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Hazardous Waste Reduction: Hexamethyldisiloxane

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CHEMICAL AND LIFE SCIENCE

Hazardous Waste Reduction

Hexamethyldisiloxane

CAPSTONE DESIGN EXPO 2016

Project Description

A waste stream is generated during the production of a silicone intermediate that must be disposed of at cost to QSi (.48$/lb). This stream contains two phases, which are mainly hexamethyldisiloxane (HMDS) and aqueous ammonium hydroxide in roughly 50/50 ratio by volume. The HMDS phase (upper) is flammable and is thus hazardous waste. The clean aqueous phase (lower) can be discarded via the sewer at no cost if the flash point is above hazardous classification (60 C). To continue production of their products, the process tanks must me emptied into drums. The volume of waste produced per year (13 tons/year) brings them over the large hazardous waste producer threshold, making them pay even more to dispose of the waste.

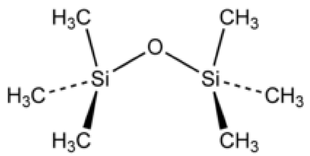

Figure 1. Hexamethyldisiloxane molecule.

Deliverables:

- Determine the amount of time and materials required for a clean separation such that the aqueous phase does not flash.
- Identify and quantify methods to accelerate the separation reducing yearly disposal to under 13 tons/year.
- Design and prototype a separation tank system that will allow an operator to safely decant the HMDS phase into drums and drain the clean aqueous phase into the sewer. The equipment must prevent the operator from draining flammable waste into the sewer while being intrinsically safe.

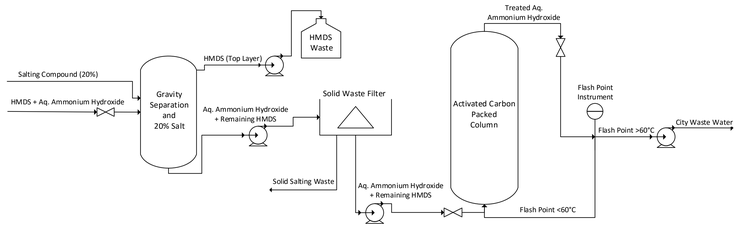

Figure 2. Process Flow Diagram for treatment of hazardous waste stream.

Separation Methods

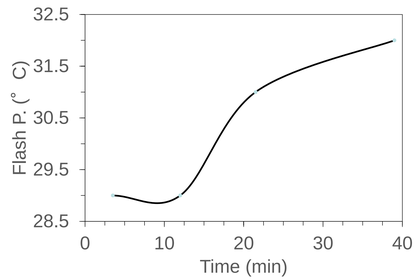

Figure 3. Flash point of aqueous samples over time of gravity separation.

Figure 4. Gravity separation utilizing salt on right and non-salting on left.

Figure 5. Activated carbon packed column test. Solution of 0.5% HMDS, pH 9, continuously stirred and fed into column at 16.2 mL/min. Samples collected at set time intervals and analyzed using GC-MS.

Packed Column Experiment		
Time (min)	Peak Area	HMDS%
0	15,954,467	0.49858%
2	5,670,223	0.17719%
5	91,413	0.00286%
10	2,360	0.00007%
15	6,383	0.00020%
30	2,180	0.00007%
75	2,805	0.00009%
105	6,961	0.00022%
120	17,097	0.00053%
165	5,662	0.00018%
195	7,125	0.00022%

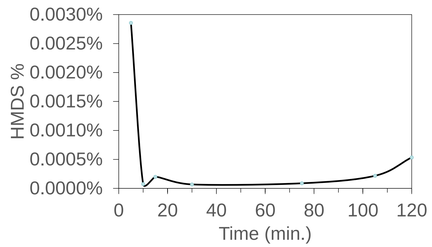

Figure 6. GC-MS data for HMDS% in samples collected from activated carbon packed column.

Design of Experiment

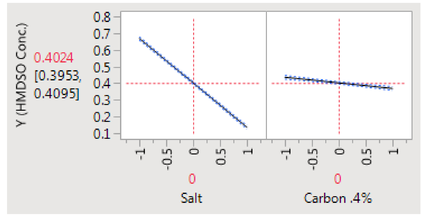

Figure 7. DOE analysis of salting and/or activated carbon treatment on HMDS%.

Return on Investment

Equipment Cost:	$ 9,000.00			ROI:	0.5040
Installation factor:	2.3			Payback period:	1.5
Years:	0	0.5	1	2	3
Equipment:	$ (20,700.00)				
Production (lbs):	0.00	18162.50	36325.00	36325.00	36325.00
Cost total dis:	0	$ (8,718.00)	$(17,436.00)	$ (17,436.00)	$(17,436.00)
Aq. phase (40%) (lbs):	0	7265	14530	14530	14530
Carbon wt%:	0	0.40%	0.40%	0.40%	0.40%
Carbon Weight (lbs):	0	29.06	58.12	58.12	58.12
Salt (NaCl) wt%:	0	20%	20%	20%	20%
Salt Weight (lbs):	0	1453	2906	2906	2906
Cost:	0	$ (97.35)	$ (194.70)	$ (194.70)	$ (194.70)
Cash Flow:	$ (20,700.00)	$ 5,133.45	$ 10,266.90	$ 10,266.90	$ 10,266.90
Total:	$ (20,700.00)	$ (15,566.55)	$ (5,299.65)	$ 4,967.25	$ 15,234.14

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VCU School of Engineering

Make it real.

VIRGINIA COMMONWEALTH UNIVERSITY