CLEANING LABORATORY EVALUATION SUMMARY

SCL #:	2019
DateRun:	07/28/2019
Experimenters:	Kevin Smith, Othon Pagounes
ClientType:	
ProjectNumber:	Project #1
Substrates:	Stainless Steel
PartType:	Coupon
Contaminants:	Coatings
Cleaning Methods:	Immersion/Soak
Analytical Methods:	Gravimetric, Visual
Purpose:	Determine a safer alternative for cleaning applications to remove solvent-based coatings using Hansen Solubility Parameters in Practice (HSPiP) off stainless steel surfaces.
Experimental Procedure:	Initial weights for the stainless-steel coupons, 2” x 4” in size, were recorded before applying the supplied coating to the bottom one third of the coupons using a swab. The coupons were enclosed from any light and aged for 24 hours. After aging, the contaminated weights were recorded before immersing each coupon in a beaker containing 50-60ml of a solvent for five minutes. Final weights were recorded after the coupons were removed and wiped with a Wypall. The same process was repeated for a set of coupons that were aged 48 hours and immersed for two minutes.
Results:	Aging Duration: 24 hours / Immersion Duration: 5 minutes

Solvent	Soil Added	Soil Removed	Percent Removal	Effective
Dimethyl carbonate	0.6895	0.6886	99.87	Yes
Propylene carbonate	0.5102	0.5069	99.35	Yes
1-Butuanol	0.5083	0.508	99.94	Yes
Dimethyl Glutarate	0.4224	0.4214	99.76	Yes
1:1 Blend (Dimethyl Carbonate: 1-Butanol)	0.4131	0.4133	100.05	Yes
Camger Current Cleaning Blend	0.3913	0.3911	99.95	Yes

Aging Duration: 48 hours / Immersion Duration: 2 minutes

Solvent	Soil Added	Soil Removed	Percent Removal	Effective
Dimethyl carbonate	0.4239	0.418	98.68	Yes
Propylene carbonate	0.3862	0.384	99.43	Yes
1-Butuanol	0.3375	0.3363	99.64	Yes
Dimethyl Glutarate	0.4222	0.4213	99.79	Yes
1:1 Blend (50% Dimethyl Carbonate: 50% 1-Butanol by volume)	0.3789	0.3776	99.66	Yes
Camger Current	0.3834	0.3826	99.79	Yes

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Cleaning Blend				

The coating sphere determined by the HSPiP software from the given soil was defined as: D = 18.27, P = 8.77, H = 13.10

The HSP values of the current blend are:

Solvent	D-Value	P-Value	H-Value
Toluene	18	1.4	2
Acetone	15.5	10.4	7
Xylenes	17.8	1	3.1
Total Blend	15.75	7.15	12.75

The HSP values of the proposed alternatives are:

Solvent	D-Value	P-Value	H-Value
Dimethyl Carbonate	15.5	8.6	9.7
Propylene Carbonate	20	18	4.1
1-Butanol	16	5.7	15.8
Dimethyl Glutarate	16.1	7.7	8.3
1:1 Blend	15.75	7.15	12.75

EHS Hazard Profile Analysis

The identified solvent alternatives were evaluated for overall environmental health and safety (EHS) compared to the original solvent blend. The following solvents were reviewed:

Original Solvent Blend:

1) Toluene
2) Acetone
3) Xylene

Alternative:

4) Dimethyl Carbonate
5) Propylene Carbonate
6) 1-Butanol
7) Dimethyl Glutarate
8) 1:1 Dimethyl Carbonate / 1-Butanol

A detailed review of the (8) Pollution Prevention Options Analysis System (P2OASys.turi.org) EHS categories was conducted for original blend (Toluene, Acetone, and Xylene) and compared to the potential alternative as seen figure below:

Categories	Toluene	Acetone	Xylene	Dimethyl Carbonate	Propylene Carbonate	1-Butanol	Dimethyl Glutarate
Acute Human Effects	9	6	9	3	7	9	2
Chronic Human Effects	8	7	8	2	2	6	2
Ecological Hazards	8	2	8	2	2	2	2
Environmental Fate & Transport	5	6	7	6	4	2	8
Atmospheric Hazard	6	2	6	2	2	2	2
Physical Properties	10	9	9	9	3	9	5
Process Factors	7	5	7	3	4	5	4
Life Cycle Factors	9	6	9	4	4	7	3
Weighted Average	7.8	5.4	7.9	3.9	3.5	5.3	3.5

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Score	*Description*
7-10	High Hazards
5-6	

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	Moderate Hazards
2-4	Low Hazards
	No Information Available
*Lower score = Lower toxicity/hazard.	

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Within the full data set in Appendix B for the alternative, a few significant differences have been identified relative to blend being currently being used.

The following is a summary of the hazards:

Original Blend Cleaner:

- Toluene: High hazard of exposure limits, oral toxicity, endocrine system, and chronic organ effects. High acute aquatic toxicity and a listed NESHAP chemical. Physical properties had a high hazard rating due to vapor pressure, high flammability, low flashpoint, and a noxious odor. Lifecycle factors had a high rating due to hazards to those working with this chemical upstream, as a consumer, and during disposal.
- Acetone: High hazard for chronic organ effects through multiple uses, air t ½ days. Physical properties had a high hazard rating due to flammability, and flashpoint.
- Xylene: High hazard of, oral toxicity, eye irritation, health, neurotoxicity, and chronic organ effects. High acute and chronic aquatic toxicity as well as rapid degradable substance. Listed as a NESHAP chemical. Physical properties had a high hazard rating due to high flammability, low flashpoint, and as a volatile organic compound. Lifecycle factors had a high rating due to hazards to those working with this chemical upstream, as a consumer, and during disposal.

Proposed Identified Alternative:

1. Dimethyl carbonate: High hazard for persistence in air, and for physical properties such as vapor pressure, flammability for liquid
2. Propylene carbonate: High hazard for eye irritation
3. 1-Butanol: High hazard for dermal and eye irritation. Physical properties had a high hazard for liquid flammability as well as a volatile organic compound. This solvent is also a high disposal hazard
4. Dimethyl glutarate: High hazard for persistence in air
5. 1:1 Blend (Dimethyl Carbonate/1-Butanol): High hazard for persistence in air, and for physical properties such as vapor pressure, flammability for liquid, gas and is a volatile organic compound. High hazard for dermal and eye irritation. This solvent is also a high disposal hazard.

Summary:

Substrates:	Stainless Steel				
Contaminants:	Coatings				
Company Name:	**Product Name:**	**Conc.:**	**Efficiency:**	**Effective:**	**Observations:**
Alfa Aesar	Dimethyl Carbonate 99%	100%	99.87	☑	
Fisher Scientific	Propylene carbonate 99.5% (CAS: 108-32-7)	100%	99.35	☑	
Alfa Aesar	1-Butanol 99.4%+	100%	99.94	☑	
Fisher Scientific	Dimethyl glutarate (CAS:1119-40-0)	100%	99.76	☑	
No Specific Vendor	1:1 Blend (Dimethyl carbonate:1-Butanol)	100%	100.05	☑	
No Specific Vendor	Toluene, Acetone, and Xylene Mixture	100%	99.95	☑	

Conclusion:

Dimethyl carbonate, Propylene carbonate, 1-Butanol, Dimethyl glutarate, 1:1 Blend (Dimethyl Carbonate/1-Butanol) are considered safer alternatives to the current cleaner solvent blend. The next step would be to undergo a cost analysis of each solvent and conduct a test in the production facility.

Update: Based on the client's feedback, only propylene carbonate and dimethyl glutarate will be tested at the facility due to their lower flammability properties compared to the other identified alternatives.