



March 2017

Solstice® Enhance
Solstice® Propellant
Enabling New and Exciting Solutions

Honeywell
THE POWER OF **CONNECTED**

Enabling New Solutions in Personal Care

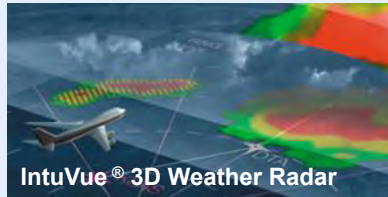
- Globally accepted next-generation patented ultra-low global warming potential (GWP) technologies
 - **Solstice[®] Enhance** is a beauty co-solvent, carrier fluid that offers multiple formulation possibilities, due to an excellent solubility profile, creates unique cooling and foaming products and provides superior surface wetting
 - **Solstice Propellant** is globally accepted, non-VOC, nonflammable liquid propellant with characteristics ideal for personal care.
- Honeywell is dedicated to bringing commercial scale volumes of these technologies to market
- Dedicated technical resources to help customers convert formulations, and support developing new and exciting ideas

Honeywell Overview

NYSE: HON | ~1,300 sites | ~131,000 employees | Morris Plains, N.J. headquarters | Fortune 100

Aerospace

\$14.8B
Sales



IntuVue® 3D Weather Radar

Unmatched Scope of Offerings

- Mechanical, Cockpit, and Software Offerings From Nose to Tail
- Apps, Services, Maintenance, Subscriptions
- End-to-End Connectivity Solutions From Hardware to Airtime
- Turbochargers for Fuel Efficiency

Home and Building Technologies

\$10.7B
Sales



evohome

Connecting Homes and Buildings

- Security and Fire
- Connecting Homes With Lyric™
- Open Software Connecting “Internet Of Things” in Buildings

Performance Materials and Technologies

\$9.3B
Sales



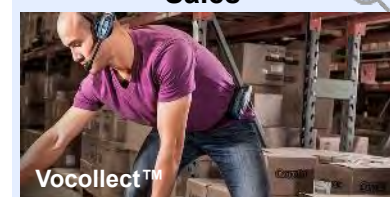
Experion® Orion Console

Winning Technology

- Refining and Petrochemical Catalysts
- Gas Processing Modular Offerings
- Solstice LGWP Materials
- SmartLine Transmitters
- Asset Optimization Software

Safety and Productivity Solutions

\$4.6B
Sales



Vocollect™

Connecting Workers

- Wireless, Voice, Mobility, Data Analytic Solutions for Workers
- Warehouse Automation
- Keeping Workers Safe

Reflects 2016 Full Year Results

Honeywell Confidential © 2017 by Honeywell International Inc. All rights reserved.

Aligned to Key Global Macro Trends

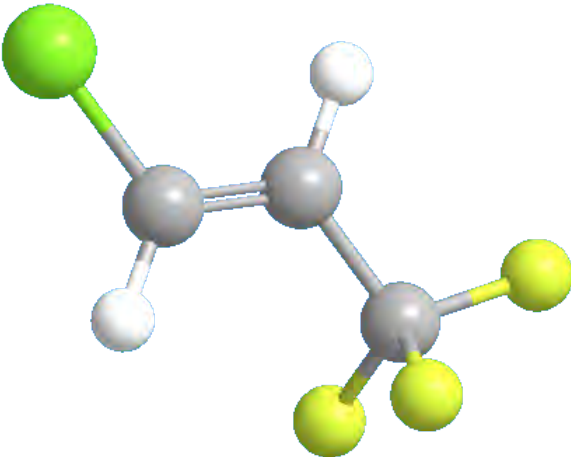
Generations of Fluorine Products

1930s – 1990s	1990s	2000s	2010s
	1987 Montreal Protocol Ozone Depletion Concerns		1996 Kyoto Protocol Global Warming Concerns
	2011 EU MAC Vehicle Refrigerant GWP < 150		
CFCs Chlorofluorocarbons	HCFCs Hydrochlorofluorocarbons	HFCs Hydrofluorocarbons	HFOs Hydrofluoroolefins
Ozone Depleting ●	●	●	●
ODP 1.0	ODP 0.1	ODP 0	ODP 0
Global Warming ●	●	●	●
GWP 8000+	GWP 2000+	GWP 1000+	GWP ≤ 1
Honeywell Products	Genetron®		Solstice
		Genetron Enovate®	

ODP Ozone Depletion Potential is relative amount of ozone degradation compared with R11 ODP = 1.0



Solstice Enhance



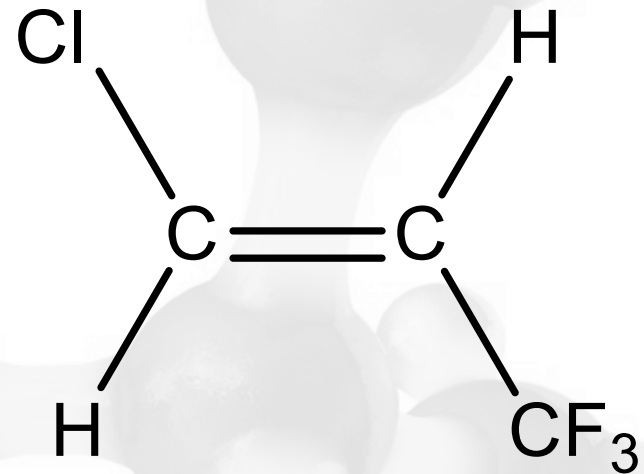
Solstice Enhance

Honeywell's Solstice Enhance is nonflammable, has an ultra-low GWP and favorable toxicity properties. It can be used as a solvent or carrier fluid.

- Improved safety (flame suppressant)
- Meets and exceeds government regulations
- **Superior performance** with flexible compatibility
- Faint to no odor

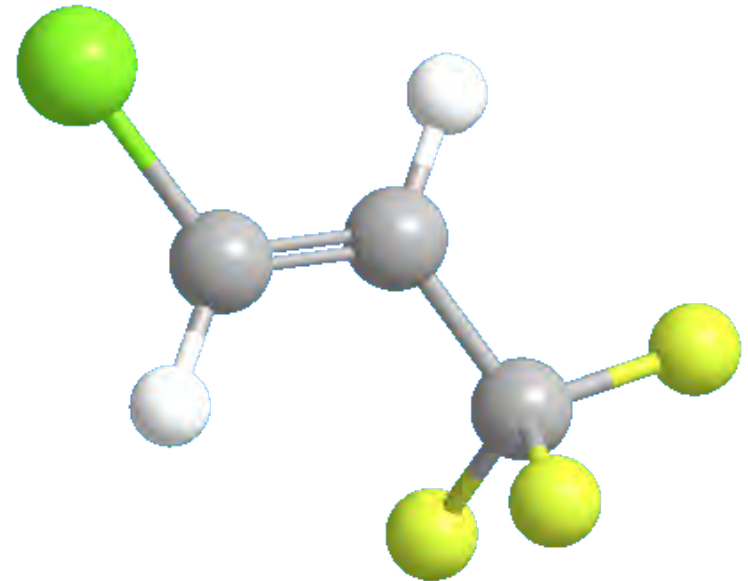
Nomenclature

- INCI - Chlorotrifluoropropene
- Trans-1-chloro-3,3,3-trifluoropropene
- 1-chloro-3,3,3-trifluoroprop-1-ene,(E)
- HFO-1233zd(E)



Solstice Enhance – Key Properties

Property	Solstice Enhance
Molecular Weight	130
Boiling Point (°F)	66 (19°C)
Heat of Vaporization (BTU/lb) at NBP	83.4
Vapor Pressure (PSIG @ 70°F (21°C))	1.4
Liquid Density (g/cc @ 70°F (21°C))	1.3
Flash Point/Vapor Flame Limits	NONE
KB Value	25
Surface Tension (dynes/cm), 25°C	12.7
Atmospheric Life	26 days
ODP	~0
GWP100	1
Flammable	No
VOC	No
Color	Colorless
Odor	Faint-None





Superior Solubility

Solstice Enhance Benefits – Offers multiple formulation flexibility and latitude

- Excellent solvent to solubilize heavy oil-based formulations, enabling a light texture and feel
- Solubilizes common protic solvents, ethers, sunscreen ingredients, triglycerides, esters, hydrocarbons, silicones, liquid fatty acids and oxygen carrying solvents like perfluorodecalin
 - Infinitely miscible with liquid surfactants such as polysorbate 20, laureth 4, oleth-2 etc. enabling new and interesting emulsions.
- Solubilizes actives like retinol, sunscreens, salicylic acid, etc., to improve formulation efficacy
- Keeps solids in suspension longer; excellent for heavy solids based formulations (such as starches, clays, etc.)

Applications

- Moisturizing creams
- Anti-acne gels/lotions
- Dry shampoos
- Sunscreens
- Face masks
- Liquid to powders

Ingredient Solubility in Solstice Enhance

- Trans-1233zd as solute at various wt%

Protic Solvents				Esters			
	50%	25%	10%		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

Ingredient Solubility in Solstice Enhance

Solstice Enhance as Solvent		
	Target %	
Retinyl Palmitate	1	Y
Cholecalciferol 1% (corn oil)	1	Y
Salicylic Acid	20	N
Salicylic Acid (50/50 ZD:SDA)	20	Y
Tocopheryl Acetate	2	Y
Tetrahexyldecyl Ascorbate	20	Y

Rationale: Use of these mixtures at 10% yields effective levels of active ingredients



Visual Foaming Action

Solstice Enhance Benefits

- Will create crackling foaming action that visually depicts a product working on skin or hair
 - Providing a strong reason to believe
 - Opportunity to create interesting new product formulations
- Breaks down concentrate instantly and easily to provide single handed easy application to consumer
- Evaporates quickly, leaving behind pure product/active and no additional residue

Applications

- Self-foaming face wash
- Self-foaming face masks
- Foaming gel products





Excellent Surface Wetting

Solstice Enhance Benefits

- Enables spreading formulation/product over a larger surface area easily
- Superior wetting delivers actives to larger skin surface for enhanced efficacy even on rough, wrinkled or uneven skin
- Solubilizes oils



Cooling

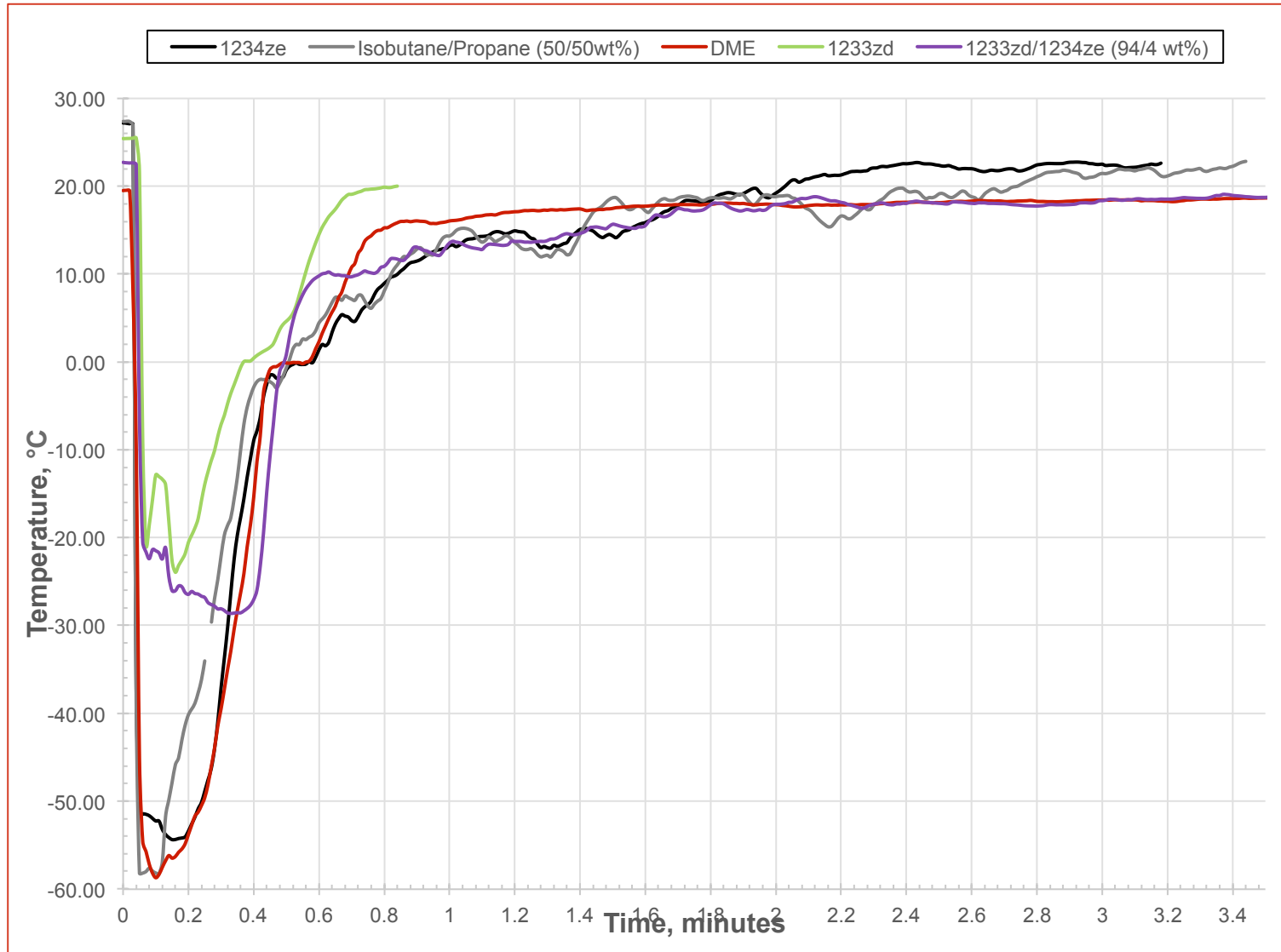
Solstice Enhance Benefits

- Unique cooling property of this material vs. other solvents
- Due to high heat of vaporization, cools the skin on contact giving a refreshing cooling sensation
- Faster drying vs. other common solvents used in beauty formulations
- Allows several possibilities to create innovative beauty formulations

Applications

- Cooling face mask
- Cooling hair treatment
- Cooling sunscreen spray

Cooling with Solstice Enhance



Ease of Adoption

Solstice Enhance Materials Compatibility

- Compatible with most plastics tested except acrylic and HIPS
- Compatible with Neoprene, Viton[®] B and other elastomers
- Aerosol valve compatibility studies by Precision and Aptar show good results with grades of buna and butyl
- Compatible with stainless steel 304, aluminum, cold rolled steel, copper, galvanized steel, titanium
- Compatible with tinsplate cans and lined cans



Toxicity profile: Solstice Enhance

- **Acute Toxicity:**
 - Inhalation: 4-hr LC₅₀ > 100,000 ppm (mouse); >207,000 ppm (rats)
 - Not a skin irritant in rabbit and not a skin sensitizer in human subjects (RIPT)
 - Not a cardiac sensitizer at 120,000 ppm
- **Genotoxicity:**
 - Not genotoxic (*In vitro*: Ames ± S9, *In Vivo*: micronucleus, UDS)
- **Repeat Exposure Toxicity:**
 - 2-week (rat)/ 13-week study (rat): NOEL 4,000 ppm
- **Developmental Toxicity: No significant adverse developmental effects**
 - NOEL 15,000 ppm (rat); NOEL 10,000 ppm (rabbit)
- **Reproduction Toxicity: No adverse reproductive effects observed**
 - NOEL 15,000 ppm (rabbit); NOEL 10,000 ppm (rat)
- **Chronic Toxicity:** No indication of carcinogenic potential
- **Ecotoxicology:** Practically non-toxic to algae and slightly toxic to fish and daphnia
- **Prop65:** Not listed
- **CMR:** Not a CMR
- **WEEL TWA:** 800 ppm

Meets and Exceeds Government Regulations

- TSCA Inventory (2012)
- Added to the US EPA SNAP list as an aerosol solvent (2012)
- US EPA VOC Exempt (August 2013), SCAQMD (2014)
 - Solstice Enhance has an MIR value of 0.04 g O₂/g VOC, which is approximately 85% lower than the value for ethane.
- California CARB VOC Exemption submitted and under review
- Registered / permitted for cosmetic use in Canada, Japan, South Korea, Australia, USA, EU
- EU REACH: Registered for volumes > 1,000 tons





Solstice Propellant

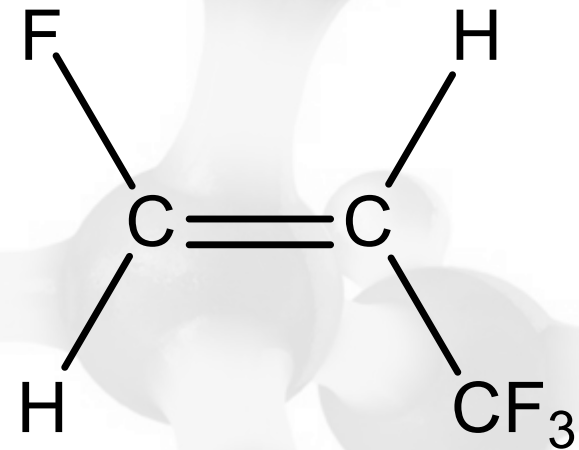
Solstice Propellant

Honeywell's Solstice Propellant is the only nonflammable, ultra-low Global Warming Potential (GWP) propellant available today.

- Improved safety
- Meets and exceeds government regulations
- Superior performance, blending and compatibility with aerosol cans and valves

Nomenclature

- INCI - Tetrafluoropropene
- Trans-1,3,3,3-tetrafluoroprop-1-ene
- 1,3,3,3-tetrafluoroprop-1-ene (E)
- HFO: hydrofluoro-olefin



Honeywell Confidential © 2017 by Honeywell International Inc. All rights reserved.

Great Performance

Solstice Propellant Properties Comparison

Requirement	Solstice Propellant HFO-1234ze(E)	HFC-152a	DME	Propane	i-Butane	n-Butane
Global Warming Potential (GWP) vs. CO₂, 100 year ITH¹	<1	138	<15	<15	<15	<15
Volatile Organic Compound (VOC)²	No	No	Yes	Yes	Yes	Yes
Flammability³	No	Yes	Yes	Yes	Yes	Yes
LFL / UFL⁴ (Vol. % in Air @70° F)	NONE	3.9/16.9	3.4/18.0	2.2/9.5	1.8/8.4	1.9/8.5
Molecular Weight	114	66	46	44	58	58
Boiling Point (°F)	-2.2	-13	-13	-44	11	31
Vapor Pressure (PSIG) @70° F	49	62	63	108	31	17
(PSIG) @130° F	147	176	174	257	97	66
KB Value	12	11	60	15	18	20
Specific Gravity @70° F	1.17	0.91	0.67	0.51	0.55	0.58

1. ITH; Integrated Time Horizon
2. VOC Exempt Status - US EPA; California Air Resources Board (CARB)
3. Flammability Testing; ASTM E681 and ISO 10156
4. LFL/UFL; Lower Flame Limit / Upper Flame Limit



Next Generation Propellant with Great Performance

Solstice Propellant Benefits

- Enables meeting VOC standards
 - US EPA VOC-Exempt (2012)
 - California CARB VOC-Exempt (2014)
- Meets and exceeds global regulations
 - GWP < 1
 - TSCA Inventory, EU REACH
- Medium Pressure: 49 PSIG at 70°F giving even consistent spray and minimal overspray
 - Ideal for hair, beauty applications
- Higher Liquid Density: 1.17 g/cc at 70°F enables better solubility in viscous formulations
 - Works very well with formulations with zinc oxide and other inorganics





Compatible, Miscible and Stable

Solstice Propellant Benefits

- Thermally and Hydrolytically Stable
 - Does not mix with water but stable in the presence of water
 - Stability at temperatures up to 230°F confirmed
- Miscible with Many Formulation Ingredients
 - Propellants: HFC-152, HFC-134a, DME, hydrocarbons – propane, butane, isobutane
 - Lower alcohols: MeOH, EtOH, IPA, etc.
 - Hydrocarbon and halocarbon solvents
- Compatible with many formulation ingredients but certain amines and high pH environments require development.
- Products such as hair sprays, dry shampoos, sunscreen, face make-up, body oils etc., have been successfully formulated with Solstice Propellant by Honeywell customers



Enables Plastics Aerosols

Solstice Propellant Benefits

- Lower diffusion rate through plastic vs. CO₂
 - From the data obtained on the micro-balance the permeability of CO₂ and Solstice Propellant through PET can be calculated.
 - $P_{\text{CO}_2} = 2.2 \times 10^{-14} \text{ cm}^3 \text{ (STP)} \cdot \text{cm}/(\text{cm}^2 \cdot \text{s} \cdot \text{Pa})$
 - $P_{\text{SP}} = 5.2 \times 10^{-16} \text{ cm}^3 \text{ (STP)} \cdot \text{cm}/(\text{cm}^2 \cdot \text{s} \cdot \text{Pa})$
 - Assume a PET bottle has surface area 500 cm² and a thickness of 0.5 cm.
 - Average pressure in the CO₂ bottle is 100 psi and will change overtime
 - Average pressure in the Solstice Propellant bottle is 55 psi and will remain constant overtime
 - How long would it take for 0.5 gm of CO₂ or Solstice Propellant to diffuse through the bottle?
 - **Time to Lose 0.5 gram Propellant:**
 - CO₂ = 7 months
 - Solstice Propellant = 17 years
- Nonflammable



29x

Plastic Bottle Compatibility Studies

Manufacturer	Graham Packaging	RCP Promens	Alpla
Bottle contents	HFO-1234ze(E) + water	HFO-1234ze(E)	HFO-1234ze(E) HFO-1234ze(E) + water
Storage time	13 months	2 years	3 months
Visual changes to PET	none	none	none
Increasing NVR	no	no	no
1234ze reactivity	Stable	Stable	Stable

Bottles maintained at 40°C during the entire storage time

Honeywell Confidential © 2017 by Honeywell International Inc. All rights reserved.

Solstice Propellant Has Exceptional Compatibility With PET Bottles

Ease of Adoption

Valve Compatibility Studies

Aptar MDI Valve Compatibility Study

- MDI valve components immersed in Solstice Propellant for 6 months: POM, PBT, polyamide, PE plastics, aluminum, springs, EPDM, nitrile, chloroprene, butyl rubber, TPE gaskets
- **After 6 months, no noticeable differences observed in mechanical properties of exposed materials with Solstice Propellant versus HFC-134a, HFC-227ea**

Precision Valve Compatibility

- Tested valve gaskets, cup gaskets, and dip tubes
- Buna, Butyl, EPDM valve gaskets – good results
- All cup gaskets and dip tubes – good results
- Neoprene – mixed results depending on grade; Viton – high swell

Summit Valve Compatibility

- Buna, Butyl – good results
- Neoprene – mixed results depending on grade; Viton – high swell

Honeywell Confidential © 2017 by Honeywell International Inc. All rights reserved.

Solstice Propellant Compatible With Most Valves

Metal Can Compatibility Studies

Unlined Tinplate

Parameters

- Tinned steel Solstice Propellant duster cans stored at room temperature and 40C
- Cans stored upright, and in inverted positions
- Analysis at 1, 3, 6, and 12 months: Weight loss, acidity, GC, visual inspection

Results

After 1 year, no sign of metal attack or HFO-1234ze(E) breakdown

DS Containers Can Liner Compatibility

Parameters

3 different cans with Solstice Propellant, aged 48 days at 40C (PET Liner in can)

Results

No visual changes in liner were observed

Exal PAM-lined and Epoxy-lined Aluminum Cans

Results

No visual changes in liner were seen after 1 year at 40C

No changes in acidity or GC

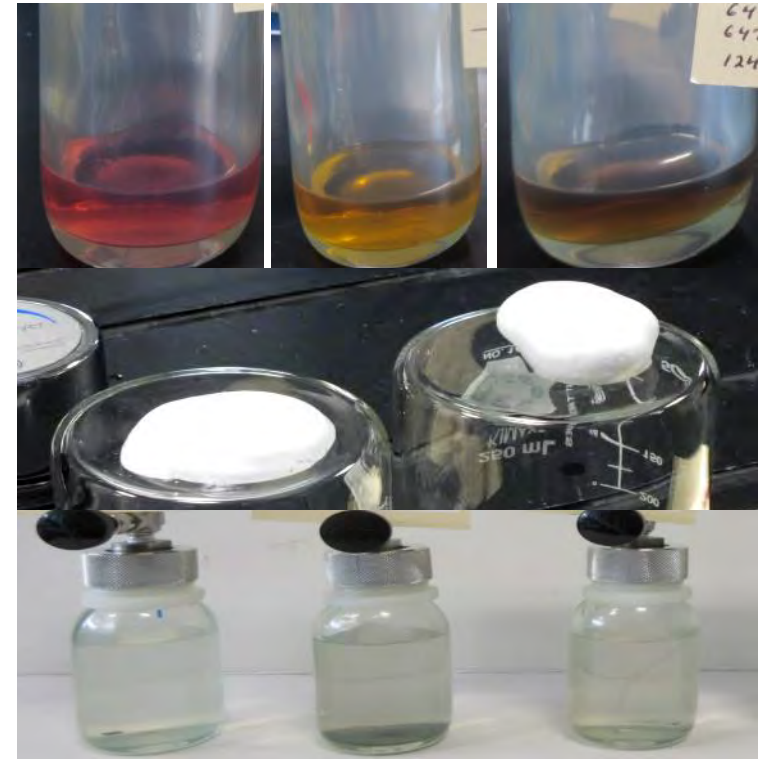
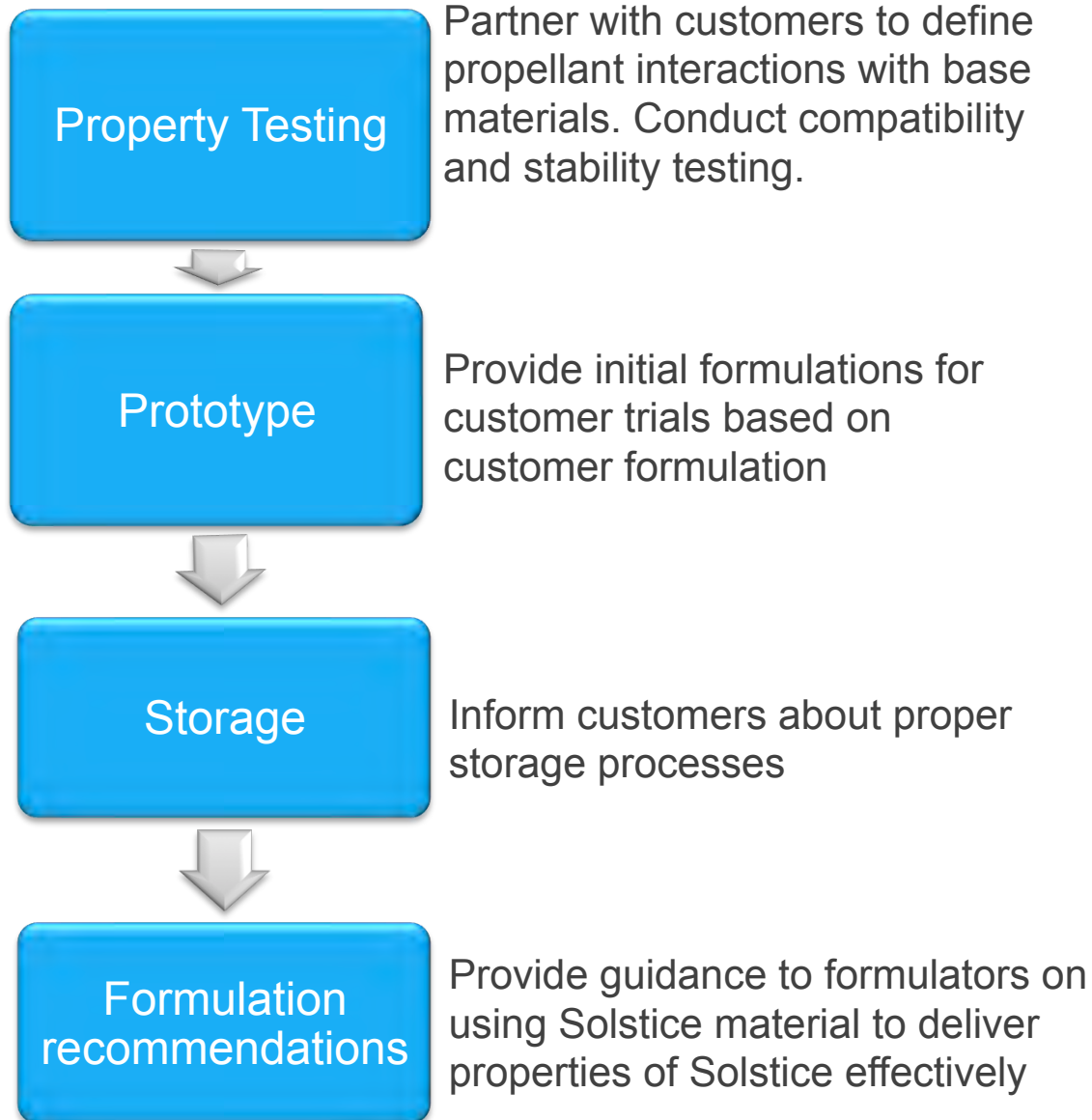
Toxicity profile: Solstice Propellant

- **Acute Toxicity:**
 - Inhalation: 4-hr LC₅₀ > 120,000 ppm (rat)
 - Not a skin irritant in rabbit and not a skin sensitizer in human subjects (RIPT)
 - Not a cardiac sensitizer at 100,000 ppm
- **Genotoxicity:**
 - Not genotoxic (In vitro: Ames ± S9, Chrom Ab, In Vivo: Bone marrow, micronucleus)
- **Repeat Exposure Toxicity:**
 - 2-week study (rat): NOEL 5,000 ppm; 4-week study (rat): NOAEL 10,000 ppm
 - 13-week study (rat): NOEL 5,000 ppm
- **Developmental Toxicity: No significant adverse developmental effects**
 - Developmental toxicity study : NOEL 15,000 ppm (rat); NOEL 15,000 ppm (rabbit)
- **Reproduction Toxicity: No adverse reproductive effects observed**
 - 2-Generation (rat): NOEL 20000 ppm (reproductive/developmental effects); NOEL 5000 ppm (parental systemic effects)
- **Chronic Toxicity:** No indication of carcinogenic potential
- **Ecotoxicology:** Practically non-toxic to fish, algae and daphnia
- **Prop65:** Not listed
- **CMR:** Not a CMR
- **WEEL TWA:** 800 ppm

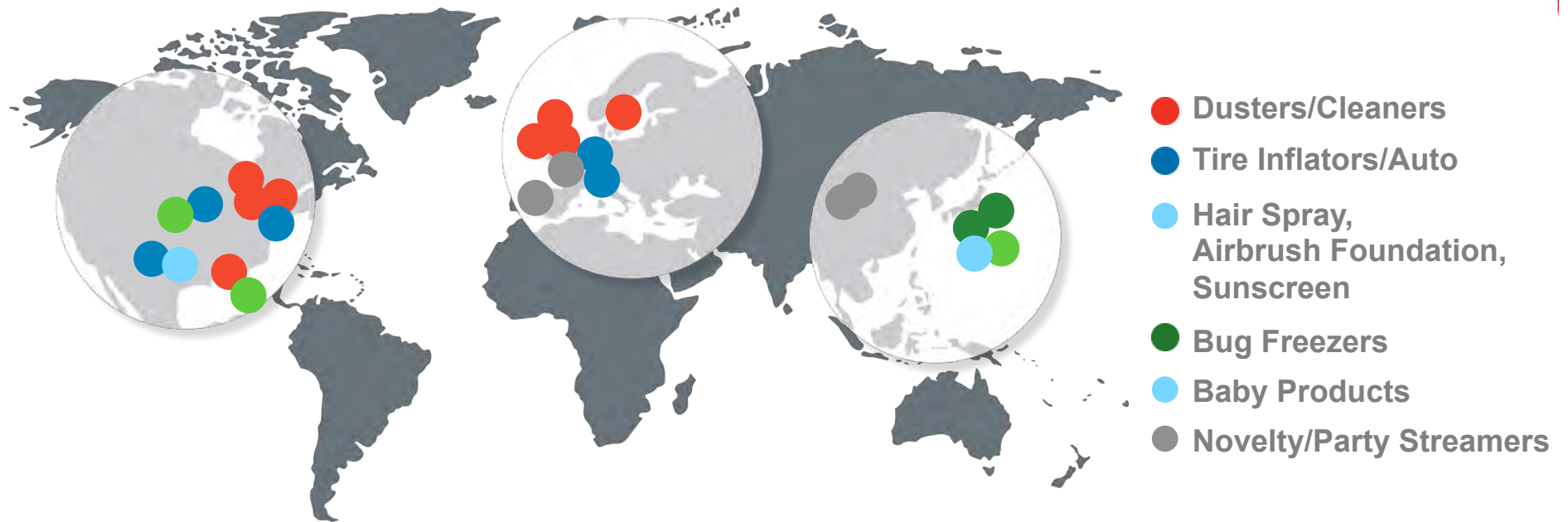


Supporting Customers Globally

Working with Customers to Solve Diverse Application Needs



Solstice Propellant Global Adoption





THANK YOU

Honeywell Confidential © 2017 by Honeywell International Inc. All rights reserved.

Honeywell
THE POWER OF **CONNECTED**

Solstice Propellant in Personal Care

A New Weapon in the Fight against Diaper Rash

As the U.S. continued its slow but steady economic recovery, birth rates rose slightly in 2013 following a three-year decline, according to a study conducted by market research firm Euromonitor International. The Baby Care market is expected to increase in value by 8% over the next five years to \$3.1 billion, with resumed spending on discretionary items expected to be led by affluent consumers.

In accordance with this trend, Mission Pharmacal Company, a San Antonio, TX-based personal care products company, unveiled Dr. Smith's Diaper Rash Spray, a follow up to the brand's popular Diaper Rash Ointment, now available in an aerosol spray format.

Without the need for rubbing in, the spray formula clings to the skin, creating a thin but even layer of protection. The formula does not cake or run, but provides a safe cooling sensation to soothe irritated skin.

Formulated with the new Solstice propellant from Honeywell, the 3.5oz spray is free of volatile organic compounds (VOCs).

"At Mission Pharmacal, we always look to innovate and create valuable products for families," said Neill Waldorf, Jr., President. "With the new Dr. Smith's Diaper Rash Spray, we are reinvigorating the way parents treat their baby's diaper rash with a gentle, environmentally-friendly and effective alternative to a traditional topical method."

Dr. Smith's Diaper Rash Spray is manufactured by Formulated Solutions for Mission Pharmacal. SPRAY



Mission Pharmacal Press Release:

<http://www.missionpharmaceutical.com/news/dr-smiths%20goes-washington-participate-white-house-hfc-industry-leadership-roundtable>