



SOLSTICE[®] **AIR**

Technical Bulletin

Honeywell

SOLSTICE® AIR

Solstice Air is a non-flammable aerosol propellant that has near-zero global warming potential (GWP) and very low photochemical reactivity. Its full chemical name is trans-1,3,3,3-tetrafluoroprop-1-ene, also known as HFO-1234ze(E). Its INCI name is tetrafluoropropene.

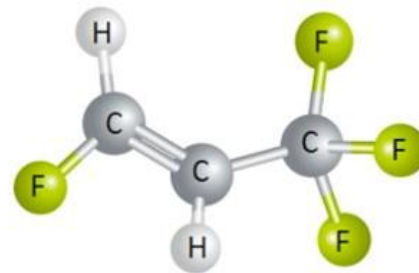


Figure 1: Chemical structure of Solstice Air

PROPELLANT PROPERTIES

Some of the physical properties of Solstice Air are shown in Table 1. Tables 2 and 3 show vapor pressures and liquid density as a function of temperature (in SI and English units).

SOLSTICEAIR		
Molecular Formula	CHF=CHCF ₃	
Molecular Weight	114 g/mol	
Boiling Point	-2.2 °F	-19 °C
Vapor Pressure at 70 °F/21 °C at 130 °F/54 °C	49 psig 147 psig	3.4 bar 10 bar
Liquid Density at 70 °F/21 °C	1.17 g/mL	
Vapor Flame Limits (Vol.% in Air) Measured at 70 °F	NONE	
Solubility of Water in 1234ze at 68 °F/20 °C	225 ppm	
Solubility of 1234ze in Water at 68 °F/20 °C	373 ppm	
Dipole Moment	1.44 debye	

Table 1.

C°	MPa	kg/m ³	C°	MPa	kg/m ³	C°	MPa	kg/m ³
-15	0.1200	1282.6	9	0.2980	1213.5	33	0.6308	1136.0
-12	0.1359	1274.3	12	0.3298	1204.3	36	0.6866	1125.6
-9	0.1534	1266.0	15	0.3642	1195.0	39	0.7460	1114.9
-6	0.1726	1257.5	18	0.4012	1185.6	42	0.8092	1104.0
-3	0.1936	1248.9	21	0.4410	1176.0	45	0.8764	1092.9
0	0.2165	1240.2	24	0.4837	1166.2	48	0.9476	1081.5
3	0.2414	1231.4	27	0.5295	1156.3	51	1.023	1069.8
6	0.2686	1222.5	30	0.5784	1146.3	54	1.103	1057.8

Table 2.

F°	PSIA	Lbs/ft ³	F°	PSIA	Lbs/ft ³	F°	PSIA	Lbs/ft ³
0	15.5	80.55	45	40.6	76.09	90	89.5	71.09
5	17.4	80.07	50	44.7	75.56	95	96.8	70.49
10	19.5	79.59	55	49.1	75.03	100	104.6	69.87
15	21.8	79.11	60	53.8	74.49	105	112.9	69.25
20	24.4	78.62	65	58.8	73.95	110	121.6	68.62
25	27.1	78.13	70	64.2	73.39	115	130.9	67.97
30	30.1	77.63	75	69.9	72.83	120	140.6	67.30
35	33.4	77.12	80	76.0	72.26	125	150.9	66.62
40	36.9	76.61	85	82.5	71.68	130	161.8	65.92

Table 3.

FLAMMABILITY

Solstice Air does not exhibit vapor flame limits under standard test conditions. It is therefore classified as non-flammable according to EC Testing Method A11: Flammability of Gases, as well as by the U.S. Department of Transportation (DOT) standard (tested according to ASTM E681). HFO-1234ze(E) is non-flammable in the ASTM flame projection test. HFO-1234ze(E) has also been tested and found to be non-flammable in the ignition distance test and the enclosed space ignition test (closed drum test).¹

MISCIBILITY

Solstice Air is miscible with other liquefied gas propellants such as HFA-134a and HFA-152a. It is also miscible with commonly used solvents such as lower alcohols, ketones, chlorinated solvents and hydrocarbons.

Vapor pressure data for blends of HFO-1234ze(E) with other propellants are shown in tables 4-5.

Weight % 1234ze	1234ze/134a		1234ze/152a	
	70°F	130°F	70°F	130°F
80	71	177	70	175
60	76	189	73	182
40	80	199	75	186
20	83	207	76	189

Table 4. Vapor Pressure (PSIA)

Weight % 1234ze	1234ze/134a		1234ze/152a	
	21°C	54°C	21°C	54°C
80	4.9	12.2	4.8	12.0
60	5.2	13.0	5.0	12.5
40	5.5	13.7	5.2	12.8
20	5.7	14.3	5.3	13.0

Table 5. Vapor Pressure (Bar absolute)

ENVIRONMENTAL PROPERTIES

In work done at the University of Copenhagen, the atmospheric lifetime of HFO-1234ze(E) was determined to be approximately two weeks. The GWP, which is largely a function of atmospheric lifetime, was determined to be <1 versus CO₂ on a 100-year integrated time horizon². In a companion study, also at the University of Copenhagen, it was determined that the atmospheric degradation products of HFO-1234ze(E) have negligible impact on the environment³.

Compounds with short atmospheric lifetimes often contribute to the generation of tropospheric, or ground-level, ozone which is one of the components of photochemical smog. That is not the case with HFO-1234ze(E). The MIR (maximum incremental reactivity) and POCP (photochemical ozone creation potential) values for HFO-1234ze(E) have been determined to be 0.09⁴ and 6.4⁵, respectively. These very low values indicate that HFO-1234ze(E) has very low photochemical reactivity and does not contribute in any significant way to tropospheric ozone generation.

The U.S. EPA has recommended that HFO-1234ze(E) be classified as a non-VOC.

Table 6 shows the environmental properties of HFO-1234ze(E) compared to those of some commonly used propellants.

	HFO- 1234ze(E)	HFA- 152a	HFA- 134a	HFA- 227ea
GWP (versus CO ₂ , 100 year ITH)	<1	138	1300	3350
Atmospheric Lifetime (years)	0.04	1.4	13.8	33
VOC Status	Exempt	Exempt	Exempt	Exempt

Table 6. Environmental Properties of MDI Propellants

COMPATIBILITY

Solstice Air exhibits good compatibility with plastics, elastomers and metals. In storage tests, it has been shown to be compatible with aluminum aerosol cans, tinplate cans and PET-lined cans. Solstice Air has also been tested with aerosol valves and found to be compatible with common gasket materials including grades of butyl rubber, buna and neoprene. Since results may vary, it is always recommended that testing be done to confirm compatibility with specific package components and materials of construction. Metered Dose Inhaler (MDI) valve compatibility tests have been run by Aptar Pharma. Contact information is available upon request.

STABILITY

HFO-1234ze(E) has been shown to be thermally and hydrolytically stable. In one experiment, samples of HFO-1234ze(E), in the presence of water and metals, were stored at 392°F (200°C) for two weeks. There was no observed effect on the metals and analysis showed no indication of breakdown of the HFO-1234ze(E). Also, samples

stored in steel cylinders for several years have been analyzed and found to be within the specification.

TOXICITY

Solstice Air has an extensive battery of toxicity studies that have been used to support FDA Investigational New Drug (IND) filings. Pre-clinical toxicity studies used to enable the IND included: acute inhalation exposure, repeated dose inhalation exposure, genotoxicity, and reproductive and developmental toxicity in multiple species. Additional long-term repeated dose studies are ongoing in multiple species. In a human clinical study, Solstice Air was not found to be a human skin sensitizer. The results of those studies concluded that Solstice Air exhibited a good safety profile for its use in Metered Dose Inhalers as well as other drug delivery systems.

STORAGE AND HANDLING

Solstice Air should be handled in a manner consistent with materials categorized as "liquefied gases under pressure." As illustrated by the vapor pressure data, HFO-1234ze(E) is a

moderate pressure gas and containers (bulk storage tanks or packages) should be rated for the pressure of HFO-1234ze(E).

Solstice Air, in approved containers, should be stored in a cool, well-ventilated area. HFO-1234ze(E) containers should neither be punctured or dropped, nor exposed to open flames, excessive heat or direct sunlight. Container valves should be tightly closed after use and when the container is empty.

As with other fluorinated materials, HFO-1234ze(E) should not be mixed with oxygen at elevated pressures. Applications necessitating pressurization – exceeding the vapor pressure of HFO-1234ze(E) – should use dry nitrogen.

The Honeywell safety data sheet (SDS) contains the most current and comprehensive information on the health, safety and environmental aspects of HFO-1234ze(E).

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3. Javadi, M.S., Sondergaard, R., Nielsen, O.J., Hurley, M.D. and Wallington, T.J.: Atmospheric chemistry of trans-CF₃CH=CHF: products and mechanisms of hydroxyl radical and chlorine atom-initiated oxidation, Atmospheric Chemistry and Physics Discussions, 8, 1069-1088, 2008.
4. Carter, W.P.: Investigation of Atmospheric Ozone Impacts of Trans 1,3,3,3-Tetrafluoropropene, Final Report to Honeywell International, 2009.
4. Wallington, T.J., Sulbaek Andersen, M.P. and Nielsen, O.J.: Estimated photochemical ozone creation potentials (POCPs) of CF₃CF=CH₂ (HFO-1234yf) and related hydrofluoroolefins (HFOs), Atmospheric Environment, 44, 1478-1481, 2010.



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