CLEANING LABORATORY EVALUATION SUMMARY

SCL #:	2019
DateRun:	07/08/2019
Experimenters:	Kevin Smith, Othon Pagounes
ClientType:	
ProjectNumber:	Project #1
Substrates:	Stainless Steel
PartType:	Coupon
Contaminants:	Coatings
Cleaning Methods:	Immersion/Soak
Analytical Methods:	HSPiP
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 were recorded before applying the supplied coating to the bottom one third of the coupons using a swab. The coupons were covered and aged for one week. After aging, the contaminated weights were recorded before immersing each coupon in a beaker containing 50-60ml of a solvent for one hour. Final weights were recorded after the coupons were removed and wiped with a Wypall.

A rating system of zero to five was developed to the efficiency of the solvent in its ability to remove the coating from the substrate. If little to no soil was removed from the coupon, the solvent would receive a zero (0), and if most or all soil was removed from the coupon, the solvent would receive a five (5). The scoring was established based on the percent weight removal of the coating. The ratings were entered into the HSPiP software, and a sphere was generated from that data.

The HSPiP sphere has size parameters that associate with its solubility. These parameters were entered into the Database of Safe Solvents (DOSS [1]), with a tolerance of +/- one value to create a range for identifying a safer solvent. DOSS provided a list of solvents that were within the values given and exported into the HSPiP optimizer option. The optimization evaluation found solvents and solvent blends that were closest to the parameters of the coating HSPiP sphere.

HSPiP Chemicals:

(1) Toluene (2) Dimethyl Carbonate, (3) Xylenes, (4) Benzyl Alcohol, (5) Ethylene Glycol, (6) Methyl Acetate, (7) Undecane, (8) Ethyl Lactate, (9) Acetone, (10) Ethyl Acetate, (11) Methanol, (12) Ethanol, (13) 1,3-Dioxolane, (14) Diethyl Carbonate, (15) 1-Propanol, (16) Iso-Propanol, (17) Propylene Carbonate, (18) Thiophene, (19) 1-Methoxy-2-Propanol, (20) Dimethyl Sulfoxide, (21) 1-Butanol, (22) Dimethyl Glutarate, (23) Anisole, (24) 2-Butoxyethyl Acetate

[1] Doss.turi.org

Results:

Results from HSPiP Test:

#	Solvent	Soil Added	Soil Removed	Percent Removal	Rating
1	Toluene	0.1235	0.1241	100.48	2
2	Dimethyl carbonate	0.0884	0.087	98.47	1
3	Xylenes	0.0722	0.0728	100.83	2
4	Benzyl alcohol	0.0362	0.0357	98.62	1
5	Ethylene glycol	0.0644	0.0633	98.29	1
6	Methyl acetate	0.0882	0.0933	105.78	5
7	Undecane	0.0538	0.0414	76.95	0
8	Ethyl lactate	0.054	0.0545	100.93	2
9	Acetone	0.0332	0.0336	101.20	3
10	Ethyl acetate	0.0456	0.0458	100.44	2
11	Methanol	0.0466	0.046	98.71	1

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12	Ethanol	0.0821	0.0823	100.24	2
13	1,3 - dioxolane	0.0425	0.043	101.17	3
14	Diethyl carbonate	0.0368	0.0373	101.35	3
15	1-Propanol	0.0347	0.0346	99.712	1
16	Iso-Propanol	0.0296	0.0292	98.65	1
17	Propylene carbonate	0.045	0.0458	101.78	3
18	Thiophene	0.052	0.0521	100.19	2
19	1-Methoxy-2-Propanol	0.0549	0.0549	100.00	2
20	Dimethyl Sulfoxide	0.0514	0.0514	100.00	2
21	1-Butanol	0.0539	0.0536	99.44	1
22	Dimethyl glutarate	0.0354	0.0353	99.72	1
23	Anisole	0.0376	0.0377	100.27	2
24	2-Butoxyethyl acetate	0.0473	0.047	99.37	1

Results from HSPiP:

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

EHS Hazard Profile Analysis

One potential alternative chemical was identified using HSPiP, and the chemical was 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

Alternatives:

4) 2-Pyridylmethanol
5) Propylene carbonate
6) Dimethyl glutarate

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.

Score	*Description*
7-10	High Hazards
5-6	Moderate Hazards
2-4	Low Hazards
	No Information Available
*Lower score = Lower toxicity/hazard.	

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	Original Solvent Blend			Alt. 1	Alt. 2	Alt. 3
Categories	Toluene	Acetone	Xylene	2-Pyridylmethanol	Propylene carbonate	Dimethyl glutarate
Acute Human Effects	9	6	9	8	7	2
Chronic Human Effects	8	7	8	5	2	2
Ecological Hazards	8	2	8	2	2	3

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Environmental Fate & Transport	5	6	7	2	4	8
Atmospheric Hazard	6	2	6	2	2	2
Physical Properties	10	9	9	3	3	5
Process Factors	7	5	7	2	4	4
Life Cycle Factors	9	6	9	3	4	3
Weighted Average	7.8	5.4	7.9	3.4	3.5	3.6

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 Alternatives:

1. 2-Pyridylmethanol: High hazard rating for both eye and dermal irritation; Specific target organ toxicity - single exposure (Category 3), Respiratory system, H335
2. Propylene carbonate: High hazard eye irritation
3. Dimethyl glutarate: Slightly persistent in air and 6.20 mmHg vapor pressure

Based upon this analysis, 2-Pyridylmethanol, Propylene carbonate, and Dimethyl glutarate presents much lower hazards of concern compared to the original blend of Toluene, Acetone, and Xylene. The majority of the high hazards listed above in the current blend will be avoided with the identified alternatives with exception of a high hazard rating for both eye and dermal irritation. Which can be avoided with the correct personal protective equipment and engineering controls.

Summary:

Substrates:	Stainless Steel				
Contaminants:	Coatings				
Company Name:	**Product Name:**	**Conc.:**	**Efficiency:**	**Effective:**	**Observations:**
Fisher Scientific	2-(Hydroxymethyl)pyridine - (2-Pyridylmethanol) (CAS: 586-98-1)	100%		☑	Identified only through HSPiP software and would theoretically be considered effective. Further testing would be needed.
Fisher Scientific	Propylene carbonate 99.5% (CAS:108-32-7)	100%	101.78	☑	
Fisher Scientific	Dimethyl glutarate (CAS: 1119-40-0)	100%	99.72	☑	

Conclusion:

2-Pyridylmethanol, propylene carbonate, and dimethyl glutarate are considered to be safer alternatives to the current cleaning solvent blend. Samples will be requested, and the next step would be to undergo testing using the same performance methodology.