Opteon™ 1100

Foam Blowing Agent

Increased Performance and Reduced Environmental Impact to Meet the Needs of the Appliance Industry

Chemours™

LOW GWP

Continuing Innovation

Chemours continues to expand its foam blowing agent (FBA) offerings to the market with next generation solutions. In response to the appliance industry's growing need for high performance products with reduced environmental impact, Chemours has developed a new innovation: Opteon™ 1100.

Easy to Convert

Based on hydrofluoro-olefin chemistry, Opteon™ 1100 provides the desired physical properties and performance characteristics as a liquid blowing agent when compared with HCFCs, HFCs, and HCs. From its optimal boiling point to its low vapor thermal conductivity and low permeation, Opteon™ 1100 allows its users to easily convert their equipment to a more sustainable solution. Opteon™ 1100 also has the added benefit of being nonflammable with a favorable toxicity profile.

Properties

- Ozone Depletion Potential (ODP) = 0 (no chlorine)
- Global Warming Potential (GWP) 100 yr ITH = 2.0 (NOAA)
- Atmospheric Lifetime = 22 days (NOAA)
- Maximum Incremental Reactivity (MIR) = 0.04 g O_3/g
- Photochemical Ozone Creation Potential (POCP) = 3.4
- Molecular Weight = 164
- Boiling Point = 33 °C (91 °F)
- Nonflammable (ASTM E681)
- Workplace Environmental Exposure Limit (WEEL) = 500 ppm 8-hr TWA
- Vapor Thermal Conductivity = 10.7 mW/mK at 25 °C (77 °F)

Table 1. Comparison of Exposure Limits for Commercially Available Foam Blowing Agents

BA	Opteon™ 1100	HCFC-141b	HFC-245fa	HFC-365mfc	Cyclopentane	Methyl Formate
TLV, OEL, or AEL* (ppm)	500**	500	300	1,000*	600	100

*Chemours Allowable Exposure Limit (8- to 12-hr TWA)
**Workplace Environmental Exposure Limit (WEEL) 8-hr TWA

Chemical Stability in Foam Systems

Opteon™ 1100 offers best-in-class stability across a broad range of foam systems. As shown in **Tables 2** and **3**, hand-mix foams prepared from Opteon™ 1100 foam systems stored at 50 °C (122 °F) for 6 months indicated no increase in reactivity or density. This chemical stability is unique to Opteon™ 1100 and provides the required shelf-life for foam systems that must remain flexible and economically viable in a variety of operations.

Table 2. Opteon™ 1100 Stability in Polyether System—6 Months Storage at 50 °C (122 °F)

Days at 50 °C in Oven	Cream Time (sec)	Tack Free (sec)	Ratio (Tack Free/Cream Time)	Foam Density (pcf)
0	25	90	3.6	2.1
4	20	90	4.5	2.2
21	21	110	5.2	2.2
53	23	100	4.3	2.4
89	25	75	3.0	2.6
122	27	120	4.4	2.6
150	28	100	3.6	2.2
187	28	100	3.6	1.9

Table 3. Opteon™ 1100 Stability in Polyester System—6 Months Storage at 50 °C (122 °F)

Days at 50 °C in Oven	Cream Time (sec)	Tack Free (sec)	Ratio (Tack Free/Cream Time)	Foam Density (pcf)
0	25	90	3.6	2.5
15	30	110	3.7	2.4
47	20	130	6.5	2.3
83	25	135	5.4	2.6
116	27	120	4.4	2.2
144	30	100	3.3	2.4
181	30	100	3.3	2.2

Opteon™ 1100 Stability in Aged Polyurethane Foam

Opteon™ 1100 shows excellent chemical stability and blowing agent retention in polyurethane foams. As demonstrated in customer trials, the GC analysis of the cell gas composition from the aged Opteon™1100/Cp foam showed stable composition of Opteon™ 1100 and Cp (**Figure 1**) and minimal k-factor loss (7%) after 640 days of aging (**Figure 2**).

Figure 1. Cell Gas Composition of Opteon™ 1100/Cp Foams From Aged Refrigerators After 640 Days at Ambient Temperature

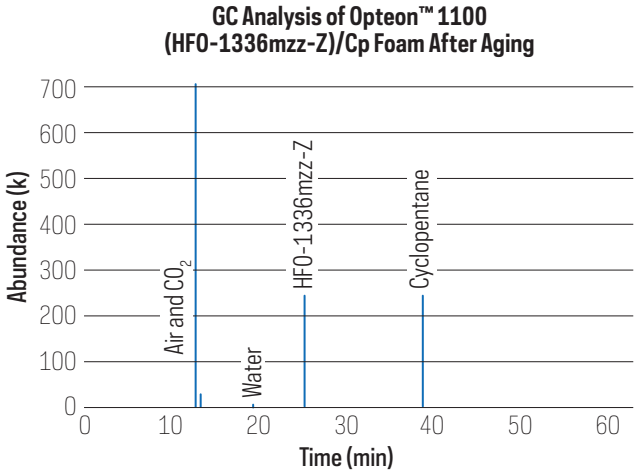


Figure 2. k-factor Change of Opteon™ 1100 Foams From Aged Refrigerator

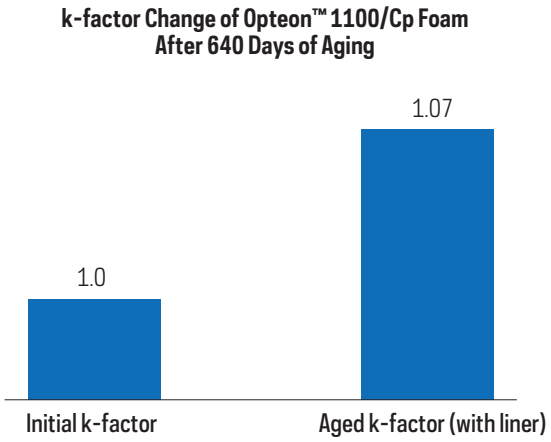


Figure 3. Vapor Pressure for Opteon™ 1100 Compared to HCFC-141b and Other Foam Blowing Agents

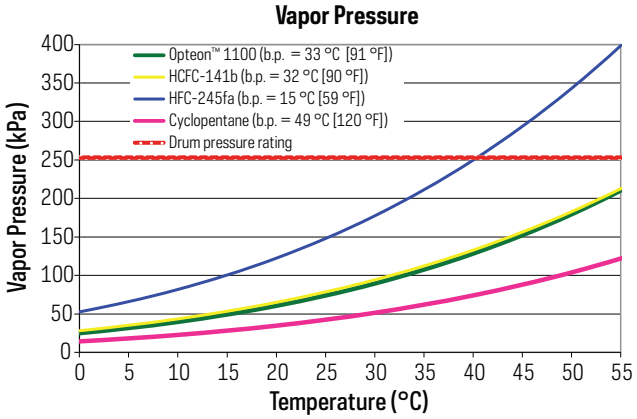
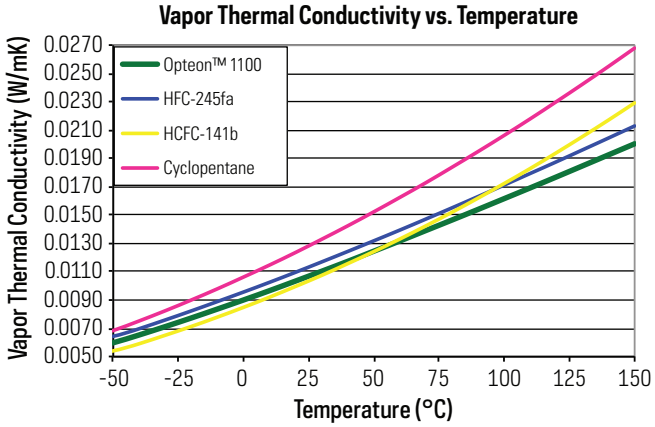


Figure 4. Vapor Thermal Conductivity for Opteon™ 1100 Compared to HCFC-141b and Other Foam Blowing Agents



Opteon™ 1100 Materials Compatibility

Opteon™ 1100 demonstrates superior material compatibility compared to HCFO-based foam blowing agents, notably when it comes to refrigerator liners (ABS and HIPS). Materials compatibility testing over 14 days showed that Opteon™ 1100 is also compatible with typical metals, elastomers, and plastics, as indicated by negligible weight, volume, and hardness change.

Table 4. Plastics Compatibility Including Refrigerator Liners (ABS and HIPS)—2 Weeks Exposure in Liquid Opteon™ 1100 at Room Temperature

Symbol	Material	Brand	% Weight Change	% Volume Change	% Hardness Change
ABS	**Acrylonitrile-Butadiene-Styrene**	**Cycolac® EX58**	**-0.1**	**-0.6**	**0.0**
HIPS	**High Impact Polystyrene**		**0.3**	**-0.4**	**-2.9**
PET	Poly(ethylene terephthalate)	Rynite®	0.0	0.7	-1.2
PS	Polystyrene	Styron®	-0.4	0.9	0.0
PVC	Polyvinyl Chloride	Bakelite®	0.0	0.0	0.0
CPVC	Chlorinated Polyvinyl Chloride		0.0	-0.3	0.0
PTFE	Fluorocarbon (PTFE)	Teflon™	1.1	0.3	-17.2
ETFE	Fluorocarbon (ETFE)	Tefzel™	0.7	0.0	12.9
	Ionomer	Surlyn®	0.3	0.0	1.9
POM	Acetal	Delrin®	0.1	-1.2	-1.3
PC	Polycarbonate	Tuffak®	0.0	-0.6	0.0
PEEK	Polyetherketone	Victrex®	0.0	0.2	0.0
	Polyarylate	Arylon®	0.2	-0.2	-4.4
LCP	Polyester	Xydar®	0.0	-0.4	-1.5
	Nylon 6/6	Zytel® 101	0.4	-0.5	3.1
PEI	Polyetherimide	Ultem®	-0.1	0.0	0.0
	Polyaryl Sulfone	Radel®	-0.2	0.3	0.0
PVDF	Poly(vinylidene fluoride)	Kynar®	0.1	-0.3	0.0
PP	Polypropylene	Tenite®	0.3	-0.5	0.0
	LCP	Zenite	-0.1	-0.9	0.0
HDPE	High Density Polyethylene	Alathon®	0.0	0.3	3.3
	Phenolic	Duzez®	0.0	-0.1	1.2

Table 5. Elastomer Compatibility—2 Weeks Exposure in Liquid Opteon™ 1100 at Room Temperature

Symbol	Material	Brand	% Weight Change	% Volume Change	% Hardness Change
NR	Natural Rubber	Natural Rubber	4.4	1.9	0.0
CR	Polychloroprene	Neoprene® W	0.8	0.1	0.0
NBR	Acrylonitrile Butadiene	BUNA N	15.3	2.6	-13.6
CSM	Chlorosulfonated Polyethylene	Hypalon® 40	0.2	0.8	-1.3
FFKM	Fluoroelastomer	Kalrez®	7.9	-3.4	-2.9
T	Polysulfide	THIOKOL FA®	0.3	6.7	-6.1
IIR	Isobutylene Isoprene	Butyl Rubber	0.3	13.1	-13.3
EPDM	Hydrocarbon (Ethylene-Propylene Terpolymer)	Nordel®	1.4	5.5	-7.1

Table 6. Metal Compatibility—2 Weeks Exposure in Liquid Opteon™ 1100 at 100 °C (212 °F)

Metal Coupons	Metal Coupon Weight	Metal Coupon Appearance	FEA Solution Appearance	FEA Solution Analysis
Stainless Steel	No weight change	No sign of corrosion	Clear	No fluoride detected*
Carbon Steel	No weight change	No sign of corrosion	Clear	No fluoride detected*
Copper	No weight change	No sign of corrosion	Clear	No fluoride detected*
Brass	No weight change	No sign of corrosion	Clear	No fluoride detected*
Aluminum	No weight change	No sign of corrosion	Clear	No fluoride detected*

*Detection limit = 0.5 ppm

Opteon™ 1100 Compatibility With Formulation Polyols

Opteon™ 1100 solubility tests show good solubility in a broad range of typical urethane foam polyols. As expected, Opteon™ 1100 solubility is generally better with polyether polyols, being completely soluble in most. Solubility with polyester polyols is generally less, but still good—ranging from 5 to 30 weight % at room temperature.

Table 7. Opteon™ 1100 Solubility in Commonly Used Polyols

Polyol Type	OH Number (mg KOH/g)	Opteon™ 1100 Solubility Limit (Weight %)	
		21 °C (70 °F)	50 °C (122 °F)
Polyethers			
Amine	391-800	5-50	40-50
Sucrose/Amine	400-499	50	50
Sucrose/Glycol	440	50	50
Sucrose/Glycerine	280-520	50	50
Sorbitol	490	50	50
Mannich-Base	300-390	5-50	29-50
Polyesters	240-307	5-30	25-35

Unique Characteristics of Opteon™ 1100 Blends

Opteon™1100 can be blended with water or hydrocarbons to improve insulation performance, while reducing the amount of blowing agent required. This has been demonstrated in trials where customers have used H_2O blends with 54 mole% Opteon™ 1100 to reduce their usage by 19%, while improving their k-factor by 1.7 °C (35 °F) (**Table 8**). One Opteon™ 1100-HC blend (**Figure 5**) showed the lowest k-factor at 10 °C (50 °F), resulting in greater energy savings for the appliance (**Figure 6**). This is a unique characteristic of Opteon™1100, as all other FBAs (HCFCs, HFCs, and HCFOs) require higher FBA levels to achieve better insulation performance; and, as a result, Opteon™ blends provide a cost-effective solution for cold temperature appliance applications.

Table 8. Comparison of Opteon™ 1100 and Opteon™ 1100-H_2O Blend (Customer Evaluation)

Formulation	Opteon™ 1100 (75 mole %)	Opteon™ 1100-H_2O Blend (54 mole %)
Polyol and Additive (pbw)	100	100
Water (pbw)	**1.31**	**2.81**
Opteon™ 1100 (pbw)	**36.8**	**29.9**
Initial Foam Properties		
Density (kg/m³)	31.7	29.4
k-factor (mW/mK) at 24 °C (75 °F)	19.3	19.3
k-factor (mW/mK) at 1.7 °C (35 °F)	18.6	17.6
Relative k-factor Changes		
k-factor (mW/mK) at 24 °C (75 °F)	Control	0.0%
k-factor (mW/mK) at 1.7 °C (35 °F)	**Control**	**-5.4%**
Relative FEA Changes		
Opteon™ 1100 (pbw)	**Control**	**-19%**

Figure 5. k-factors of Opteon™ 1100 and Opteon™ 1100-HC Blends (Customer Evaluation)

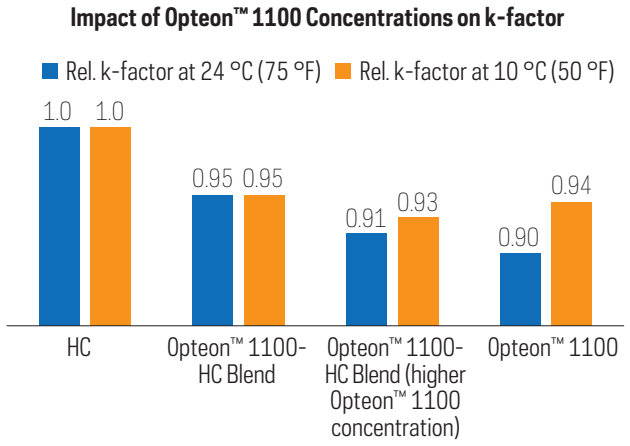
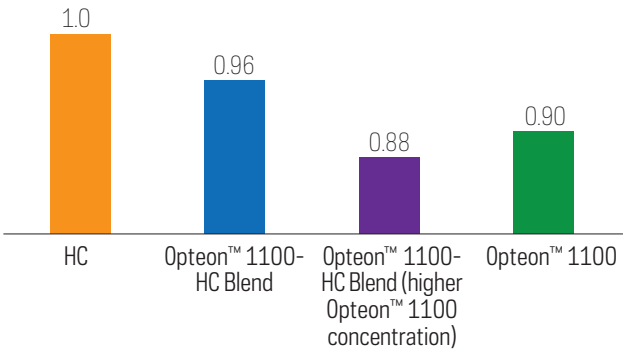


Figure 6. Energy Consumption of Opteon™ 1100 and Opteon™ 1100 Blends (Customer Evaluation)



Overall Ease of Conversion Advantages

- Excellent material compatibility with metals, elastomers, and plastics, including refrigerator liners (ABS and HIPS), avoiding change of materials or new refrigerator liner development
- Blends with water or hydrocarbon to improve insulation performance at reduced Opteon™ 1100 usage
- Good chemical stability in foam system and polyurethane foams, providing flexible and economically viable operations
- Nonflammable to avoid flammability and need to explosion-proof equipment
- Ideal boiling point (vapor pressure) to avoid pressure-rated tanks, piping, or containers for transportation or storage

Better Performance for Your Business. And the Environment.

With its optimal balance of properties, Opteon™ 1100 provides the appliance industry with a solution that not only meets its need for a sustainable foam blowing agent, but, in many cases, even outperforms the previous generation of products. Opteon™ 1100 is commercially available today and has already been utilized by leading polyurethane spray foam producers to create superior spray foam products.

For more information on Opteon™ foam blowing agents, visit opteon.com or call (800) 235-7882.

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