

NEW **DISCOVERIES**

Explore new horizons for personal care products
with Earth-friendly Solstice® Enhance.

Solstice® Enhance

A woman with long dark hair in a ponytail, wearing a light purple t-shirt, stands with her arms outstretched, smiling and looking up towards the sun. The background is a blurred, sunlit landscape, possibly a valley or mountains, with a warm, golden glow from the sun. The overall mood is one of joy and connection with nature.

Honeywell

SOLSTICE® ENHANCE FOR PERSONAL CARE

It's time to discover new ways that we can all help preserve our planet without compromising on product performance. **Solstice Enhance** (HFO-1233zd(E)), a breakthrough solvent and carrier fluid, is ideal for face, body, hair, and sun care products. It offers exciting possibilities to develop unique products that your customers are seeking.

Based on our next-generation hydrofluoro-olefin (HFO) technology, Solstice Enhance can help reduce climate impact. With an Earth-friendly¹ ultra-low global warming potential (GWP) of one, it can be used as a multifunctional ingredient that can replace hydrofluorocarbons (HFCs), hydrocarbons, alcohols, menthols, cyclic silicones, and other ingredients. Not only does Solstice Enhance help keep your products ahead of changing environmental regulations, it provides exceptional formulating benefits such as:

- Nonflammable (ASTM E-681, EU A11) – an effective alternative to flammable ingredients, or to help reduce formulation flammability²

- Enables non-irritating instant cooling, fast drying, unique foaming action and new textures
- Can be used in combination with **Solstice® Propellant** and other ingredients to create novel recipes
- Can replace cyclic silicones, such as cyclopentasiloxanes (D5), which are under regulatory scrutiny in Europe. It can be used in formulations when blended with natural oils and other cosmetic oils.
- Soluble with a wide range of personal care ingredients
- Excellent surface wetting and spreadability

Additional environmental benefits include:

- Ultra-low GWP = 1 – reduces carbon dioxide equivalent emissions by 99.9% compared to hydrofluorocarbons (HFCs)
- Non-ozone-depleting
- VOC-exempt (per U.S. EPA) – pending CARB VOC-exemption approval
- Negligible contribution to smog formation

This brochure provides technical information about Solstice Enhance including its physical properties, environmental attributes, exposure guidelines, and other important features. The information provided is but some of a mosaic of properties that must be evaluated in assessing candidate ingredients.



Table 1. Physical Property Summary

| PROPERTIES | VALUES |
|--|--|
| Chemical Family | HFO -1233zd(E), 1233zd(E), trans-1233zd |
| INCI | Chlorotrifluoropropene |
| Formula | Trans-1-chloro-3,3,3- trifluoropropene Trans CF ₃ -CH=CClH |
| Molecular Weight | 130.5 g/mol |
| Appearance | Colorless |
| Boiling Point | 19°C (66°F) |
| Latent Heat of Vaporization at Boiling | 192 kJ/kg (82.5 BTU/lb) |
| Freezing Point | -107°C (-161°F) |
| Vapor Pressure at 25°C (77°F) | 0.30 bar g (4.11 psig) |
| Liquid Density at 25°C (77°F) | 1.26 g/ml (78.8 lb/ft ³) |
| Surface Tension at 25°C (77°F) | 12.7 dyne/cm |
| Solubility of Water in Solvent at 25°C (77°F) | 460 ppm |
| Hansen Solubility Parameters | |
| - Dispersion | 15.5 |
| - Hydrogen Bonding | 2.2 |
| - Polarity | 4.8 |
| Kb (Kauri-butanol) Value | 25 |
| Stable pH Range³ (evaluated range) | 3.5 – 11.7 |

Figure 1. Vapor Pressure vs. Temperature (English Units)

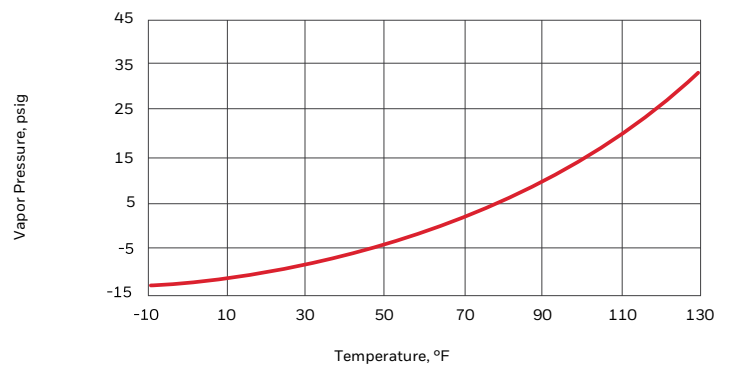


Figure 2. Vapor Pressure vs. Temperature (SI Units)

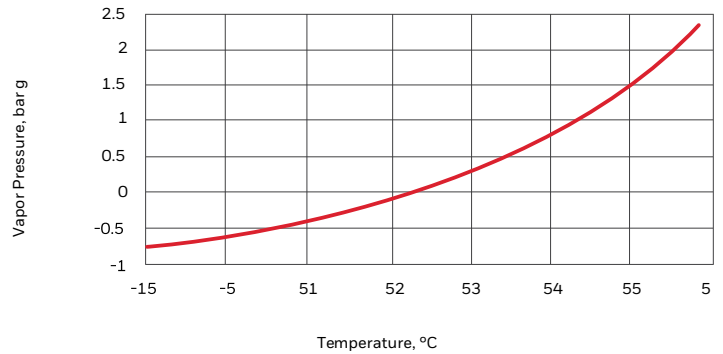


Table 2. Vapor Pressure and Liquid Density (English Units)

| °F | PSIG | LB/FT ³ | °F | PSIG | LB/FT ³ | °F | PSIG | LB/FT ³ |
|----|-------|--------------------|-----|------|--------------------|-----|------|--------------------|
| 0 | -11.7 | 85.0 | 45 | -5.2 | 81.5 | 90 | 9.5 | 77.7 |
| 5 | -11.3 | 84.6 | 50 | -4.1 | 81.1 | 95 | 11.9 | 77.3 |
| 10 | -10.9 | 84.2 | 55 | -2.8 | 80.6 | 100 | 14.4 | 76.9 |
| 15 | -10.2 | 83.8 | 60 | -1.5 | 80.2 | 105 | 17.1 | 76.4 |
| 20 | -9.6 | 83.4 | 66* | 0.0 | 79.8 | 110 | 20.0 | 76.0 |
| 25 | -8.9 | 83.0 | 70 | 1.6 | 79.4 | 115 | 23.1 | 75.5 |
| 30 | -8.1 | 82.6 | 75 | 3.4 | 79.0 | 120 | 26.5 | 75.1 |
| 35 | -7.2 | 82.2 | 80 | 5.3 | 78.6 | 125 | 30.0 | 74.6 |
| 40 | -6.3 | 81.9 | 85 | 7.3 | 78.2 | 130 | 33.8 | 74.2 |

*The boiling point of Solstice Enhance.

Table 3. Vapor Pressure and Liquid Density (SI Units)

| °C | BAR G | KG/M ³ | °C | BAR G | KG/M ³ | °C | BAR G | KG/M ³ |
|-----|-------|-------------------|-----|-------|-------------------|----|-------|-------------------|
| -15 | -0.77 | 1360 | 9 | -0.30 | 1301 | 33 | 0.71 | 1240 |
| -12 | -0.73 | 1350 | 12 | -0.21 | 1290 | 36 | 0.89 | 1240 |
| -9 | -0.68 | 1340 | 15 | -0.11 | 1290 | 39 | 1.09 | 1230 |
| -6 | -0.64 | 1340 | 19* | 0.00 | 1280 | 42 | 1.30 | 1220 |
| -3 | -0.58 | 1330 | 21 | 0.12 | 1270 | 45 | 1.52 | 1210 |
| 0 | -0.52 | 1320 | 24 | 0.25 | 1270 | 48 | 1.76 | 1210 |
| 3 | -0.45 | 1320 | 27 | 0.39 | 1260 | 51 | 2.02 | 1200 |
| 6 | -0.38 | 1310 | 30 | 0.55 | 1250 | 54 | 2.30 | 1190 |

*The boiling point of Solstice Enhance.



FORMULATING FLEXIBILITY WITH SOLSTICE ENHANCE

Solstice Enhance is completely miscible with halogenated solvents, hydrocarbon solvents, alcohols, ketones, and commonly-used propellants. Because Solstice Enhance offers excellent solubility across a wide range of personal care ingredients, it provides unique formulation flexibility and latitude (Table 4). Cooling gels, dry shampoos, cooling misting sprays, and self-foaming cleansers are just some of the innovative formulations being developed.

Table 4. Ingredient Solubility in Solstice Enhance⁴

| PROTIC SOLVENTS | 50% | 25% | 10% | ESTERS | 50% | 25% | 10% |
|------------------------------|-----|-----|-----|-------------------------------|-----|-----|-----|
| Ethanol | Y | Y | Y | C12-14 Alkyl Benzoate | Y | Y | Y |
| Glycerin | N | N | N | Neopentyl Glycol Diheptanoate | Y | Y | Y |
| 1,3 Butylene Glycol | N | N | N | Trioctyldodecyl Citrate | Y | Y | Y |
| Propanediol (Zemea) | N | N | N | Glycereth-7 Citrate | N | N | Y |
| Phenoxyethanol | Y | Y | Y | Triisocetyl Citrate | Y | Y | Y |
| ETHERS/POLYETHERS | | | | Octylhydroxystearate | Y | Y | Y |
| Dimethyl Isosorbide | Y | Y | Y | Diisopropyl Adipate | Y | Y | Y |
| Ethoxydiglycol | Y | Y | Y | Ethylhexyl Palmitate | Y | Y | Y |
| Polysorbate 20 | Y | Y | Y | HYDROCARBONS | | | |
| Laureth 4 | Y | Y | Y | Isododecane | Y | Y | Y |
| SUNSCREENS | | | | Hydrogenated Polyisobutene | Y | Y | Y |
| Octinoxate | Y | Y | Y | Squalane | Y | Y | Y |
| Octasalate | Y | Y | Y | SILICONES | | | |
| Octocrylene | Y | Y | Y | Dimethicone (350 cks) | Y | Y | Y |
| Homomenthyl Salicylate | Y | Y | Y | Dimethicone (0.65 cks) | Y | Y | Y |
| TRIGLYCERIDES | | | | Cyclopentasiloxane (DC 345) | Y | Y | Y |
| Caprylic/Capric Triglyceride | Y | Y | Y | Phenyl Trimethicone | Y | Y | Y |
| Olive Oil | Y | Y | Y | LIQUID FATTY ALCOHOLS | | | |
| Safflower Oil | Y | Y | Y | Octyl Dodecanol | Y | Y | Y |
| Soybean Oil | Y | Y | Y | OTHER | | | |
| | | | | Perfluorodecalin | Y | Y | Y |

MATERIALS COMPATIBILITY

Solstice Enhance is compatible with many commonly-used plastics (Table 5) and elastomers (Table 6). It is important to recognize that results may vary with different grades and manufacturers of the same polymer. Therefore, when evaluating a material for compatibility with Solstice Enhance, it is recommended that the manufacturer be consulted, or further independent testing be completed. Results shown should be used only as a guide.

Solstice Enhance is compatible with many commonly used metals. Halide analysis indicated no chemical breakdown, no degradation, rusting, or pitting observed for the metals tested (Table 7).

HIGH THERMAL AND HYDROLYTIC STABILITY

Laboratory tests indicate that Solstice Enhance has a high degree of thermal and hydrolytic stability. In sealed tube studies, the neat material was judged to be thermally stable after 2 weeks of exposure at 150°C (302°F). Additional sealed tube studies were conducted to evaluate both the thermal and hydrolytic stability of Solstice Enhance with metals and water. After 2 weeks of exposure at 150°C (302°F) in the presence of metals (3003 aluminum, copper, and / or 316 stainless steel), in the presence of water (at 300 ppm), and in the presence of metals and water, no chemical breakdown of Solstice Enhance was detected.

Cans: Solstice Enhance is compatible with typical aerosol packaging materials, such as tinplate cans and lined cans (Table 8).

Valves: Several aerosol valve manufacturers evaluated the compatibility of Solstice Enhance with valve seals. Aptar Pharma⁷ and Precision Global⁸ both reported good results with grades of buna and butyl rubber. Summit Packaging Systems developed bag-on-valve (BOV) compatibility data showing Solstice Enhance is compatible with 3-ply polyethylene (PE), 4-ply PE, and 4-ply polypropylene laminated BOV pouches.⁹ For assistance with valve selection, consultation with a supplier is recommended.

Table 5. Compatible with Commonly Used Plastics

| PLASTICS | AVERAGE PERCENTAGE CHANGE | | | |
|----------------|---------------------------|----------------------|-------------------|----------------------|
| | WEIGHT | | VOLUME | |
| | 2 weeks Rm. Temp. | 4 weeks 50°C (122°F) | 2 weeks Rm. Temp. | 4 weeks 50°C (122°F) |
| ABS | 3.6 | 38.7 | 3.6 | 27.8 |
| HDPE | 1.7 | 3.5 | 1.2 | 2.5 |
| HIPS | 23.3 | 25.4 | 83.1 | 45.3 |
| Nylon 66 | -0.1 | -0.3 | -0.1 | -1.8 |
| PEEK | -0.0 | N/A | -0.3 | N/A |
| PET | 0.1 | 0.2 | 0.0 | 0.5 |
| PET (bottle) | N/A | 1.6 | N/A | 1.5 |
| Polycarbonate | 3.5 | 13.7 | 3.0 | 8.7 |
| Polyetherimide | 0.0 | 0.5 | -0.5 | -0.5 |
| Polypropylene | 5.0 | 6.1 | 3.7 | 5.2 |
| PTFE | 2.1 | 2.7 | 3.9 | 3.5 |
| PVC-type 1 | 0.1 | 1.7 | 0.0 | 0.1 |
| PVDF | 0.1 | 0.9 | -0.3 | 0.9 |

This table summarizes a study in which polymer samples were fully immersed in Solstice Enhance for 2 weeks (room temp.) and 4 weeks (50°C / 122°F).

Table 6. Compatible with Commonly Used Elastomers

| ELASTOMERS | AVERAGE PERCENTAGE CHANGE | | |
|---------------------------------|---------------------------|--------|--------|
| | HARDNESS | WEIGHT | VOLUME |
| Buna N | +38 | -15 | -21 |
| Butyl Rubber | +8.9 | +1.2 | -2.4 |
| EPDM | +41 | -28 | -27 |
| Epichlorohydrin | -0.7 | +0.3 | -0.5 |
| Fluoroelastomer ⁵ | -6.2 | +5.6 | +8.6 |
| Neoprene | +4.4 | +1.0 | +0.3 |
| Perfluoroelastomer ⁶ | -10 | +7 | +11 |
| SBR/CR/NBR | +26 | -19 | -29 |
| Silicone | -1.4 | -4.1 | -5.9 |
| Thermoplastic PU | -2.2 | +8.6 | +6.9 |

This table summarizes a study in which polymer samples were fully immersed in Solstice Enhance for 2 weeks (room temp.).

Table 7. List of Compatible Metals

| | |
|---------------------|---------------------------|
| Stainless steel 304 | Aluminum |
| Cold rolled steel | Titanium |
| Galvanized steel | Magnesium/ Aluminum alloy |
| Copper | |

For this study, metal coupons were immersed in Solstice Enhance containing 2,000 ppm water and refluxed for 1 week.

Table 8. Compatible with Common Aerosol Packaging Materials

| LINER MATERIAL | SUPPLIER | STORAGE TIME @ 40°C / 104°F | RESULTS |
|----------------|--------------|-----------------------------|------------|
| PET | DS Container | 19 months | Compatible |
| Epoxy | Exal | 1 year | Compatible |
| PAM | Exal | 1 year | Compatible |

Lined aerosol cans containing Solstice Enhance were monitored during aging at 40°C (104°F) for changes in liner appearance, acidity, and non-volatile residue. Results demonstrated good compatibility.

ENVIRONMENTAL, HEALTH, AND SAFETY

Solstice Enhance is nonflammable (ASTM E-681, EU A11), non-ozone-depleting (ODP ~0), and has an ultra-low global warming potential (GWP=1). Unlike hydrocarbons, Solstice Enhance is not a volatile organic compound (VOC). Due to its low Maximum Incremental Reactivity (MIR), it does not contribute to smog or create ground level ozone. Solstice Enhance exhibits no flash point at 21°C (70°F). Also, no vapor flame limits were observed up to 100°C (212°F), the highest temperature tested by Honeywell.

The results of extensive toxicity testing support the conclusion that Solstice Enhance exhibits a very low order of toxicity. Accordingly, the Occupational Alliance on Risk Science (OARS) committee has assigned a Workplace Environmental Exposure Limit (WEEL) of 800 ppm (8-hour time-weighted average).¹⁰

Solstice Enhance has a low environmental half-life (26 days atmospheric lifetime). The final decomposition products are not new and at levels much lower than naturally present. These decomposition products are then rained out and mineralized with no additional effect on ozone or on climate¹¹. During decomposition, no trifluoroacetic acid (TFA) is formed.¹²

SAFE USE AND HANDLING

Before handling or using Solstice Enhance, Honeywell recommends carefully reviewing the information in the Safety Data Sheet (SDS). The SDS may be viewed online at the Honeywell SDS Resource Center:

www.honeywellmsds.com. Copies of the SDS may also be obtained by contacting Honeywell at **1-800-631-8138** within the U.S. and Canada, or by contacting the local Honeywell sales office.

Solstice Enhance is supplied in cylinders that meet U.S. Department of Transportation (DOT) requirements and comply with all applicable codes

Table 9. Environmental and Safety Aspects

| ASPECT | VALUE |
|---------------------------------|------------|
| Vapor Flame Limits (ASTM E-681) | None |
| Flash Point (ASTM D3278) | None |
| VOC (U.S. EPA) | Exempt |
| REACH | Registered |
| WEEL | 800 ppm |
| ODP | ~0 |
| GWP (100 yr.) ¹ | 1.0 |



and regulations for the regions in which they are transported. The material should be stored at room temperature (>24°C / 75°F) to allow for easy liquid dispensing, and in a well-ventilated area.

Solstice Enhance can be handled as a liquid during formulation work and laboratory studies. Although its boiling point is just below room temperature (19°C / 66°F), it has a high heat of vaporization so it does not instantly vaporize at room temperature. This allows ample time to formulate and work with the product.

The 10-lb. sample cylinder outlet has a CGA 165 fitting which accepts a standard 1/4" S.A.E. 45° flare connector. This is a common refrigeration fitting.

Connect the fitting/tubing assembly to the red liquid valve outlet. Liquid should flow freely when the valve is opened. You can collect the liquid in a pressure-resistant, sealable glass container for convenient handling. If you find there is not enough pressure in the cylinder to dispense the liquid, you can invert the cylinder and dispense liquid through the blue vapor valve.

When not in use, store Solstice Enhance in a clearly labelled, pressure-resistant, sealable container in a refrigerator (not used for food). This helps to lower pressure inside the container. For additional information on safe use and handling of Solstice Enhance, please consult a Honeywell Technical Service Representative.

REFERENCES

1. Ultra-low Global Warming Potential = 1: Intergovernmental Panel on Climate Change (IPCC), Appendix 8A, pg. 731: http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf
2. Your specific formulation incorporating Solstice Enhance would require flash point or other flammability testing to confirm it is nonflammable
3. Samples of Solstice Enhance ranging from pH = 3.5 - 11.7 were aged for 10 days at 40°C (104°F). Solstice Enhance remained stable at all pH levels as evidenced by very low fluoride ion concentration, < 10 ppm. Fluoride ion concentrations reaching levels of 150-200 ppm can indicate HFO breakdown, which would warrant further investigation.
4. Solstice Enhance as a solute at various wt.%
5. Used in test: "Viton B" Registered trademark of The Chemours Company
6. Used in test: "Kalrez 6375" Registered trademark of DuPont
7. Details of study methodology and results are available from Aptar Pharma
8. Details of study methodology and results are available from Precision Global
9. Details of study methodology and results are available from Summit Packaging Systems
10. Occupational Alliance on Risk Science (OARS) committee: <https://www.tera.org/OARS/WEELS/1233zdE%20HCFO%20OARS%20WEEL%20FINAL.pdf>
11. Published work from Jet Propulsion Lab at Caltech and University of Copenhagen : Phys. Chem. Chem. Phys. 2012, 14, 1735-1748
12. Recent modeling suggest that HFO-1233zd can theoretically yield an indirect contribution of up to 2 %, but experiments were unable to detect any TFA formed

For more information

Visit: <http://hwll.co/PersonalCare>

Call: 1-800-631-8138 (U.S. and
Canada) or your local sales office

Honeywell Advanced Materials

115 Tabor Road
Morris Plains, NJ 07950

Although Honeywell International Inc. believes that the information contained herein is accurate and reliable, it is presented without guarantee or responsibility of any kind and does not constitute any representation or warranty of Honeywell International Inc., either expressed or implied. A number of factors may affect the performance of any products used in conjunction with user's materials, such as other raw materials, application, formulation, environmental factors and manufacturing conditions among others, all of which must be taken into account by the user in producing or using the products. The user should not assume that all necessary data for the proper evaluation of these products are contained herein. Information provided herein does not relieve the user from the responsibility of carrying out its own tests and experiments, and the user assumes all risks and liabilities (including, but not limited to, risks relating to results, patent infringement, regulatory compliance and health, safety and environment) related to the use of the products and/or information contained herein.



7672_ New Discoveries | 06/20
© 2020 Honeywell International Inc.

Honeywell