

Laboratory Performance Testing & Implementation

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Samples from Clients

- Contaminant being removed
 - Request 200-500ml
 - Identify hardest contaminant to remove first



- Check other contaminants after for effectiveness
- Parts
 - Three parts for each identified potential alternative per test
 - Start with coupons first to identify cleaners that are effective first





Developing a Test Plan

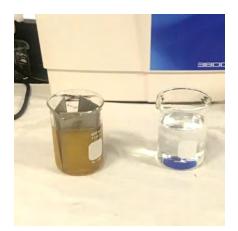
- Things to consider:
 - Cleaning method
 - Current equipment vs new equipment considerations
 - Vapor Degreaser \rightarrow Ultrasonics
 - Rinse and dry step?
 - Chemistry compatibility with substrate/equipment
 - Vendor information
 - Non-client testing
 - Time
 - Refer back to Test Request Form



Initial Testing: Immersion Cleaning

- Pick 8-10 cleaners
 - CleanerSolutions Database or Online Search
 - EHS Evaluation using P2OASys
- Use Coupons
 - Use substrates that are the same as parts
- Immersion Testing
 - Evaluating the chemistry performance
 - Temperature
 - Concentration
 - Time
 - Doesn't work only or only showed partial removal?
 - Tweak parameters that seem appropriate







Next Step: Incorporating Equipment

- Pick 6-8 cleaners that worked best
- Choose appropriate equipment or method for the process:
 - Ultrasonics
 - Lab uses 40 kHz Branson 3800 & 80 kHz FB11201
 - Immersion Tank
 - Spray Wash(High and Low Pressure)
 - Vapor Degreasing
 - Manual Wipe
 - Vacuum Cycling Nucleation (VCN)







Vacuum Cycling Nucleation (VCN)

- New equipment the lab is researching
 - Aqueous specific
 - RIT in NY has solvent version
 - Great for tiny orifices, piping, and very complex geometries
 - Trying out a variety of contaminants and parts
 - Compare to other equipment currently out there





Aqueous Vacuum Cycling Nucleation (VCN) System

	Ultrasonics	VCN
Internal Cleaning	No	Yes
Damage to Delicate Parts	Yes	No
Load Dependent	Yes	No
Uniform Treatment	No	Yes
Targets Contaminant	No	Yes
Chemical Delivery to Surface	No	Yes
Fluid Boundary Layer	Yes	No
Effectiveness With Solvents	Low	High
Concentrations Required	Hi	Low
Effective Rinse Method	No	Yes
Temperature Dependence	Hi	Low

http://vacuumprocessingsystems.net/





Testing with Parts

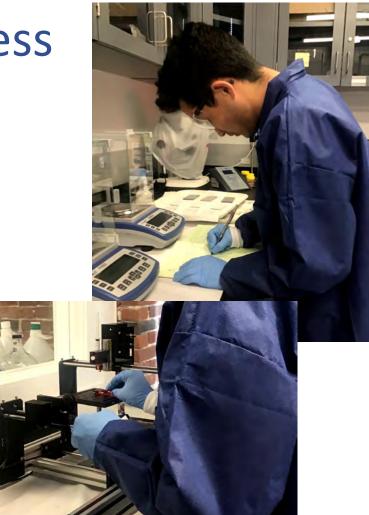
- Pick 3-4 cleaners that worked best
- Test on contaminated parts
 - Use temperature and concentration identified
 - Use equipment identified
- Compare to provided clean parts as a baseline of cleanliness





Determining cleanliness

- Most companies only need visual verification
- Quantitative data for a company's customers:
 - Gravimetric
 - Contact angle
- May need more verification testing
 - Military standards



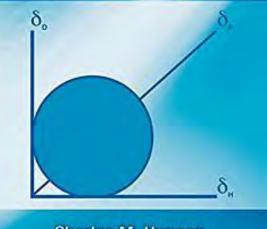


So None of the Market Cleaners Worked... Now What?





HANSEN SOLUBILITY PARAMETERS A User's Handbook



Charles M. Hansen

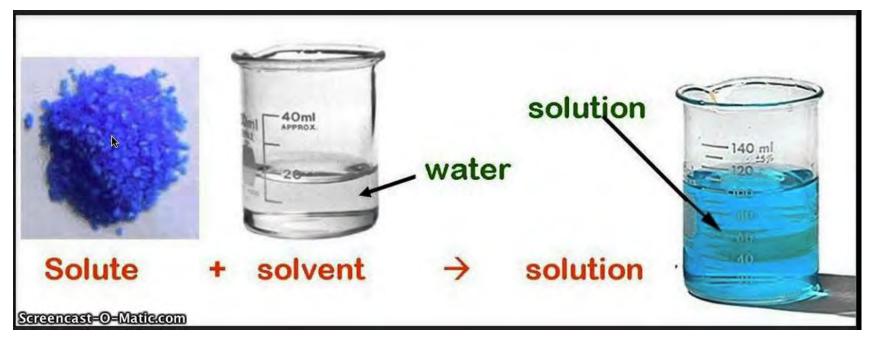
Hansen Solubility Parameters Theory

https://hansen-solubility.com/



Solute, Solvent, and a Solution

Solute + Solvent = Solution



- The solid solute is the substance being dissolved (e.g. a polymer)
- The liquid solvent dissolves the solute. Both substances must be similar to dissolve
- When the solute is dissolved a solution is created



Solubility

- Hansen Solubility Parameters (HSP) theory is based on the relationship between energies of the solute and solvent
- "Like Dissolves Like" is the fundamental concept

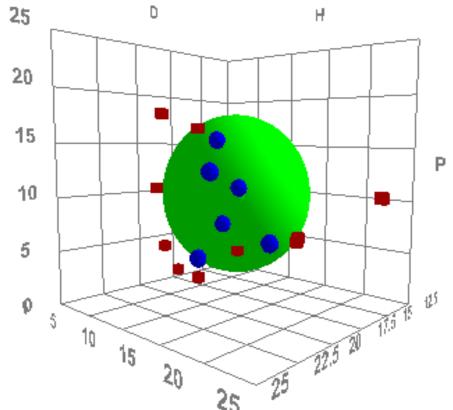


HSP and Inter-molecular Forces

- 1. <u>Dispersion force</u> (also called London Force)
- 2. Polar force (also called dipole-dipole force)
- 3. Hydrogen bonding force
- 4. <u>Ionic Force</u> (not included in HSP theory mostly used for aqueous applications)

Strength of forces: hydrogen bonding > polar > dispersion





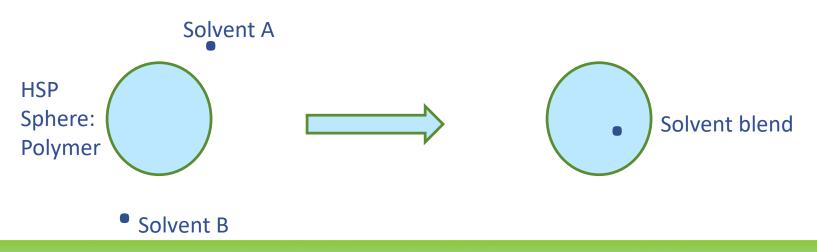
 δD , δP , and δH are plotted in 3D space for solute and solvents.

Around the solute center point is a Green sphere of solubility, with a unique radius.

- Blue Dots: solvents that will dissolve the solute (inside or on surface of the green sphere)
- Red Cubes: solvents that will not dissolve the solute (outside of the green sphere)

Solvent Blends - Example

Solvent	Volume %	D	Р	н
Solvent A	100	12	4	21
Solvent B	100	18	11	3
Solvent Blend	50:50	15	7.5	12





Factors that Affect HSP Performance

- Molar Volume (or Molecular Weight Effect)
 - Important when dealing with polymers
- Temperature Effect
 - Working on refining process for identifying alternatives for drop-in alternatives for vapor degreasing applications
- Viscosity Effect
 - Can act as a brake and reduce ability to mix
- Time Effect
 - Transport properties can impact rate of equilibrium
 - Affect heat, mass, and momentum transfer



The HSPiP Solvent Test

- Come up with a test plan
 - Review Test Request Form
 - Consider how chemical is being used and replicate
- Created a set of 24-30 solvents to develop sphere from scores
 - Currently working on a list of safer solvents/solvent
 blends to replace current set of solvents for test





Hansen Solubility Parameters in Practice (HSPiP) Software

	Solvent	δD	δP	δΗ	Score	RED	MVol	CAS	SMILES
	Acetaldehyde	14.7	12,5	7.9			56.5	75-07-0	CC([H])=0
2	Acetaldoxime	16.3	4	20.2			61.2	107-29-9	C/C=N/O
3	Acetamide	17.3	18.7	19.3			59	60-35-5	CC(N)=O
4	Acetanilide	20.6	14.4	13.5			131	103-84-4	CC(=0)N
5	Acetic Acid	14.5	8	13.5			57.6	64-19-7	CC(0)=0
6	Acetic Anhydride	16	11.7	10.2			95	108-24-7	CC(OC(C)
7	Acetone	15.5	10.4	7			73.8	67-64-1	CC(C)=0
8	Acetonecyanhydrin	16.6	12.2	15.5			91.8	75-86-5	CC(C)(O)C
9	Acetonemethyloxime	14.7	4.6	4.6			96.7	3376-35-0	CC(=NOC)C
10	Acetonitrile	15.3	18	6.1			52.9	75-05-8	CC#N
11	Acetophenone	18.8	9	4			117.4	98-86-2	CC(C1=C
12	Acetoxime	16.3	3.7	10.9			80.2	127-06-0	CC(=NO)C
765	1-Acetoxy-1,3-Butadiene	16.1	4.4	8.3			118.4	1515-76-0	CC(=0)0
1116	Acetyl Salicylic Acid	19	6.9	9.7			149.4	50-78-2	CC(=0)0
785	2-Acetyl Thiophene	19.1	12.2	9.3			108	88-15-3	CC(C1=C
	δΡ ν δΗ		5	δΗ ν δD				δΡ ν δD	



HSPiP Software with Sphere

No.	Solvent	Dispersion	Polar	Hydrogen	Score	RED	MolVol	· P S O S Double Ock R Fiting "hade"
	Acetone	15.5	10.4	70	1	0.745	73.8	Best-slow • 1
2	1-Butanol	16.0	5.7	15.8	0	1.209	92	In= 11 Out= 8 Total= 19 Both only • D= 18.61 P=9.80 H=7.97
15	y Butyrolactone	19	16.6	7.4	1	0.807	76.8	Hde unuted DCR R= 8.5
48	Chiorobenzene	19.0	43	2.0	1	0.959	102.1	Fit= 1.000
55	Diethyl Ether	14.5	2.9	5.t	0	1.308	104.7	
6	1.4-Dioxane	19	1.8	7.4	1	0.948	85.7	
26	Bhanolamine	17.5	6.8	18.0	0	1.260	60.3	12 Add from master list
75	Bhylene Glycol Monobutyl B:	16.0	5.1	12.3	1	0.972	131.8	
91	Methyl Isobutyl Ketone	15.3	6.1	41	0	1 003	125.8	1
31	Nitrobenzene	20.0	10.6	3.1	1	0.666	102.7	
32	Nitroethane	16.0	15.5	4.5	1	0.997	72	25 0 #
84	Propylene Carbonate	20.0	18.0	4.1	D.	1.115	85.2	
37	Toluene.	18.0	1.4	2.0	0	1.221	105.6	20
49	Trichloroethylene	18.0	3.1	5.3	1	0.851	90 t	
58	Ethylene Glycol	17.0	11.0	25.0	Ó	2.160	55.9	15
21	N-Methyl-Pyrrolidone	18	12.3	7.2	1	0.340	96.5	P
-	PVH	HVD		PvD			10 10	
			-		~)	5 9 10 15 20 25 213 75 215 210 10 10 10 10 10 10 10 10 10 10 10 10 1



Database of Safer Solvents (DoSS)

- "Safer" chemicals
 - Avoiding solvents that are
 - Carcinogens
 - Reproductive/ developmental toxicants
 - Mutagens
 - Neurotoxicants
 - Endocrine disruptors
 - Halogenated solvents
 - Still refining list of chemicals for different endpoints
 - Application
 - Choose solvent appropriate environment
 - Cost
 - Bulk costs aren't reliable; may be cheaper

Sie Soven						
Iptimization Guide o learn how to best use the Optimization Guide visit.	the Resources pa	ge. Visit the Abo	ut page to learn	about th	ne criteria	of a "safer" sol
learch solvent database						
Cas Number:						
Name:						
EHS.Information		Solubility	Theory			
Glove Type:		D: Low Lin		Detweer	High L	mit
General EHS		P: Low Lin	nit	between	High LI	imit
NFPA Health Hazard Rating:	•	H: Low Lin		between		
NFPA Fire Hazard Rating:		Physical Pr			- ingres	
GHS Flammability Limit:	*		Weight (g/mol)	g/mol		
Oral Exposure			me (ml/mol):	ml/mol		
GHS Oral Acute Toxicity Limit:	•					
Dermal Exposure			int Limit (°C):	TC .		
GHS Dermal Acute Toxicity Limit:	•		int Limit (°C):	°C		
GHS Skin Corrosion/Irritation Limit:	*	Viscosity L	imit (cp)	сp		
GHS Target Organ-Single-Skin Limit:	•	Flash Poin	t Limit ("C):	"C		
Occular Exposure		Density:	Low Limit g/L		between	High Limit g/L
GHS Eye Damage/Irritation Limit:	*	Refractive	Low Limit		between	High Limit
Inhalation Exposure		Index				
GHS Inhalation Acute Toxicity Limit:	*	RER	Low Limit HSP		between	High Limit HS
GHS Target Organ-Single-Respiratory Limit:	*	Cost				
SHS Aspiration Toxicity Limit:	•	Bulk Price	olvent based or	online v	ender inte	ormation,
Aquatic Toxicity						
GHS Acute Aquatic Toxicity Limit:		Lab Price:	10/E			
GHS Chronic Aquatic toxicity Limit:	*					



Examples of How We Are Using HSPiP

- Finding alternative to TCE to spot clean/immerse flux contaminated graphite molds
 - Company is currently throwing out molds
- Finding alternative to Toluene and NMP for immersion and spot cleaning to remove adhesive mixtures off stainless steel rollers
- Finding an alternative paint stripper for wood and metal to replace Methylene chloride



We Identified an Alternative!

- Implementation
 - Gather key informants and decision makers
 - Budget
 - Training
 - Connect with technical organization
 - MA OTA
 - MN MnTAP
 - Connect client to the vendor(s)
 - Chemistry
 - Equipment
- Evaluation
 - Are there issues with the new chemistry or equipment?
 - Feedback from workers





Questions?

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