



SUNSPHERES™ LCG Hollow Sphere Technology An SPF Booster for More Aesthetically Pleasing Formulations

Features, Benefits, and Applications

SunSpheres SPF Boosters are built on a unique hollow sphere technology that enables greater SPF efficiency* in sun care and daily wear SPF products. The hollow spheres raise the UV absorption over the whole UVA/UVB spectrum, working equally well with organic and inorganic actives. SunSpheres SPF Boosters are also compatible with a broad range of cosmetic ingredients, including emollients, solvents and skin conditioners.

A Cost-Effective Solution: Use Less UV Actives

The ability of SunSpheres SPF Boosters to raise the efficacy of UVA/UVB filters in formulations allows the formulator to use significantly less UV actives to deliver the same level of SPF, or to deliver a higher SPF for a given level of UV actives. As an extra benefit, potential irritation caused by these actives is reduced, and the formulator is able to create more aesthetically-pleasing products.

SunSpheres SPF Boosters are offered in two different forms:

- SunSpheres Powder – 88-90% solids.
- SunSpheres LCG aqueous emulsion containing 27% solids. This grade is not available in Europe.

*SunSpheres™ SPF Boosters are not UV active ingredients.

CTFA/INCI Name: Styrene/Acrylates Copolymer

Features

- Boosts UV protection over the whole UVA/UVB spectrum
- Compatible in water-resistant products
- Compatible with organic and inorganic UV actives and all commonly used ingredients
- Liquid can be processed cold
- Very small particle size
- Supported by comprehensive environmental, health and safety data
- Available in a powder form as well as liquid

Benefits

- Allows reduced amount of UV actives
- Reduces potential for irritation due to UV actives
- Excellent for water-resistant formulations
- Useful for a wide range of products
- Easy to formulate
- Invisible to the eye; excellent for aesthetically-pleasing formulations
- Non-irritating, non-toxic, non-photosensitizing
- Powder is suitable for inverse (W/O) emulsions

Applications

SunSpheres SPF Boosters can be used in a wide range of sun care and daily wear SPF products containing UV active ingredients. SunSpheres Powder is recommended for use in inverse (water-in-oil) emulsions.

- UVA/UVB sunscreens
- Sunscreens with inorganic and/or organic actives
- Water-resistant sunscreens
- Cosmetic products containing sunscreen actives:
 - Makeup creams and lotions
 - Hand and face creams and lotions
 - Alpha hydroxy acid creams and lotions
 - Medicated and moisturizing creams
 - Leave-on cosmetic products

Typical Properties

These properties are typical but do not constitute specifications.

	SunSpheres LCG (Not available in Europe)	SunSpheres Powder
Appearance	Milky, white liquid	White powder
Active, Percent	27	88 – 90
Solvent	Water	Not applicable
pH (1% dispersion in water)	6.5 – 7.5	10.0 – 11.0
Specific Gravity	1.0 – 1.1	Not applicable
Bulk Density	Not applicable	0.22 – 0.32
Viscosity	< 100 cps (Brookfield, LVT#2, 60 rpm)	Not applicable
Residuals		
Total Acrylates	<100 ppm	<100 ppm
Styrene	<35 ppm	<35 ppm

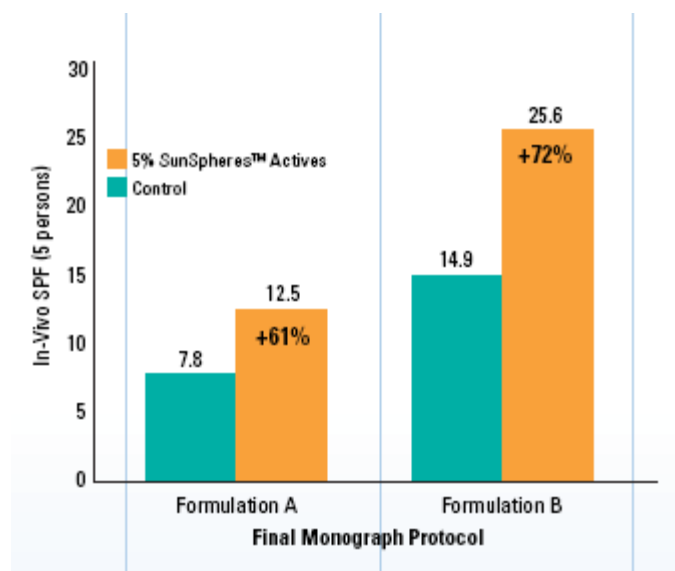
Performance in Typical Formulations

Proven Performance

To test the efficacy of SunSpheres SPF Boosters in personal care applications, two different sunscreen formulas were prepared and evaluated in vivo. As shown in the graph below, even in these non-optimized systems, 5% solids of the SunSpheres SPF Booster clearly increases SPF by 60 to 70 percent.

Physical stability was also monitored weekly for three months, yielding a stable product and a stable boost.

Screening Formulations: In Vivo Results



Formulation A is a relatively simple formulation containing low oil and utilizing an anionic emulsion system. The expected SPF of this formulation is 8. Sunscreen Formulation B is a more complex formulation with a nonionic emulsifier and an expected SPF of approximately 15. Neither of these formulas was designed to optimize the performance of the SunSpheres SPF Booster. They were chosen based on their proven stability under the desired testing conditions.

Both screening formulations were tested for static SPF using the in vivo protocol specified in the Food and Drug Administration's (FDA) Final OTC Monograph (21 CFR Parts 310, 352, 700 and 740, May 21, 1999). Each sunscreen contained 5% solids SunSpheres SPF Booster.

Sunscreen Formulation A with 6% Ethylhexyl methoxycinnamate and 1% Benzophenone 3

Phase	Ingredients	Control %w/w	Test %w/w
A	Water, DI	80.72	62.22
A	Aculyn 33 Rheology Modifier	3.33	3.33
A	Glycerin	1.00	1.00
A	Tetrasodium EDTA	0.10	0.10
A	SunSpheres LCG	0.00	18.50
B	Ethylhexyl methoxycinnamate	6.00	6.00
B	Benzophenone 3	1.00	1.00
B	C12–15 alkyl lactate	2.00	2.00
B	PVP/eicosene copolymer	1.50	1.50
B	Cyclomethicone	2.00	2.00
B	Stearic acid	1.50	1.50
C	Triethanolamine	0.85	0.85

Sunscreen Formulation B with 7.5% Ethylhexyl methoxycinnamate, 2% Benzophenone 3 and 3% Ethylhexyl salicylate

Phase	Ingredients	Control %w/w	Test %w/w
A	Water, DI	71.70	53.20
A	PVM/MA decadiene crosspolymer	0.50	0.50
A	Butylene glycol	3.00	3.00
A	SunSpheres LCG	0.00	18.50
B	PEG-20 stearate	1.50	1.50
B	Glyceryl stearate & laureth-23	2.00	2.00
B	Octyldodecyl neopentanoate	1.00	1.00
B	Ethylhexyl palmitate	2.00	2.00
B	Glyceryl dilaurate	0.50	0.50
B	Ethylhexyl methoxycinnamate	7.50	7.50
B	Benzophenone 3	2.00	2.00
B	Ethylhexyl salicylate	3.00	3.00
C	Sodium hydroxide, 10%	1.30	1.30
C	Glyceryl polymethacrylate & propylene glycol	3.00	3.00
C	Glyceryl polymethacrylate & propylene glycol & PVM/MA copolymer	0.50	0.50
D	Diazolidinyl urea & iodopropynyl butylcarbamate	0.30	0.30
D	Methylparaben	0.20	0.20

Recommended Use Levels

Generally, the UV absorption capacity of a formulation will increase with increasing concentrations of SunSpheres

SPF Boosters. However, we recommend that during formulation development, different levels of SunSpheres SPF Booster be screened to ensure maximum and efficient SPF boost. Maximum use level is recommended at 5% solids, which is 18.5% SunSpheres LCG or 5.5% SunSpheres Powder.

Compatibility with Sunscreen and Cosmetic Ingredients

The SunSpheres polymer has been evaluated with a variety of typical cosmetic ingredients. Based on the results of these studies, it appears the SunSpheres hollow spheres have broad compatibility with most ingredients used for personal care products with only a few exceptions. In general, cationic ingredients should be avoided because the polymeric shell of the SunSpheres polymer has a slight anionic charge that could interact with cationics. Associative rheology modifiers/thickeners should be tested individually for viscosity effects. Extraordinary viscosity increases have been observed with some associative thickeners. Adipates are known to be aggressive plasticizers for many polymers, and therefore it is recommended that SunSpheres SPF Boosters not be used in formulations containing these ingredients.

Compatibility

SunSpheres SPF Boosters are compatible with a wide range of ingredients, including:

Sunscreen Active Ingredients

Organic Actives

- Ethylhexyl methoxycinnamate
- Octocrylene
- Ethylhexyl salicylate
- Phenylbenzimidazole sulfonic acid
- Benzophenone 3
- 4-Methylbenzylidene camphor
- Butyl methoxydibenzoylmethane
- Octyl triazone

Inorganic Actives

- Titanium dioxide
- Zinc oxide

Emollients

Silicones

- Cyclomethicone
- Dimethicone

Oils

- Mineral oil
- Sunflower seed oil

Esters

- C12–15 Alkyl benzoate
- C12–15 Alkyl lactate
- Octyl palmitate
- Isopropyl myristate
- Laureth-2 octanoate
- Isostearyl isostearate
- Octyldodecyl neopentanoate

Other Ingredients

Emulsifiers

- Anionic
- Nonionic

Thickeners

- Gums
- Stabileze®
- Carbomers
- Aculyn Rheology Modifiers

Insect Repellent

- DEET

Water-resistance Agents

- Soltex™ OPT
- Waterproofing Polymers

Incorporating SunSpheres SPF Boosters into Formulations

SunSpheres LCG

SunSpheres LCG is best incorporated into a formulation by dispersing it in the aqueous phase prior to emulsification. It is generally recommended to add the SunSpheres LCG into the water after dissolution of any water soluble solids. SunSpheres LCG can also be incorporated into a formulation during the cool down stage of the emulsion as long as the viscosity of the product is not too high (>30,000 cps). SunSpheres LCG is the recommended form for cold processing.

SunSpheres Powder

SunSpheres Powder requires appropriate equipment for handling, as this is a low density solid. Avoid inhalation when handling.

Incorporate SunSpheres Powder either in the aqueous phase or oil phase prior to emulsion formation.

SunSpheres Powder is in the form of an agglomerate, with a mean particle size of about 100 microns. These agglomerates are less dusty than a non-agglomerated equivalent. However, they must be broken down in the final formulation to liberate the primary SunSpheres™ SPF Booster particles. If this step is not performed, the expected performance boost will not be achieved. In addition, a granular appearance will be observed in the formulation, and the emulsion may feel “gritty” to the touch.

In order to break down the agglomerates, a high shear process is recommended. This can be performed using a homogenizer. Homogenization can be run on the aqueous dispersion of SunSpheres Powder before forming the emulsion. This dispersion is facilitated by heating to at least 50°C. Due to the high shear, it is possible foaming may be an issue. In this case, a small part of the non-aqueous phase such as mineral oils or esters, can be added to the blend to alleviate the problem. If low levels of silicones are a component of the formulation, these can also be employed. Propylene glycol appears to assist in the aqueous dispersion of the powder during homogenization.

An alternative means of dispersing SunSpheres Powder and breaking down the agglomerates is by dispersing them in water and then recycling the dispersion through a centrifugal pump.

If the formulation is a low viscosity emulsion (<1000 cps), incorporation of SunSpheres Powder with homogenization can occur at the end of the processing with the biocide. However, uniform dispersion of the powder in very viscous creams may be a problem.

When formulating with silicones, it is recommended that SunSpheres Powder (see “Storage and Handling” before

use) be blended into an oil phase containing aliphatic oils, but in the absence of silicones, because flocculation of the SunSpheres Powder can occur. In such a system, either add the SunSpheres polymer into the water phase, or if dispersed in the organic phase, prepare the emulsion, and post add the silicones.

Formulations

The following formulations are provided as starting recommendations for a variety of sunscreen and daily wear product types.

Sunscreen Formulation with 5% Titanium Dioxide

Phase	Ingredients	Control %w/w	Test %w/w
A	Water, DI	74.50	63.39
A	Glycerin	2.00	2.00
A	Tetrasodium EDTA	0.10	0.10
B	Titanium dioxide & isononyl isononanoate & polyglyceryl-6 polyricinoleate & stearic acid & aluminum hydroxide	10.00	10.00
B	Stearyl alcohol & cetareth-20	1.00	1.00
B	PEG-20 stearate	0.50	0.50
B	C12-15 alkyl benzoate	3.00	3.00
B	Ethylhexyl palmitate	3.00	3.00
B	Sorbitan oleate	1.00	1.00
B	Dimethicone	1.00	1.00
B	Stearic acid	1.50	1.50
C	Triethanolamine	0.40	0.40
D	Aculyn 44 Rheology Modifier	2.00	2.00
D	SunSpheres LCG	0.00	11.11

Procedure:

1. Combine the ingredients of phase A and with mixing, heat to 75°C.
2. Combine the ingredients of phase B separately and heat to 75°C with mixing.
3. Add phase B to phase A with homogenization at 75 – 80°C.
4. Switch to sweep mixing. Add phase C.
5. Begin to cool with mixing.
6. Add phase D individually with mixing.
7. Cool to room temperature with continual mixing.

An in vivo SPF test was conducted as specified in the Food and Drug Administration's (FDA) Final OTC Monograph (21 CFR Parts 310, 352, 700, and 740, May 21, 1999) protocol on a five person panel. The control formulation yielded an in vivo SPF value of 11, while the formulation with SunSpheres LCG had an in vivo SPF of 17. This is a 35% boost for 3% solids of the polymer.

Water-Resistant Sunscreen Formulation

Phase	Ingredients	Control %w/w	Test %w/w
A	Water, DI	67.85	49.35
A	Magnesium aluminum silicate	1.00	1.00
A	Carboxymethyl cellulose	0.50	0.50
A	Butylene glycol	3.00	3.00
A	Disodium EDTA	0.10	0.10
A	Glyceryl polymethacrylate & propylene glycol & PVM/MA copolymer	0.75	0.75
B	Glyceryl stearate & behenyl alcohol &	4.00	4.00

palmitic acid & stearic acid & lecithin &
lauryl alcohol & myristyl alcohol & cetyl
alcohol

B	PVP/eicosene copolymer	1.00	1.00
B	Ethylhexyl palmitate	2.00	2.00
B	Ethylhexyl methoxycinnamate	7.50	7.50
B	Ethylhexyl salicylate	3.00	3.00
B	Benzophenone 3	2.00	2.00
B	Tridecyl neopentanoate	3.00	3.00
B	Glyceryl dilaurate	0.50	0.50
B	Phenyl trimethicone	0.30	0.30
B	Cyclomethicone	3.00	3.00
C	Diazolidinyl urea & Iodopropynyl butylcarbamate	0.30	0.30
C	Methylparaben	0.20	0.20
D	SunSpheres LCG	0.00	18.50

Procedure:

1. Combine the ingredients of phase A and with mixing, heat to 75°C.
2. Combine the ingredients of phase B separately and heat to 75°C with mixing.
3. Add phase B to phase A with homogenization at 75 – 80°C.
4. Switch to sweep mixing and begin to cool.
5. At 45°C add phase C individually with mixing.
6. Add phase D with mixing.
7. Cool to room temperature with continual mixing.

SunSpheres hollow spheres have minimal-to-no effect on the water resistance of water-resistant formulations. The test was conducted as specified in the Food and Drug Administration's (FDA) Final OTC Monograph (21 CFR Parts 310, 352, 700, and 740, May 21, 1999) protocol for determination of water resistance on a five person panel. The control, as expected, was determined to have an in vivo SPF of 17.4 prior to immersion and an in vivo SPF of 17.1 post-immersion. The sunscreen formulation containing SunSpheres LCG gave a pre-immersion in vivo SPF of 27.6 (59% boost over control) and a post-immersion in vivo SPF result of 25.5, a 49% boost over the post-immersion control.

Water-in-Oil Sunscreen Formulation Containing Zinc Oxide and Titanium Dioxide

Phase	Ingredients	Control %w/w	Test %w/w
A	Polyglyceryl-4 isostearate & cetyl PEG/PPG 10/1 dimethicone & hexyl laurate	5.00	5.00
A	Dipentaerythrityl hexacaprylate/hexacaprate & tridecyl trimellitate & tridecyl stearate & neopentyl glycol dicaprylate/dicaprate	11.00	11.00
A	Cyclomethicone	7.50	7.50
A	Cetyl dimethicone	3.00	3.00
A	Methyl glucose distearate	0.50	0.50
A	Diethylhexyl malate	2.00	2.00
B	Zinc oxide	6.00	6.00
C	Titanium dioxide	6.00	6.00
D	SunSpheres Powder	0.00	5.00
E	Water, DI	55.70	50.70
E	Aculyn 44 Rheology Modifier	2.50	2.50
F	Sodium chloride	0.50	0.50
G	Neolone 950 Preservative	0.10	0.10
G	Methylparaben	0.20	0.20

Procedure:

1. Combine the ingredients of phase A and with mixing, heat to 75°C.
2. Add phase B to phase A with homogenization at 75 – 80°C.
3. Add phase C to phase A/B with homogenization at 75 – 80°C.
4. Add phase D to phase A/B/C with homogenization at 75 – 80°C. Homogenize for 7-10 minutes.
5. Switch to sweep mixing and begin to cool.
6. Premix phase E. Add phase F to phase E.
7. Add phase E/F to A/B/C/D with mixing.
8. Begin to cool to 45°C. Add phase G with mixing.
9. Cool to room temperature with continual mixing.

An in vivo SPF test was conducted as specified in the Food and Drug Administration’s (FDA) Final OTC Monograph (21 CFR Parts 310, 352, 700, and 740, May 21, 1999) protocol on a five person panel. The control formulation yielded an in vivo SPF value of 21.4, while the formulation with SunSpheres Powder had an in vivo SPF of 32.8. This is a 53% boost for 4.5% solids of the polymer

Nonaqueous Sunscreen Stick Formulation

Phase	Ingredients	Control %w/w	Test % w/w
A	Mineral oil	38.00	34.67
A	Ozokerite	18.00	18.00
A	Paraffin	14.00	14.00
A	Octocrylene	8.00	8.00
A	Ethylhexyl methoxycinnamate	7.50	7.50
A	Benzophenone 3	5.50	5.50
A	Ethylhexyl salicylate	2.00	2.00
A	Euphorbia Cerifera (Candelilla) Wax	5.00	5.00
B	Zinc oxide	2.00	2.00
B	SunSpheres Powder	0.00	3.33

Procedure:

1. Combine the ingredients of phase A and with mixing, heat to 90°C.
2. At 90°C, add the zinc oxide and SunSpheres Powder.
3. Homogenize for 7 – 10 minutes.
4. Pour into molds and cool quickly.

An in vivo SPF test was conducted as specified in the Food and Drug Administration’s (FDA) Final OTC Monograph (21 CFR Parts 310, 352, 700, and 740, May 21, 1999) protocol on a five person panel. The control formulation yielded an in vivo SPF value of 45.6, while the formulation with SunSpheres Powder had an in vivo SPF of 57.3. This is a 26% boost for 3% solids of the polymer.

An in vivo test for water resistance was also measured on a twenty person panel with this formulation. The in vivo SPF was measured at 55.5 post-immersion.

SPF 30 Water-Resistant Spray Sunscreen Formulation

Phase	Ingredients	Test %w/w
A	Water, DI	52.77
A	Aculyn 33 Rheology Modifier	1.25
A	Hexylene glycol	3.00
A	Tetrasodium EDTA	0.10
B	Steareth-2	2.25
B	Steareth-21	0.75

B	Tridecyl neopentanoate	3.00
B	Ethylhexyl palmitate	1.00
B	Triconyl PVP	1.00
B	Cyclomethicone	4.00
B	Ethylhexyl methoxycinnamate	7.50
B	Ethylhexyl salicylate	5.00
B	Benzophenone 3	4.00
B	SunSpheres Powder	5.00
B	Glyceryl polymethacrylate & propylene glycol & PVM/MA copolymer	1.00
C	Water	5.00
C	Sodium hydroxide, 10%	0.64
D	Neolone MxP Preservative	0.67
E	Soltex™ OPT Waterproofing Polymer	2.07

Procedure:

1. Combine the ingredients of phase A and with mixing, heat to 75°C.
2. Combine the ingredients of phase B separately and heat to 75°C with mixing.
3. Add phase B to phase A with homogenization at 75 – 80°C.
4. Homogenize for 7 – 10 minutes.
5. Switch to sweep mixing.
6. Premix phase C. Add to phase A/B and begin to cool.
7. At 40°C, add phase D with mixing.
8. Add phase E with mixing.
9. Cool to room temperature with continual mixing.

Emulsifier Free Daily Wear Formulation with Sunscreen

Phase	Ingredients	Test %w/w
A	Water, DI	66.05
A	Aculyn 33 Rheology Modifier	2.00
A	Aculyn 88 Rheology Modifier	3.00
A	Propylene glycol	3.00
A	Disodium EDTA	0.10
B	Isopropyl isostearate	2.00
B	Triethylhexanoin	4.00
B	Isopropyl myristate	2.00
B	Cyclomethicone	1.00
B	PCA dimethicone	1.50
B	Tocopheryl acetate	0.10
B	Ethylhexyl methoxycinnamate	7.50
B	Butyl methoxydibenzoylmethane	3.00
B	SunSpheres Powder	3.00
C	Sodium hydroxide, 10%	1.15
D	Neolone MxP Preservative	0.50
E	Fragrance	0.10

Procedure:

1. Combine the ingredients of phase A and with mixing, heat to 75°C.
2. Combine the ingredients of phase B separately and heat to 75°C with mixing.
3. Add phase B to phase A with homogenization at 75 – 80°C.

4. Homogenize for 7 – 10 minutes.
5. Switch to sweep mixing.
6. Add phase C to phase A/B and begin to cool.
7. At 45°C add phase D with mixing.
8. Add phase E with mixing.
9. Cool to room temperature with continual mixing.

An in vivo test yielded an SPF of 18.8 on a five person panel test. SunSpheres technology has also proven to be effective in providing additional benefits to other cosmetic and personal care formulations containing UV actives in addition to the boost. In this daily wear formulation, which is also emulsifier free due to the use of the Aculyn Rheology Modifiers, the SunSpheres Powder provides a silky feel on the skin, after the film is allowed to dry.

Environmental, Health and Safety Profile

Regulatory Status

In the United States, the SunSpheres SPF Booster is inert by definition, does not impart SPF at levels up to 6% solids, and is therefore not regulated as a sunscreen ingredient. In Europe, the SunSpheres polymer is acceptable for use in EINECS countries because all monomers in the SunSpheres polymer are registered.

In Japan, the use of the SunSpheres SPF Boosters are permitted according to the 1998 CLS ingredient code 522011 (“Alkyl Acrylate-Styrene Copolymer Emulsion”). In Australia, the SunSpheres polymer is NICNAS listed.

Toxicology

SunSpheres technology is considered non-toxic by single oral and dermal exposure, produces minimal-to-no irritation to the eyes and skin, is a non-sensitizer and non-irritating to humans, non-mutagenic in the Ames assay, and non-toxic to aquatic organisms. This material is safe and appropriate for use in a broad range of rinse-off and leave-on personal care applications.

Acute Toxicity Profile

Test/Species	Results
Oral LD ₅₀ – rat	>5 g/kg – non toxic
Dermal LD ₅₀ – rabbit	>5 g/kg – non toxic
Eye irritation (liquid) – rabbit	Non irritating (US and EEC)
Eye irritation (powder) – rabbit	Slightly irritating (US) Non irritating (EEC)
Skin irritation – rabbit	Slightly irritating (US), Non irritating (EEC)
Inhalation (powder)	>5.3 mg/L – non toxic
<i>US – United States classification</i>	
<i>EEC – European Economic Community classification</i>	

Genetic Toxicity Profile

Test/Species	Results
Ames Test	Non mutagenic with and without metabolic activation

Human Toxicity Profile

Test/Species	Results
HRIPT	Non sensitizing and Non irritating

Environmental Fate

Test	Results
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Biodegradation Not readily biodegraded

Ecotoxicity Profile

Test/Species	Results
Algae EC50 – 72 hr	>100 ppm – non toxic
Daphnia Magna LC ₅₀ – 48 hr	>100 ppm – non toxic
Rainbow Trout LC ₅₀ – 96 hr	>100 ppm – non toxic

Storage and handling

No special conditions are required for the storage of SunSpheres Powder, but the material should be kept from humidity. When handling this product, take the usual precautions for dusty materials.

SunSpheres LCG polymer should be kept from freezing. The minimum recommended storage temperature for this material is 1°C/ 34°F. The maximum recommended storage temperature for SunSpheres LCG polymer is 49°C/120°F

Material Safety Data Sheets

Rohm and Haas Material Safety Data Sheets (MSDS) contain pertinent information that you may need to protect your employees and customers against any known health or safety hazards associated with our products. Under the OSHA Hazard Communication Standard, workers must have access to and understand MSDS on all hazardous substances to which they are exposed. Thus, it is important that you provide appropriate training and information to your employees and make sure they have available to them MSDS on any hazardous products in the workplace.

Upon initial shipment of non-OSHA-hazardous and OSHA-hazardous products (including samples), Rohm and Haas Company sends the appropriate MSDS to the recipient. If you do not have access to one of these MSDS, please contact your local Rohm and Haas representative for a copy. Updated MSDS are sent upon revision to all customers of record. MSDS are also sent annually to all customers receiving products deemed hazardous under the Superfund Amendments and Reauthorization Act (SARA). MSDS should be obtained from suppliers of other materials recommended in this bulletin.

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Material Safety Data Sheets outlining known health and safety hazards and handling methods for our products are available on request.

