Safe Handling Guide

UV-curable materials

HEALTH · NUTRITION · MATERIALS

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

DSM Functional Materials* is a leading developer of high-performance, UV-curable materials for a variety of today's top industries. Our products include DeSolite®, Cablelite® and Bufferlite™ fiber optic materials, Somos® solid imaging resins, UVaCorr® tube and pipe coatings and UVolve® Instant Floor Coatings.

Formulated differently than conventional materials, UV-curable products require particular instruction for their safe handling. The information provided in this guide is designed to acquaint you with UV-cure technology, identify its potential hazards, and provide general direction and guidelines for the safe application and efficient use of DSM Functional Materials solvent-free, UV-curable products.

This booklet is a guide for safe handling only. The precautions outlined here should be followed in close combination with instructions provided on our product labels and Material Safety Data Sheets (MSDS), as well as in consultation with your DSM Functional Materials representative regarding your specific DSM product.

*Effective April 1, 2011, DSM Desotech Inc., DSM Desotech BV, and DSM Desotech Specialty Chemicals Shanghai Ltd., are doing business as DSM Functional Materials.

UV-Cure Technology

Conventional coatings are generally dissolved in organic solvents or dispersed in water. Curing (or hardening) then proceeds by solvent evaporation and/or a chemical reaction. While UV-curable coatings may contain solvent to aid in application or to achieve very thin coating films, the curing reaction is initiated by exposure to intense ultraviolet light.

A light source which emits energy having a wave length of 200-450 nanometers is used to activate a photoinitiator contained in the product. This begins the polymerization—or curing—process which is completed in a few seconds or less. In general, UV-curable materials require less energy and less time to cure than conventional products.

Typical components of DSM Functional Materials UV-curable products may include: a reactive resin, a multi-functional crosslinker, a reactive diluent, one or more photoinitiators and, in some cases, a solvent to aid in application.

Depending upon end-use and application, these components may be formulated with adhesion promoters, stabilizers, pigments and other additives. The following general categories best describe the chemistry used in our UV-curable products:

Acrylates. Acrylate-based coatings are cured by a free radical mechanism and utilize oligomers, multi-functional and monomeric reactive diluents with reactive acrylate groups. Acrylate monomers, acrylated epoxies and urethanes are often included for hardness, toughness, and good physical properties.

Epoxies. Epoxies are polymerized cationically by a photoinitiator generating an acid rather than free radicals. Hydroxyl-containing intermediates are also commonly included in these systems as co-reactants. Unlike free radical initiated UV systems which cure primarily in the areas of direct light exposure, the cationically initiated epoxy systems will continue reacting after the UV source is removed.

Storage of UV-Curable Materials

UV-curable materials are composed of reactive monomers and oligomers. If improperly stored, these compositions may undergo polymerization with the evolution of heat. Improperly stored UV materials increase in viscosity and eventually result in a gelled (polymerized) product in the storage container.

For this reason, products should always be maintained according to storage and handling recommendations, and per applicable fire department and insurance recommendations.

Containers
Most DSM Functional Materials products are supplied in lined (baked phenolic) steel, plastic or fiber containers with plastic linings or inserts. Polyethylene bottles or liners are acceptable as long as they are opaque to ultraviolet light and not used to hold solvent containing materials.

UV-curable products containing acrylates should not be allowed to come in contact with iron, copper or copper containing alloys to insure product stability. Plastic containers made from organic soluble materials such as polystyrene or polyvinyl-chloride (PVC) should not be used for storage.

Container lids should be tightly sealed in order to protect UV products from contamination and/or stray light when not in use. Also, a tightly sealed container will guard against product spillage if the container is accidentally dropped during handling.

Shelf Life
Most DSM Functional Materials products have a minimum shelf life of six months from the date they are shipped. Provisions should be made to insure inventory rotation: first in, first used. Some products may have a longer shelf life, please refer to material safety data sheets.

Light
UV-curable materials should be shielded from sunlight or other sources of actinic radiation such as fluorescent or mercury vapor lights. Exposure to actinic radiation will lead to increased product viscosity and eventually to product polymerization.

Temperature
Containers or bulk storage tanks containing UV materials should be kept indoors at temperatures between 15°C (59°F) and 30°C (86°F). Temperatures above 30°C will accelerate the depletion of the stabilizers contained in the product. Once the stabilizers are exhausted, polymerization will occur.

For pigmented materials, elevated temperatures will increase the rate of pigment settling. Refer to specific data sheets for individual products.

Temperatures below 15°C may lead to phase separation (individual components separating from solution) or possible precipitation of stabilizers. If the product is believed to have been below 15°C for a prolonged period of time, it should be thoroughly mixed and checked for performance prior to use.

Product that has undergone separation can be fully restored to initial properties by gently mixing the contents of the container at room temperature. Care should be taken not to induce bubbles into the material during mixing.

Contamination
Free radical sources, such as peroxides and iron contaminants, can initiate polymerization of acrylate based products. Epoxy based products will undergo rapid polymerization when contaminated with strong acids.

Introduction of free radical scavengers (phenolic compounds and others) will retard the cure rate of acrylate based products. Alkali or amine contamination will retard the cure rate of epoxy based products. Accidental contamination with polymerization inhibitors will result in slower cure speed. It is also important to prevent accidental product contamination with organic solvents or water.

Transfer and Handling

The manner in which UV-curable materials are transferred from shipping container to application equipment will depend on many factors including: volume of usage, container size and type of coating equipment.

Consult DSM Functional Materials on the design of an appropriate transfer system to suit specific needs. The following fundamental considerations must be taken into account in designing a successful material transfer system.

Composition of Transfer Equipment
All transfer lines, hoses and fittings should be made of a material which is opaque, non-reactive, and not affected by UV-curable material (such as stainless steel). Some plastics, such as polyethylene or Teflon®, may also be used as long as they are not affected by the UV material and are opaque to ultraviolet light. Otherwise, curing may take place in the tubing with some ultraviolet systems.

Avoid any alloys containing copper or iron, which may result in premature curing (polymerization) and color degradation.

Pumps and Pressurized Air
It is generally advisable to avoid high shear pumps, such as gear or piston types, because the high degree of shear may cause the coating to cure and the pump to seize. When using pumps, peristaltic or diaphragm pumps are preferred.

Pressurized air can also be used to transfer products, if all of the vessels and lines are certified and capable of resisting the air pressure. A maximum air pressure of 0.35 MPa (50 psi) is suggested. If air pressure is used, make sure the air is clean and dry. Avoid using nitrogen gas, which can cause gellation.

Flammability
The degree of flammability hazard is often expressed as the flash point of a material or the temperature to which a material must be heated before a flame will ignite the vapors. In general, DSM Functional Materials products without solvents have a flash point greater than 93°C (200°F). Products containing solvents will be flammable or combustible.

Special precautions should be taken to prevent exposure of UV-curable materials to heat, flame, sparks or any source of ignition. Containers exposed to extreme heat may explode. Follow appropriate bonding and grounding procedures when transferring UV-curable materials.

Warming
In some cases, material will need to be heated for application or transfer. If this is necessary, it is advisable to apply heat slowly and uniformly. Preferred heating methods include circulating hot air, a water bath, or circulating oil. Although it takes longer, these methods are generally uniform and can be reliably controlled.

Heating belts and immersion heaters should always be avoided because they produce hot spots and tend to have poor thermostatic control.

Adequate ovens or baths can be purchased or built for small containers. For large volume usage such

as drum quantities, it is recommended that a hot room or preheat tank be installed to provide an adequate and continuous production feed.

Should transfer lines require heating to assist in transfer, water jacketing is recommended. Although moderate heating can be used, localized overheating (above 70°C or 160°F) should be avoided.

Agitation
Under normal storage temperatures, DSM Functional Materials clear UV-curable products do not need agitation. However, pigmented materials may require mixing to prevent settling to redisperse pigments.

If agitation is required, small round containers can be rolled on a flat surface. While large containers will require slow mixing with an agitator. High viscosity materials may require heating to facilitate easier mixing. Care should be taken not to induce bubbles during mixing.

Handling
During warming and transfer steps, it is essential to protect UV-curable materials from exposure to light and contaminants of any sort. Therefore, it is recommended that the containers be covered but measures should be taken to prevent pressure build-up.

Ultraviolet absorbing plastic sleeves should be installed over fluorescent lights in work or application areas to prevent premature curing of the product. Likewise, windows should be covered with a plastic barrier or film that will screen out ultraviolet light.

Before using any metal tanks or pipes, it is essential to thoroughly clean and flush the system before introducing the material. All transfer lines and pumps should be blown clear with clean, dry air following completion of transfer.

Adequate ventilation must be provided in preparation or application areas, as small amounts of vapors may be emitted. Refer to section 8 of applicable MSDS for ventilation advisement.

Safe Use of Curing Equipment

The application of UV curing requires the use of specialized curing equipment which utilizes electricity to accomplish the curing mechanism. The electricity is converted into ultraviolet light which initiates a photochemical reaction and polymerization. Some generation of heat during this process is not uncommon.

Commercially available UV-curing equipment can be designed for most industrial environments. Like other industrial equipment, it contains hazards which must be understood in order to maintain a safe workplace. A well written operating/maintenance/safety manual should be developed with the equipment manufacturer for each piece of curing equipment.

Since UV-curing technology involves equipment which is different from conventional thermal drying/curing systems, equipment selection should take into consideration the following:

• Equipment should be purchased from reputable manufacturers and should meet all current safety standards and relevant governmental regulations. The equipment manufacturer should supervise installation of the equipment to insure its proper operation.

• The equipment manufacturer should thoroughly train operators in safe operation of the equipment.

• Instructions must emphasize a complete understanding of the associated hazards.

• A detailed instruction manual should be available in the workplace for each piece of equipment.

• Concise safety and operating instructions should be prominently posted in the work area.

Adequate exhaust and ventilation systems should be a part of each UV processor. Such a system will prevent the buildup of ozone and oxygen depletion (where an inert gas such as nitrogen is used). Ventilation should be designed remove any volatiles emitted during the curing process.

Equipment condition should be assessed prior to use to ensure no UV or electron/x-ray radiation leakage.

Somos® stereolithography resins are imaged with lasers which emit ultraviolet light. Stereolithography equipment is designed to limit opportunities for worker exposure to the intense light emitted by the laser. It is critical that the equipment is maintained

in good working order and that safety devices are not defeated.

Removal of guards, optical maintenance and laser tuning should be performed only by trained personnel. Eye protection which filters out 200 - 450 nm UV light should be worn by lab personnel while laser/optical maintenance is performed, and non-essential personnel should be restricted from areas where they may be exposed to UV laser light.

All UV curing systems must provide safeguards against exposure to the generated light, ozone, high voltage and hot exposed areas. Any equipment maintenance should be preformed by a trained professional.

Spray Application

Safety and ventilation techniques appropriate for any solvent-containing coating must be followed.

Control of Exposure
The following recommendations should be closely adhered to: Engineering controls are the preferred method for reducing worker exposure if the process is unable to be automated. This includes the use of local exhaust ventilation in the application area. Explosion-proof construction may be required if spray application is used. All ventilation equipment should be electrically bonded and grounded.

To minimize exposure to UV-curable materials, they should be spray applied by conveyorized, automated, and enclosed methods.

Proper PPE and appropriate/approved respirators must be utilized where engineering controls are not adequate. In no case should products containing acrylate monomers be applied in production by hand spray!

Measurement of airborne concentrations of solvents, acrylates and other coating system components should be performed by a qualified industrial hygienist at the startup of an operation and routinely thereafter to insure continued effective control of potential inhalation hazards. The ventilation system should be routinely checked to insure adequate exhaust.

Equipment Considerations for Spray
UV-curable materials present new challenges for equipment suppliers due to their reactivity and thermal sensitivity. Airless spray is generally unsuitable.

Solvent diluted UV-curable materials should be tested for compatibility with airless spray equipment on an individual basis. High speed turbine bells may provide the means of applying solventless, non-volatile UV-curable products without addition of solvents. Where applicable, electrostatic spray can be used.

The overspray of UV curable materials does not “dry” to a hard film but rather remains “wet” until exposed to UV light. Spray booths should be lined with a fiber matting type material that can be exposed to UV light or passed through the UV processor to cure the wet film. The lining material can then be disposed of in a suitable manner.

Water treatment considerations associated with water wash spray booths should not be that different with UV-curable products than with conventional coatings, but this should be determined on an individual case basis through discussions with regulatory agencies.

All piping should be stainless steel or suitable plastic. Care should be taken to avoid bare steel, copper, or brass, which may contaminate the coating (see “Transfer and Handling” section).

Toxicity

Safety, health and material toxicity are expressed in our Material Safety Data Sheet (MSDS), please refer to applicable MSDS for toxicity information.

Toxicity
Toxicity is the inherent ability of a chemical to produce a deleterious response in a biological system. All materials have some toxicity associated with them. Please refer to applicable MSDS for additional toxicity information.

Skin Irritation
Brief contact or prolonged exposure of acrylate-containing materials may cause irritation, itching, redness, dry patchy scaling and/or discharge. Skin irritation is generally confined to the area of direct contact and reaction to exposure may be delayed. Prolonged exposure may cause burns.

Skin Sensitization
Sensitization dermatitis is the result of an allergic reaction to a given substance. Direct skin contact is necessary to cause sensitization. Individuals may become sensitized to a substance after a trouble-free period of exposure.

There are many factors which affect a person's susceptibility, including existing skin diseases, personal habits, and individual sensitivity. Once a person is sensitized, even a minute exposure may trigger a severe dermatitis reaction which may spread over the body. Sensitization is permanent, so a sensitized individual should be removed from potential contact with the sensitizer.

All UV-curable materials are potential sensitizers. To avoid skin irritation or sensitization, do not allow uncured material to contact skin. Consult Material Safety Data Sheets (MSDS) for specific information about the sensitization potential of UV-curable materials.

Eye Irritation
UV-curable materials may cause moderate to severe eye irritation upon direct contact.

Inhalation
Inhalation of UV-curable, solvent-free materials has been regarded as less of a problem than skin or eye contact due to their low volatility—though volatility does vary by composition. Vapors, however, may accumulate in areas without adequate ventilation. Acrylate vapors will irritate the nose, throat and lungs. All areas where acrylates or epoxies are handled should be thoroughly ventilated.

In spray applications, the coating ingredients are atomized directly into the air and thus may be inhaled. Breathing spray mist may irritate the respiratory tract. Measures should be taken to prevent inhalation of the spray mist since exposure can result in respiratory irritation with potential for sensitization.

Occupational Exposure Limits
Consult the Material Safety Data Sheet (MSDS) for any occupational exposure limits that may exist.

Ingestion
DSM Functional Materials products may be toxic by ingestion. These materials must not be present where food and drink are stored, prepared or consumed.

Carcinogenicity
While DSM Functional Materials avoids the use of carcinogenic ingredients where possible, their presence in a DSM product is specifically noted on the Material Safety Data Sheet (MSDS).

Toxicity of the Cured Coating
After curing, DSM Functional Materials products exist as a cross-linked material which should present no hazard to health under normal use conditions. However, if the cure is not complete, low levels of volatile components may still remain. If these volatilize in an area with poor ventilation, irritating airborne contaminant levels may develop. Moreover, skin contact with incompletely cured material may result in skin irritation or sensitization.

Burning of the cured material may result in toxic gas formation depending on such factors as temperature, amount of oxygen present, and the specific formulation.

Exposure Control

For UV-curable materials, the following personal protective equipment and controls are recommended:

Skin Protection
Chemically resistant gloves should be worn at all times when working with UV-curable materials. Glove manufacturers should be consulted as to appropriate gloves. When handling large quantities of UV-curable materials, long-sleeved, chemically resistant uniforms should be worn, including both tops and bottoms. Disposable uniforms provide only limited protection against UV curable materials. Shoe coverings such as rubber boots or disposable booties should also be utilized.

Eye Protection
Safety glasses with side shields will provide adequate protection when working with small quantities of UV-curable material. Face shields should be used where exposure to large quantities is possible. Contact lenses should not be worn.

Respiratory Protection
Respiratory protection is often not necessary if engineering controls are implemented and if low volatility materials are used. However, the need for respiratory protection must be evaluated for each use of a UV-curable material.

If respiratory protection is utilized, a respiratory protection program complying with 29 CFR 1910.134 must be implemented. A NIOSH/MSHA* approved half mask or full face respirator with organic vapor cartridges may be used if airborne contaminant levels do not exceed ten times the occupational exposure limits.

DSM Functional Materials does not recommend that employees hand spray acrylate based UV-curable materials. If an employee is involved in spraying epoxy-based UV-curable materials, a NIOSH/MSHA approved air supplied respirator provides the best protection. NIOSH/MSHA approved full face respirators with spray paint cartridges (pre-filters and organic vapor cartridges) may also provide protection. See "Spray Application" section for additional information.

Work Uniforms
Work uniforms should not be taken home for cleaning. Laundering of work uniforms should be performed by a professional laundry. Inform the laundry of the presence of UV-curable materials. It may be advisable to segregate uniforms worn while working with UV-curable materials containing acrylates from other soiled uniforms to avoid cross-contamination.

Hygiene
Good hygienic practices should be rigorously followed including washing before meals, breaks, smoking, applying cosmetics, using toilet facilities and after work. Moisturize hands after the skin is washed after work to prevent drying.

Safety Showers and Eye Wash Stations
Safety showers and eye wash stations should be installed in the work areas in all locations necessary to insure ready employee access in case of exposure. Employees should be trained in their use. Generally, if an exposure has occurred, the affected employee should flush for at least 15 minutes. Consult your Material Safety Data Sheet (MSDS) for specific instructions.

Housekeeping
Good housekeeping should be practiced in the work area. UV-curable materials should be cleaned up immediately, so as to prevent the potential exposure to other employees.

Solvents should be used for cleaning equipment only if adequate engineering controls are in place. Appropriate respiratory protection should be worn. Disposable wiping towels should be used rather than reusable rags. All cleaning materials should be disposed of according to legal and regulatory requirements.

Training
Employees must be trained in the hazards and control of UV-curable materials. Such training should be provided to new employees before they begin working and to other employees at least annually.

If exposure has occurred, consult a medical professional immediately.

Cleanup Procedures

Organic solvents are normally required to clean equipment and tools. The following solvents are recommended:

Isopropanol (IPA) – for most UV materials

Acetone – for difficult to dissolve materials and cured film

IPA is a less aggressive solvent with a higher flash point, which makes its use preferred for health and safety considerations. Where improved solvency is necessary, acetone will do a better cleanup job. A final wash with soap and water will remove the last traces of UV materials. Small parts can be cleaned most effectively in an ultrasonic cleaner.

The surface to be cleaned should first be tested with the cleaning solvent before use, as these solvents are capable of dissolving certain rubbers and plastics.

When handling objects fabricated from Somos® resins in a partially cured state (after initial laser cure), wear nitrile or other chemical resistant gloves to avoid skin contact. The fabricated objects should be thoroughly washed with solvent (e.g. tripropylene glycol monomethyl ether, isopropyl alcohol), and allowed to thoroughly vaporize followed by post exposure to UV light and/or an ovenbake at temperatures above 130ºC. These post-cured objects may be handled without gloves. When sanding fully cured surfaces, suitable respirator protection for dust should be used.

*U.S. National Institute for Occupational Safety and Health/Mine Safety and Health Administration

Vapor degreasers have proven the most effective means of cleaning coating applicators and their associated parts.

Safe handling procedures should be followed during cleanup. Consult the specific Material Safety Data Sheet (MSDS) of the solvent supplier for handling information.

Spill Control
Small spills can be cleaned up using disposable towels, rags or an absorbent material such as sawdust, clay, diatomaceous earth, etc., which should then be placed in a sealed, marked container. The spill area can then be cleaned with an approved cleaning agent, followed by a thorough washing with soap and water.

Large spills. The following procedures are recommended when cleaning up a large spill:

A. Cleanup personnel must wear protective clothing and NIOSH/MSHA approved respiratory equipment. Ensure that adequate oxygen levels are maintained.

B. The area should be isolated immediately and diked to contain the spill.

C. The spill should be covered with absorbent material such as sawdust, clay, diatomaceous earth, etc.

D. When the absorbent is saturated, it should be sealed in a marked container and disposed of according to regulatory requirements.

E. The spill area should be thoroughly cleaned with solvent or soap and water and the waste disposed of properly.

Worker Cleanup
A. UV-curable materials should be wiped off protective clothing with clean disposable towels and any clothing contaminated with UV-cured materials should be disposed of properly.

B. Protective clothing should be removed in this order: boots, gloves, suit, and face protection. After removing gloves, use disposable towels to protect your hands from contact with the UV liquid coating material.

C. Place contaminated clothing in a sealed container for proper disposal.

D. All personnel should shower with soap and cool water.

Disposal and Maintenance

Fully cured UV materials ordinarily present no safety or health related disposal hazards. Nonetheless, some areas may still regulate cured coatings as hazardous industrial waste. Contact the governmental body in your area which regulates waste disposal to determine the specific requirements for cured UV-coating waste.

Partially or uncured UV material waste may be classified as hazardous in some areas, thereby requiring special packaging, transportation and disposal. Check with the governmental body which regulates waste disposal in your area to ascertain, if any, specific disposal requirements exist.

The packaging, transportation and disposal methods which are used must prevent any form of human contact with the waste, even if it is classified as nonhazardous or unregulated. This precludes the use of disposal methods which will result in groundwater or surface water contamination.

Cleanup solvents (containing UV-curable material) should be isolated in a sealed, marked container and disposed of as “Hazardous Waste” in accordance with all applicable laws and regulations.

Cleanup materials, soiled clothing, empty containers, etc., should be disposed of in accordance with the preceding guidelines. Whenever any of these contain uncured or partially cured UV-curable materials, the disposal method must preclude any form of human contact, including any which could result in ground water or surface water contamination. Generally, non-solvent containing UV-curable materials may be disposed of as non-hazardous waste. Contact a reputable waste hauler for a complete analysis and classification of all wastes streams.

A. Discard contaminated shoes by isolating in a sealed container and disposing of as solid waste in accordance with local legislation.

B. Empty plastic bottles should be drained thoroughly and disposed of as solid waste.

C. Empty drums should be sent to a qualified drum reconditioner.

Maintenance
Maintenance employees must be informed about the hazards of UV-curable materials prior to working on UV associated equipment or performing other duties which may result in exposure to UV-materials.

Whenever possible, maintenance work should not be performed until the equipment has been thoroughly cleaned of UV-curable materials. Tools which may be contaminated with UV-curable material must be thoroughly cleaned prior to reuse.

Fire Fighting

Extinguishing media that should be used on fires involving these materials are National Fire Protection Association Class B extinguishers such as carbon dioxide, dry chemical or foam.

Vapors and combustion products produced from burning UV-curable materials can be irritating to the respiratory system and must be avoided. If it is necessary to approach a fire or smoldering UV-curable material, wear eye, skin and respiratory protection equipment such as a NIOSH/MSHA approved self-contained breathing apparatus.

Water may be used to cool closed containers to prevent pressure buildup and possible auto ignition or explosion when exposed to extreme heat. If water is used, fog nozzles are preferable.

First Aid

This section includes first aid procedures in the event of human exposure to DSM Functional Materials UV-curable materials. Always refer to the DSM Functional Materials container label and Material Safety Data Sheet for information specific to the product being handled.

Skin
If UV-curable materials come in contact with the skin, immediately wash the contacted area thoroughly with soap and cool water while removing contaminated clothing. Particular attention should be paid to flushing the hair, ears, nose and other parts of the body that are not easily cleaned. The use of cool water is important to avoid opening the pores which may allow more material to penetrate the skin.

If skin has been exposed and irritation develops a physician must be consulted.

During first aid procedures, avoid the accidental transfer of UV-curable material from the hands to other areas of the body, especially to the eyes. In the event of skin contact, do not reapply barrier cream until the skin has been completely cleansed.

Do not launder contaminated clothing at home. Dispose of contaminated shoes, belts and other leather items because they may absorb UV-curable materials and re-expose the user at a later point in time.

Eyes
If eye contact occurs, flush the eyes immediately with large amounts of tepid water for at least 15 minutes, followed immediately by a physician's examination.

Inhalation
Vapors from UV-curable materials, as well as their combustion products, can be very irritating to the respiratory system. Upon inhalation exposure to vapors or the products of combustion, immediately remove the victim to fresh air. If breathing has stopped, immediately begin artificial respiration or cardiopulmonary resuscitation. Get medical attention immediately.

Oxygen should be administered only by authorized personnel. The patient should be kept warm but not hot. An unconscious person should never be given anything by mouth.

Ingestion
If swallowed, consult the container label for specific instructions. Get medical attention immediately.

Notes

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