



HIGH SOLVENT POWER **LOW ENVIRONMENTAL IMPACT**

Solstice®PF-C in
Adhesives Formulations

Honeywell

SOLSTICE® PF-C

Nonflammable solvent adhesives that use n-propyl bromide (nPB), trichloroethylene (TCE), or methylene chloride (MeCl₂) are coming under regulatory pressure due to environmental or health concerns¹. MeCl₂ and TCE are considered hazardous air pollutants (HAPs)². TCE and nPB are classified as volatile organic compounds (VOCs)³. End-users are looking for solutions. **Solstice PF-C** is a nonflammable, breakthrough solvent designed to provide, excellent solubility and favorable health, safety, and environmental (HSE) characteristics.⁺ When blended with other solvents (such as trans-Dichloroethylene – tDCE, or tert-Butyl acetate – TBAC), it can yield a blend that also has favorable HSE properties, providing a proven alternative to nPB, TCE, and MeCl₂.

1 Listed in the US EPA's Risk Evaluations for Existing Chemicals under TSCA:
<https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-evaluations-existing-chemicals-under-tsca>

2 Per the National Emission Standards for Hazardous Air Pollutants (NESHAP):
<https://www.epa.gov/stationary-sources-air-pollution/halogenated-solvent-cleaning-national-emission-standards-hazardous>

3 Per U.S. EPA: 40 CFR 51.100(s).

+ Ultra-low global warming potential=1, non-ozone-depleting, VOC-exempt (per U.S. EPA)

KEY PROPERTIES AND APPLICATIONS

Solstice PF-C is an effective nonflammable carrier solvent that has solvency power and excellent HSE attributes⁺ (see Tables 1 and 2).

ADHESIVE APPLICATIONS

Nonflammable adhesive products are ideal for the applications listed below. Using such products can help avoid the potential of fire generated either by an electrical static discharge or a nearby ignition source commonly found in the areas where adhesives are used. Additionally, using a nonflammable product mitigates the need for maintaining expensive fire protection equipment. Finally, storage requirements of nonflammable products are less restrictive than for flammable products.

- Wood working (laminare installations for kitchens, bathrooms, office furniture, etc.)
- Furniture (upholstery and foam mattresses)
- Automotive (interior carpet and headliner manufacture/installation)
- Construction

Table 1

SOLSTICE® PF-C PROPERTIES	
Chemical Family	Hydrofluoro-olefin (HFO)
Formula	trans-1-chloro-3,3,3-trifluoropropene
Molecular Weight	130 g/mol
Boiling Point	19°C
Heat of Vaporization	194 KJ/kg (83.4 BTU/lb)
Liquid Density at 25°C	1.26 g/ml
Appearance	Colorless
Nonflammable	ASTM E-681, EU A11
Flash Point	None
Flame Limits	None
Solubility (Kb Value)	25
OEL (ppm)	800
GWP	1
ODP	~0
VOC-exempt (U.S. EPA)	Yes

FORMULATING WITH SOLSTICE PF-C

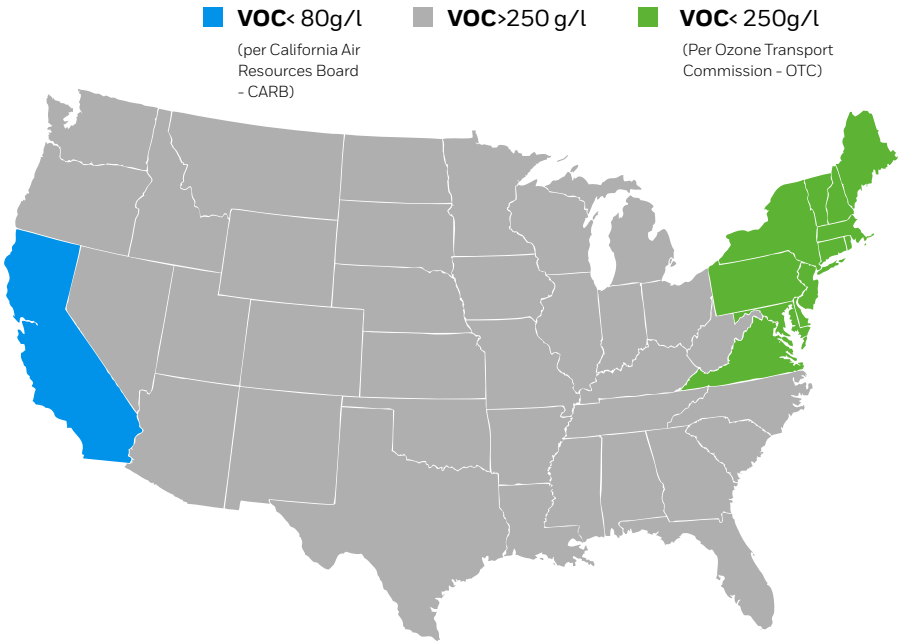
Table 2: Key Properties Comparison

PROPERTY	INCUMBENT	ALTERNATIVE SOLVENT BLENDS		
	MeCl ₂	Solstice PF-C tDCE/TBAC	Solstice PF-C /Toluene	Solstice PF-C /tDCE
Functional Adhesive Ingredient Solubility	Very Good Kb 129	Very Good TBAC: Kb 114 PF-C: Kb 25	Very Good Toluene: Kb 105 PF-C: Kb 25	Very Good tDCE: Kb 117 PF-C: Kb 25
Safety: Flammable*	No	No	No	No
Health: OEL	25 ppm	PF-C: 800 ppm tDCE: 200 ppm TBAC: 200 ppm	PF-C: 800 ppm Toluene: 20 ppm	PF-C: 800 ppm tDCE: 200 ppm

* ASTM D3278 (Setaflash Closed Cup)

STARTING FORMULATIONS

In the U.S., the permissible VOC levels vary by states and regions. Meeting regulatory compliance for a region or state can pose formulation challenges. Thus, a solvent with solvency power, performance, and favorable HSE attributes offers the formulator options to stay below permitted VOC levels. Solstice PF-C provides many performance and HSE benefits to help address formulation challenges. The following formulations for a styrene block copolymer (SBC) adhesive-based system are suggested as starting points for a non-methylene chloride adhesive. The formulator can consider whether the product is offered in a cylinder or bulk (pail or drum).



GUIDE TO FORMULATION EXAMPLES DEPENDING ON VOC CONTENT AND PACKAGING*

	VOC >250 g/l (grey states on map)	VOC < 250 g/l (green states on map)
Cylinder	Table 3 A/B	Table 4 A/B
Bulk (pail/drum)	Table 5 A/B	In development

*Not CARB compliant

For SBC adhesive systems having a VOC content >250 g/l, the starting formulation for cylinder packaging is shown in **Table 3A** and typical performance properties are shown in **Table 3B**.

Table 3A

INGREDIENTS	WEIGHT %
SBC Polymer	10.0
Mid-Block Resin	14.5
End-Block Resin	2.0
Antioxidant	0.5
Solvent Blend	
Solstice PF-C	11.0
trans-Dichloroethylene	62.0
Total	100.0

Table 3B

PROPERTIES	
Flammability	>60°C flash point (per ASTM D3278)
Tack Time	1 minute
Open Time	> 40 minutes
Solids Content (wt.%)	27%
Stability	Homogeneous between 4°C - 55°C

For SBC adhesive systems having a VOC content < 250 g/l (OTC State compliant), the starting formulation for cylinder packaging is shown in **Table 4A** and typical performance properties are shown in **Table 4B**.

Table 4A

INGREDIENTS	WEIGHT %
SBC Polymer	12.0
Mid-Block Resin	17.5
End-Block Resin	2.4
Antioxidant	0.5
Solvent Blend	
Solstice PF-C	32.6
trans-Dichloroethylene	10.4
tert-Butyl acetate	24.6
Total	100.0

Table 4B

PROPERTIES	
Flammability	>60°C flash point (per ASTM D3278)
Tack Time	45 seconds
Open Time	>40 minutes
Vapor Pressure	<15 psig at 55°C
Solids Content (wt.%)	32.4%
Stability	Homogeneous between 4°C - 55°C

For SBC adhesive systems having lower vapor pressure and VOC content >250 g/l, the starting formulation for bulk packaging (drums/5 gal. pails) is shown in **Table 5A** and typical performance properties are shown in **Table 5B**.

Table 5A

INGREDIENTS	WEIGHT %
SBC Polymer	12.0
Mid-Block Resin	17.4
End-Block Resin	2.4
Antioxidant	0.6
Solvent Blend	
Solstice PF-C	10.1
trans-Dichloroethylene	57.5
Total	100.0

Table 5B

PROPERTIES	
Flammability	>60°C flash point (per ASTM D3278)
Tack Time	1 minute
Open Time	> 40 minutes
Vapor Pressure	< 10 psig at 55°C
Solids Content (wt%)	32.4%
Stability	Homogeneous between 4°C - 55°C

Note: Starting formulations shown in Tables 3A, 4A, and 5A are examples only. Formulations are dependent on customer requirements and Honeywell makes no representation regarding the safety or efficacy of any formulation.



As an example, adhesive formulations using Solstice PF-C are well suited for laminate installations of kitchen countertops and cabinet facings.

MIXING SUGGESTIONS:

While manufacturing formulations for bulk or cylinder packaging, it is suggested to use a sealed mixing vessel.

1. Add and blend all solvent(s) except the Solstice PF-C solvents in the mixing vessel.
2. While mixing slowly, add the SBC polymer(s).
3. Prior to full dissolution, add the midblock resin(s) while mixing.
4. Then add the end-block resin.
5. Mix until fully dissolved.
6. Add Solstice PF-C, as below:
 - **Option 1:** If cooling is available, cool the mixture to 15°C and add Solstice PF-C to limit evaporation. The batch can be packed into either a cylinder or bulk container.
 - **Option 2:** If cooling is not available, add the Solstice PF-C below the adhesive liquid level while mixing. Solstice PF-C will blend quickly if added below the liquid level, minimizing evaporation. The batch can be packed into either a cylinder or bulk container.
 - **Option 3:** For cylinder formulations, the masterbatch without Solstice PF-C can be packed into cylinders. Solstice PF-C can be added directly to the cylinder to mitigate evaporation losses.

ENVIRONMENTAL & SAFETY PRECAUTIONS

It is extremely important to consider the effect on the surrounding area and the safety of those who come in contact with carrier solvents. The environmental impact of Solstice PF-C has been studied and is shown to have negligible ozone depletion and very low global warming potential. The maximum incremental reactivity (MIR) also indicates that Solstice PF-C creates less ground-level ozone or smog than ethane. Solstice PF-C has also been found to be nonflammable (per ASTM E-681, EU A11) in that it does not have a flash point or vapor flame limit to 100°C, which was the highest temperature tested.

STORAGE & HANDLING

Solstice PF-C is nonflammable and is resistant to thermal and hydrolytic breakdown. Ensure that all containers are pressure rated for the transportation and storage of Solstice PF-C. Solstice PF-C is shipped in cylinders or ISO quantities. For recommended storage and handling information, please review the safety data sheets.





For more information:

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