Working with UV Curable 3D Printing – Safety and Handling

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Objectives

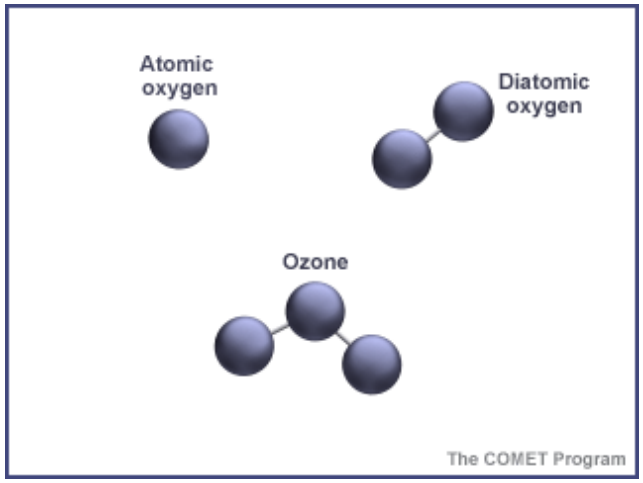
- Overview of the potential physical and processing hazards for UV curable 3D printing
- Emphasize the importance of the Safety Data Sheet
- Review the chemical hazards of the UV curable chemistry
- How to work safely with UV curable chemicals
- Comparison between common solvent systems and UV curable chemistry in regards to hazards
- Introduce the RadTech 3D Safety Fact Sheet

Potential Physical and Process Hazards

- Ozone
- Non-Ionizing Radiation (Ultraviolet)
- UV Curable Chemical Handling Issues
- Potential for premature polymerization

Ozone

- No significant emissions
- Low intensity UV bulbs and UV-LED lights minimizes the problem



Non-Ionizing UV Radiation

- Shielding minimizes UV light escape into the workplace
- American Conference of Industrial Hygienists (ACGIH) / National Institute for Occupational Safety and Health (NIOSH) UV exposure limits
  - Near UV (315 - 400 nm) 1 milliwatt/cm2 for exposures > 16 min
  - Actinic (200 - 315 nm) 0.1 milliwatt/cm2 for 8-hour exposure
- Exposure limits prevent skin and eye effects in most workers
- Sensitized individuals may exhibit effects even at low exposures

UV Chemical Handling Issues

- Component and Formulation Toxicity
- Preventing premature polymerization

Safety Data Sheets (SDS)

- The Hazard Communication Standard (HCS) requires chemical manufacturers, distributors, or importers to provide Safety Data Sheets (SDS) for all chemical products
- There should be a SDS document for each individual chemical and resin formulation being used in an UV curable 3D printer system.
- The SDS document will contain information such as potential hazards, First Aid, Protective Equipment recommendations, toxicological and other key information for the chemical or formulation
- The SDS document should be reviewed before working with a new chemical or resin formulation

Skin corrosion
Serious eye damage

UV Chemical Hazards

LOW MOLECULAR WEIGHT (METH)ACRYLATE MONOMER TOXICITY

- Ingestion — Low toxicity, high LD50
- Inhalation — Vapor pressures mostly <0.1 mm Hg @ 25°C
- Skin Absorption — Low, generally does not lead to systemic toxicity
- Skin sensitization — Can occur
- Dermal Irritation — Mild to moderate. Delayed action, exposure can go unnoticed. Blisters on prolonged contact
- Eye Irritation — Mild to severe
- Chronic effects — No significant chronic effects known.

Acrylate Monomers - Draize Testing

- Draize Test is an acute toxicity test developed by the Food and Drug Administration (FDA) used to test for irritants
- Differentiates between chemicals with widely varying irritation
- Draize scores are only rough estimates of irritation potential
- Tests for the same material can yield significantly different results

(Meth)Acrylate Monomers Toxicity Studies

- Low acute toxicity via oral or dermal routes
- Few systemic (human system wide) effects
- Eye irritation ranged from non-irritating to corrosive
- Skin irritation ranged from mild to severe
- No teratogenic or fetotoxic effects

Additional Acrylate Toxicity Studies

- No excess cancer reported in Environmental Protection Agency (EPA) sponsored NIOSH plant surveys
- EPA co-sponsored long-term skin painting
  - Dermal cancer bioassay showed no carcinogenic effect
  - No systemic toxicity

Acrylate Oligomers vs. Monomers

- In general, (meth)acrylate oligomers are less irritating than monomers
- Oligomers have substantially higher molecular weight
- Oligomers have a lower net acrylate functionality
- Skin and eye irritation normally are minimal to mild
- Very low acute toxicity

Minimizing the Risk Of Dermatitis

- Prevent skin contact
- Always wear gloves and watch where you touch with gloves as they may be contaminated
- Contaminated equipment can be a source of exposure
- UV materials do not evaporate; spills and contamination will remain until cleaned up
- Wipe up spills, contact areas immediately
- Keep away from food and beverages
- Use adequate ventilation in the room to reduce exposure
- Postcure the 3D object by exposing it to a UV lamp.

Minimizing the Risk Of Dermatitis

PROTECTIVE CLOTHING:

- Refer to the Safety Data Sheets (SDS) on the chemicals for recommendations on the Personal Protective Equipment (PPE)
- Select gloves resistant to solvents when skin contact is possible
- Take gloves off and dispose before touching door handles
- Use barrier creams to minimize exposure to skin
- Barrier creams help when washing off material which might have penetrated the PPE
- Do not apply barrier creams after exposure
- Wash gloves, hands and arms frequently

Minimizing the Risk Of Dermatitis

Personal Protective Equipment (PPE)

- Protective clothing contaminated with small amounts of UV curing materials can be laundered in an alkaline detergent and re-used.
- Heavily contaminated protective clothing should be properly discarded.
- Contaminated shoes, belts or other leather goods should be discarded.

Eye Protection

- Wear eye protection when handling any chemical
- Eye protection materials should absorb UV light. Sunglasses are not acceptable.
- Never look directly at UV lamps or strong reflections, even with eye protection
- Never adjust or remove UV shielding on the 3D Printer

Clean Up Procedures

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

Preventing Premature Polymerization

- Polymerization inhibitors
- Avoid displacing oxygen
- Avoid exposure to light
- Avoid contact with polymerization initiators
- Avoid excessive localized heating
- Avoid high shear conditions
- Adhere to maximum storage and handling temperatures
- Do not exceed recommended shelf life

Solvent vs. UV Systems

	Typical Solvents	Typical UV
Acute Toxicity	respiratory irritation, skin rash, eye irritation, narcosis, kidney damage, blood damage, liver damage, reproductive damage, fetal injury, death	skin rash, eye irritation, blisters
Chronic Toxicity	cancer, permanent liver, nerve, blood, kidney damage	possible weak carcinogen, sensitization
Exposure Routes	skin absorption, eyes, inhalation, ingestion	skin surface, eyes, ingestion, inhalation (aerosol)

Solvent vs. UV Systems

	Typical Solvents	Typical UV
Oral LD50 (rat)	470 - 9,600 mg/kg	1,350 - 15,000 mg/kg
Dermal LD50 (rabbit)	220 - 14,100 mg/kg	2,000 - 13,000 mg/kg
Skin/Eye Irritant	Yes	Yes
Reproductive Hazard	Yes in many cases	No
Mutagen	Yes/No	Yes/No

Solvent vs. UV Systems

	Typical Solvents	Typical UV
Flammable	Mostly Yes	Mostly No
Explosive Vapors	Mostly Yes	Mostly No
VOC	Mostly Yes	Mostly No
Hazardous Waste	Yes	Mostly No
Reactive	No	Yes
Community R-T-K (Right To Know)	Yes	No

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Safe Handling of UV Materials Used in 3D

Ultraviolet (UV) cured materials, or formulations known as photopolymers, are growing in use for additive manufacturing that creates highly refined three dimensional (3D) objects. Photopolymers cure instantly when exposed to UV light and typically have a higher build resolution than other materials used in 3D printing. However, although they are designed to be as safe as possible, as with all chemicals, photopolymers must be handled in a safe manner. Correct handling will avoid any potential health and safety hazards.

This information in this fact sheet is meant to be a guideline for the handling of UV curable materials and photopolymers used in 3D printing systems such as stereolithography (SLA), digital light processing (DLP) or inkjet. Following this guide does not guarantee compliance with any law or regulation. Companies involved in distributing, handling, processing, and using 3D printing systems should consult with their suppliers to learn more about applicable and possible future regulations.

Printer operators should be informed about the potential hazards prior to performing operations which may result in exposure to uncured material.

Safety Data Sheet (SDS)

SDSs provided by the supplier of the photopolymers should be consulted as the primary safety and handling documents. It is the responsibility of the users to read and understand the SDS. The SDS includes information such as the properties of the chemical, its physical, health, and environmental health hazards, protective measures to be used, and safety precautions for handling, storing, and transporting it properly.

Personal Protective Equipment (PPE)

- Avoid direct contact between the photopolymer and any of parts of the body or clothing
- Use safety glasses/goggles with UV protection, as needed
- Wear appropriate chemical resistant gloves (nitrile or neoprene) -- DO NOT use latex gloves
- A dusk mask should be worn when sanding or post-finishing parts

Housekeeping

- Before removing a cartridge containing photopolymer from its protective container, and before loading it into the printer, inspect the cartridge for signs of leakage or physical damage.
- Do not load a cartridge that is leaking or is damaged -- dispose of it according to your local regulations and contact your supplier
- Carefully pour the liquid photopolymer from the storage bottle to the printer tray, avoiding spills and drips
- Keep work area clean
- Keep food and beverages out of the workspace
- Tools that may be contaminated with the material should be cleaned prior to reuse
- 3D printers have built-in safety features that are designed to prevent operator exposure to uncured photopolymer -- do not try to change or disable these features
- Cleaning spills on carpeting can be difficult so avoid placing printer over carpeted areas or use a barrier to avoid the possibility of carpet damage
- Do not expose print material to heat (at or above 110°C/ 230°F), flames, sparks, or any source of ignition

Personal Hygiene

- Do not eat, drink or smoke in work area
- Avoid contact with surfaces/objects that may be contaminated
- Avoid prolonged exposure as it may result in irritation
- Remove and clean jewelry (ring, watches) that may come in contact with UV/EB material
- Wash hands, face and contaminated clothing with mild skin cleanser and soaps after handling UV materials -- do not use solvents
- Do not reuse contaminated clothing or jewelry until properly cleaned
- Discard contaminated shoes and leather goods

First Aid

- Flush contaminated eyes or skin thoroughly with water for 15 minutes
- Use soap and water on skin or waterless cleaner if needed
- Some individuals may develop skin sensitization over a period of time and should seek medical treatment
- If ingested, do not induce vomiting, but seek medical attention

Storage

- Protect UV materials from exposure to light or contamination, by keeping them in their polyethylene bottles or steel containers that are either polymer coated or plastic lined
- If container lids are kept tightly sealed, accidental spillage can be minimized
- Keep the containers within the temperature range suggested by the manufacturer
- Maintain head space to support the oxygen requirements of the inhibitor
- Keep UV materials out of direct sunlight

Clean-Up

- Use absorbent rags to clean spills immediately
- Clean and rinse off any contacted surface to prevent contamination of others
- Spill area can be cleaned with window cleaner, denatured or isopropyl alcohol, followed by a thorough washing with soap and water

Disposal

- Fully cured materials present no special safety or health related disposal issues and can be handled or disposed of in the same manner as standard household plastic products
- Before disposal, cure the unreacted waste on the rags by leaving them in sunlight for a few hours or expose them to a UV light
- Partially or uncured resin waste may be classified as hazardous waste in some areas
- Clean up solvents containing UV materials should be isolated in sealed, labeled containers and disposed of as hazardous waste

The information contained in this guide is believed to be current of the date of the publication. The use of the information and the conditions of use of particular 3D printing systems are not within the control of RadTech. It is the user's obligation to determine the conditions of the safe use of a particular 3D printing system. This guide is offered in good faith and is believed to be reliable but no warranty or representations, express or implied, is made with respect to any or all of the contents of this document. RadTech and its member companies assume no legal responsibility with respect to any or all of the contents of this document. Nothing contained herein should be as a recommendation to use any particular company's product. Contact your chemical and equipment suppliers for additional information.

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3D Safety Fact Sheet

- Safety Data Sheet (SDS)
- Personal Protective Equipment (PPE)
- Housekeeping
- Personal Hygiene
- First Aid
- Storage
- Clean-Up
- Disposal

3D Safety Fact Sheet

•Disposal

- Fully cured materials present no special safety or health related disposal issues and can be handled or disposed of in the same manner as standard household plastic products
- Before disposal, cure the unreacted waste on the rags by leaving them in sunlight for a few hours or expose them to a UV light
- Larger quantities of uncured waste resin can also be cured by transferring to a small tray and exposing to sunlight or UV light
- Partially or uncured resin waste may be classified as hazardous waste in some areas
- Clean up solvents containing UV materials should be isolated in sealed, labeled containers and disposed of as hazardous waste

Summary

- Always refer to the Safety Data Sheet (SDS) before working with a chemical or formulation
- Experience shows that UV materials can be handled safely
- UV curable materials have low systemic toxicity
- (Meth)Acrylates are not carcinogenic as a class via dermal exposure
- In general, UV curing materials are equal to or less hazardous than typical solvents
- RadTech 3D Safety Fact Sheet

Thank You

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