIH recommendation

GOOD MANUFACTURING PRACTICES

As for any industrial process, UV and EB curing requires:

- Knowledge of the technology and hazards
- Well planned procedures
- Good documentation
- Effective employee training
- Constant attention to safe work practices
- Regular review and improvement

Safe Handling Of UV/EB Curing Materials

SAFE HANDLING OF UV/EB MATERIALS

- Understand the hazards and develop appropriate procedures
- Training in good industrial hygiene practices
- Overcome bad safety and handling habits

SAFE HANDLING OF UV/EB MATERIALS

MINIMIZING THE RISK OF DERMATITIS

- Prevent skin contact
- UV/EB materials do not evaporate; spills and contamination will remain until cleaned up
- Contaminated equipment can be a source of exposure

SAFE HANDLING OF UV/EB MATERIALS

MINIMIZING THE RISK OF DERMATITIS

- Watch where you touch with gloves
- Wipe up spills and potential contact areas immediately
- Dispose of or launder rags appropriately
- Use non-contact handling equipment when possible
- Keep away from food and beverages

SAFE HANDLING OF UV/EB MATERIALS

MINIMIZING THE RISK OF DERMATITIS: PROTECTIVE CLOTHING

- Recommended protective clothing depends on the potential mode of exposure
- Fabric or non-woven, long-sleeve, full-leg clothing or coveralls normally are sufficient tp prevent incidental contact

SAFE HANDLING OF UV/EB MATERIALS

MINIMIZING THE RISK OF DERMATITIS: PROTECTIVE CLOTHING

- Shoes must provide full foot covering; no sandals or open toes shoes
- Use rubber boots when exposure to solvent or liquid chemicals could occur

SAFE HANDLING OF UV/EB MATERIALS

MINIMIZING THE RISK OF DERMATITIS: PROTECTIVE CLOTHING

- Latex prevents short-term incidental contact
- Use rubber gloves when longer contact with acrylates is expected or when using solvents
- Nitrile rubber resists acrylate penetration
- Use gloves resistant to solvents for clean-up
- Use a rubber apron or suit when working with solvents or corrosive materials

SAFE HANDLING OF UV/EB MATERIALS

MINIMIZING THE RISK OF DERMATITIS: PROTECTIVE CLOTHING

- Wash gloves, hands and arms frequently
- Remove and clean jewelry and watches that may have come in contact with UV/EB curing materials
- Barrier creams help when washing off material which might have penetrated protective clothing

SAFE HANDLING OF UV/EB MATERIALS

MINIMIZING THE RISK OF DERMATITIS: PROTECTIVE CLOTHING

- Protective clothing contaminated with small amounts of UV/EB curing materials can be laundered in an alkaline detergent and re-used
- Always launder at a commercial laundry; do not take contaminated clothing home

SAFE HANDLING OF UV/EB MATERIALS

MINIMIZING THE RISK OF DERMATITIS: PROTECTIVE CLOTHING

- Heavily contaminated protective clothing should be discarded properly
- Contaminated shoes, belts or other leather goods should be discarded

SAFE HANDLING OF UV/EB MATERIALS

EYE PROTECTION

- Wear eye protection when handling any chemical
- Use a full face shield if splashing is likely

SAFE HANDLING OF UV/EB MATERIALS

EYE PROTECTION

- Eye protection equipment should absorb UV light
- Never look directly at UV lamps or strong reflections, even with eye protection
- Never adjust UV or EB shielding without qualified supervision

SAFE HANDLING OF UV/EB MATERIALS

INHALATION EXPOSURE: VAPOR

- Vapor pressures are so low that vapor inhalation usually is not a problem
- Ventilation for odor control is advisable
- With appropriate ventilation no special respiratory protection equipment is required

SAFE HANDLING OF UV/EB MATERIALS

INHALATION EXPOSURE: AEROSOLS

- Aerosols may form during spray applications, at liquid transfer points or during application with high speed rollers
- Such operations should be enclosed and well ventilated
- A fresh air mask or organic vapor respirator should be worn when engineering controls are not capable of preventing exposure to aerosols

SAFE HANDLING OF UV/EB MATERIALS

DETECTING ACRYLATE AEROSOLS

- ACGIH WEEL Guides recommend 1 mg/m^3 for maximum workplace airborne acrylate exposure
- RadTech has developed an industrial hygiene test method to measure airborne acrylates

SAFE HANDLING OF UV/EB MATERIALS

EXCEPTIONAL CONDITIONS

- Aerosols also can form under the conditions of fire or uncontrolled polymerization
- A fresh air mask or organic vapor respirator always must be worn under out-of-control conditions that could generate smoke and aerosols

SAFE HANDLING OF UV/EB MATERIALS

CLEAN UP PROCEDURES

- UV/EB curing materials remain liquid and can be cleaned up with less aggressive solvents
- Normally use soap and water or citrus and vegetable oil cleaners

SAFE HANDLING OF UV/EB MATERIALS

CLEAN UP PROCEDURES

- Solvents can be used for cleaning, but only if appropriate protective clothing is worn
- Do not use solvents to wash the skin; they increase the possibility of absorption
- Use hand creams to prevent skin irritation due to frequent washing

SAFE HANDLING OF UV/EB MATERIALS

CLEAN UP PROCEDURES

- See RadTech “Guidance On Cleanup & Disposal Of UV/EB Curing Waste Materials” at www.radtech.org

SAFE HANDLING OF UV/EB MATERIALS

GOOD HANDLING PROCEDURES: FIRE

- Flashpoints typically are > 200^{o}F
- Formulated products may contain solvents
- Best practice is to avoid ignition sources
- Avoid aerosol combustion products

PREMATURE POLYMERIZATION

- Acrylic acid and a few undiluted high functionality acrylates can undergo uncontrolled exothermic bulk polymerization
  - PETA
  - DiTMPTA
- Indicators: Bulging drums, drums hot to touch, steam escaping from drum
- Drum lid can blow off
- Self ignition can occur

PREVENTING PREMATURE POLYMERIZATION

- Ensure presence of adequate polymerization inhibitors
- Store in closed containers at temperatures recommended by manufacturer
- Do not exceed the recommended shelf life
- Avoid displacing oxygen
- Maintain head space to support the oxygen requirements of the inhibitor

PREVENTING PREMATURE POLYMERIZATION

- Avoid contact with polymerization initiators (peroxides, strong oxidizing agents, copper, copper alloys, carbon steel, iron, rust, strong acids, amines, thiols, strong nucleophilic bases)
- Select appropriate materials of construction for storage, handling and process equipment

PREVENTING PREMATURE POLYMERIZATION

- Keep out of direct sunlight; avoid exposure to light
- Avoid freezing (crystallizes out the inhibitor)
- Avoid excessive localized heating
- Avoid steam or electrical drum heaters for thawing and viscosity reduction
- Avoid high shear conditions when pumping and agitating

REGULATIONS

- Most UV/EB curing materials are not regulated by DOT as flammable or corrosive
- Some acrylates are designated as Marine Pollutants
- UV/EB curing materials are not "hazardous waste" as defined under RCRA regulations
- UV/EB curing materials are not "reactive" as defined under RCRA regulations

REGULATIONS

- UV/EB curing materials are not currently specified in any federal or state Community Right-To-Know list
- Little to no VOC or HAPS
- Some acrylates may fall into the same classification as Glycol Ethers

UV/EB HEALTH AND SAFETY

CONCLUSIONS

- UV/EB curing materials have low systemic toxicity
- UV/EB curing materials are not carcinogenic as a class via dermal exposure
- UV/EB curing materials are not mutagenic as a class via oral exposure
- In general, UV/EB curing materials are less hazardous than solvents

UV/EB HEALTH AND SAFETY

CONCLUSIONS

- Experience shows that UV/EB materials and processing can be handled safely
- Bad safety habits can lead to skin irritation
- Worker training and good hygiene are essential for safe handling of any chemical
- RadTech offers valuable resources to assist in safe handling and regulatory compliance

RADTECH WORKPLACE SAFETY RESOURCES

- RadTech Health And Safety Guide (English, French and Spanish)
- RadTech video on Safe Handling of Materials
- RadTech UV/EB EHS Web Page
- RadTech Health & Safety Topics Web Page
- Guidance On Cleanup & Disposal Of UV/EB Curing Waste Materials
- Ultraviolet Curing Lamp Safety And Handling
- RadTech Conference Presentations on Environmental, Health & Safety

RADTECH REGULATORY COMPLIANCE RESOURCES

- UV And EB Regulatory Briefs
- BACT Listings
- UV and EB Technology and the South Coast Air Quality Management District--A Users Guide
- Eliminating Air Pollution at the Source through UV & EB
- Navigating the Clean Air Act/Glossary of Clean Air Terms
- Breezing Through Clean Air Act Permitting with UV/EB Coatings - User Guide
- RadTech REACH Compliance web page

RADTECH CONSUMER PROTECTION RESOURCES

- UV/EB Coatings for Food Packaging
- UV/EB Inks for Food Packaging
- UV/EB Coatings & Food Contact
- UV/EB Adhesives & Food Contacts
- Coatings in Packaging Children's Products

QUESTIONS?

FocalPoint Consulting LLC

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