CYTEC

Surface Specialties

SANTOSOL® Dimethyl Esters

Properties and Uses

About Us

Cytec Industries Inc.

Cytec Industries is a specialty chemicals and materials technology company with sales of about $ 3 billion. Its growth strategies are based on developing technologically advanced customer solutions for global markets including: aerospace, coatings, mining, plastics and water treatment.

Cytec Surface Specialties

Cytec Surface Specialties manufactures and markets a broad range of technically innovative products for applications in key coating markets such as architecture and construction, automotive and transportation, graphic arts, wood and paper, plastics and general industries.

A leader in environmentally-friendly coatings technologies, we are a total solution provider – offering an extensive range of high-performance products, supported by a deep level of technical expertise.

Product Range

Cytec Surface Specialties offers a comprehensive product range, including many world-class technologies that have earned leading positions in their target markets. These are divided into three main groups:

– Liquid Coating Resins and Additives

– ***RADCURE***® and Powder Resins

– Adhesives, Bonding and Formulation Resins

Cytec Surface Specialties leads in

- UV/EB curable systems
- Powder coating resins
- Waterborne alkyds
- Waterborne epoxies
- Waterborne resin systems in primer surfacer, base and clear coats for automotive OEMs

Global Presence

Headquartered in Brussels (Belgium), **Cytec Surface Specialties** operates ISO-certified manufacturing facilities.

Our ten technology centers – located in Europe, Asia and North America – offer customers ready access to world-class technical support and applications research.

We also have sales offices in more than 30 countries, enabling us to provide responsive service around the globe, and to help our customers identify and profit from emerging opportunities.

Contents

Introduction

SANTOSOL® products are dimethyl esters of adipic, glutaric and succinic acids. They are employed in a wide variety of applications as solvents, formulating agents and chemical intermediates. They are cl ear, colorless liquids offering a unique combination of high solvency power, low volatility and cost, high flash point, and are readily biodegradable.

Cytec Surface Specialties offers several grades of Santosol dimethyl esters (DMEs), ranging from highly purified individual grades to specific mixtures of two or three ester components. In certain cases, Surface Specialties can provide Santosol dimethyl esters in custom blends. This allows you to determine the optimal ester product composition for your specific applications. Contact your technical services or sales representative for more details regarding specialized composition requirements.

For further information about **Cytec Surface Specialties** and our wide range of products, visit our web site at

www.surfacespecialties.com

ISO 9001–2000 Certification

The ***SANTOSOL*** dimethyl esters process was awarded ISO 9001–2000 certification in May 2003.

ISO certification is based on internationally uniform standards for quality assurance and management, as formulated by the International Organization for Standardization (ISO). These standards help to ensure consistent quality of goods and services produced throughout the world.

ISO recognition covers all areas of production, from supply to manufacturing.

The evaluation and certification process establishes a minimum level of achievement for each of 20 separate areas – from inspection and testing, purchasing and process control, to handling and storage, employee training and management responsibility. The entire production process and quality system are intensely scrutinized by an accredited registrar; in this case, the internally known Quality Management Institute.

Products and Specifications (Table 1)

	DMS	DMG	DMA	DME	DME-1	DME-2	DME-3	Test Method
Compositional Ranges, wt. %								
Dimethyl succinate	≥ 98.5	–	–	17–21	17–25	≤1.0	≤1.0	01504
Dimethyl glutarate	–	≥ 99.0	–	61–65	59–73	72–76	8–12	01504
Dimethyl adipate	–	–	≥ 99.0	14–22	10–14	23–27	87–91	01504
Acid Content, mg KOH/g, max.	0.1	0.1	0.1	0.3	0.3	0.1	0.1	01396
Water Content, wt. %, max.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	01395
Methanol Content, wt. %, max.	0.1	0.1	0.1	0.2	0.2	0.1	0.1	01504
Color, APHA, max.	50	50	50	50	50	50	50	01397
Dimethyl Ester Content, wt. %, min.	99.0	99.0	99.0	99.0	99.0	99.0	99.0	01504

Basic Chemistry

SANTOSOL® dimethyl esters consist of both purified and mixed grades of adipic, glutaric and succinic dimethyl esters.

They are produced by reacting methanol with a mixed dibasic acid stream and then separated via fractionation to yield the various grades.

$2CH_3OH + COOH\ (CH_2)n\ COOH \rightarrow CH_3O2C\ (CH_2)n\ CO_2CH_3 + 2H2O$

where n = 2, dimethyl succinate
= 3, dimethyl glutarate
= 4, dimethyl adipate

Close control of the esterification and separation processes allows ***SANTOSOL*** dimethyl esters to be produced with very low levels of water, methanol, color and acid content.

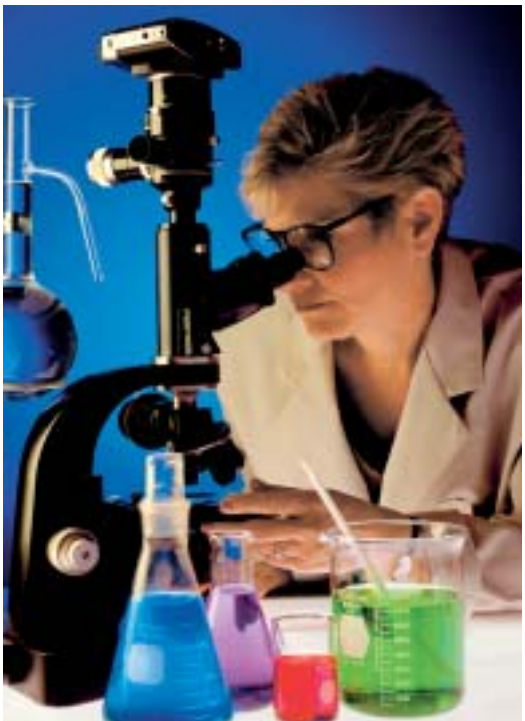
Chemical properties

SANTOSOL dimethyl esters are very stable under ambient conditions of humidity and temperature. They provide typical ester group reactivity, including saponification and hydrolysis. Transesterification reactions using alcohols or glycols are typically utilized to convert esters into useful plasticizer(s) and other polyester functional products.

Products and Specifications
Basic Chemistry, Properties (continued)

Physical Properties (Table 2)

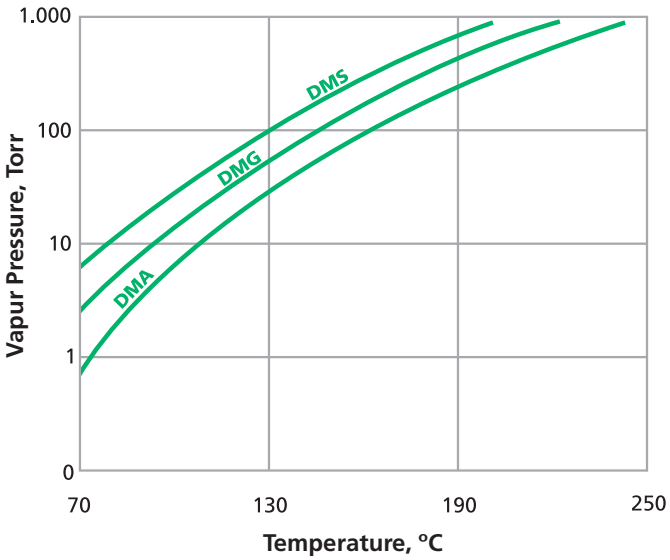
	DMS	DMG	DMA	DME	DME-1	DME-2	DME-3
Molecular Weight	146	160	174	160	159	163	172
Distillation Range, °C	192 – 201	203 – 214	216 – 230	200 – 220	195 – 216	203 – 220	211 – 229
Density, #/gal, @ 25 °C	9.28	9.03	8.82	9.06	9.10	8.98	8.83
Specific Gravity @ 25 °C	1.112	1.082	1.057	1.086	1.091	1.076	1.058
Viscosity, cps, @ 25 °C	3.91	3.66	4.33	3.88	3.88	3.31	3.71
Solubility in Water, wt. %	10.3	5.1	2.1	5.5	5.5	4.3	2.6
Water Solubility in DMEs, wt. %	4.0	2.9	2.9	3.6	3.6	3.2	2.8
Freezing Point, °C	16.8	–37.5	9.4	–40.2	–40.0	–42.4	2.8
Flash Point, °F (Pensky-Martin cc)	201	224	255	216	212	226	235
Flash Point, °C (Pensky-Martin cc)	94	107	124	102	100	108	113
Surface Tension, dynes/cm	34.6	35.6	35.1	35.4	35.3	35	32.5
Electrical Resistance, megohms	1.3	2.3	5.0	1.3	1.3	1.9	3.0
Vapor Pressure, torr, @ 20 °C	0.12	0.05	0.01	0.06	0.06	0.04	0.02



SANTOSOL® dimethyl esters present attractive alternatives to many established solvents, some of which have become increasingly regulated for environmental and health impact. Chlorinated solvents, such as methylene chloride and 1,1,1 trichloroethane and glycol ethers and their acetates, are examples of solvents which can be replaced with dimethyl esters.

As VOC levels become increasingly more restrictive, ***SANTOSOL*** dimethyl esters offer an effective, long-term solution for meeting VOC compliance in the formulation of coatings, cleaning solvents and other products.

Vapor Pressure Curves Vapor Pressure vs. Temperature (Graph 1)



For determining approximate vapor pressures at lower temperatures, the following equations may be used:

$$DMS_{vp} = \log P = 6.990707 - \frac{1512.082}{170.876 + T}$$

$$DMG_{vp} = \log P = 7.167485 - \frac{1693.981}{180.246 + T}$$

$$DMA_{vp} = \log P = 6.838338 - \frac{1512.946}{148.887 + T}$$

where P = vapor pressure in torr
T = temperature in °C

$DME\text{-}1_{vp}$ = 0.06 mm Hg @ 20 C

8 Selection Criteria

Solubility and Solvency

SANTOSOL® dimethyl esters are miscible in many common solvent types, including alcohols, ethers, ketones and most hydrocarbons. They are only slightly soluble in water but can be made miscible by the addition of a non-ionic surfactant.

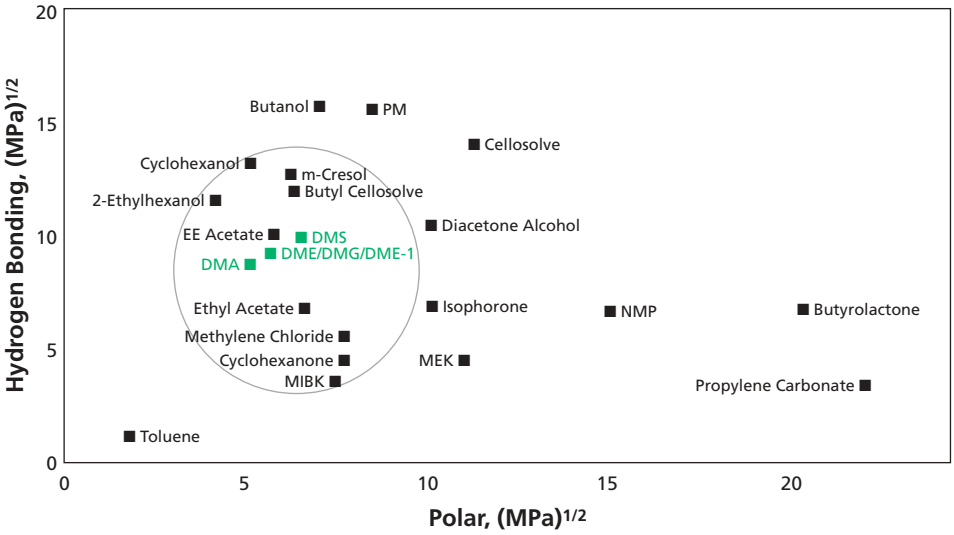
They are very efficient as solvents or in solvent blends, based on most solvent selection criterion. Solvent formulation guidelines and assistance is available from **Cytec Surface Specialties.**

Solubility of *SANTOSOL* in Various Solvents (Table 3)

Solvent	Solubility
Alcohols	
Methanol	S
Ethanol	S
n-Propanol	S
Isopropanol	S
n-Butanol	S
Isobutanol	S
t-Butanol	S
n-Pentanol	S
Cyclo-hexanol	S
2-Ethylhexanol	S
Esters	
Ethyl Acetate	S
Butyl Acetate	S
Propylene Carbonate	S
Cellosolve Acetate	S
Butyl Cellosolve Acetate	S
Propylene Glycol	S
Methyl Ether Acetate	S
Glycol Ethers	
Methyl Cellosolve	S
Cellosolve	S
Butyl Cellosolve	S
Propylene Glycol Methyl Ether	S
Diethylene Glycol Methyl Ether	S
Diethylene Glycol Ethyl Ether	S
Dipropylene Glycol Methyl Ether	S
Methylene Chloride	S
Trichloroethylene	S
Chloroform	S
Hydrocarbons	
Toluene	S
Ethyl Benzene	S
Xylene	S
Aromatic 150™	S
Heptane	I*
Ketones	
Acetone	S
Methyl Ethyl Ketone	S
Methyl Isobutyl Ketone	S
Methyl Amyll Ketone	S
Cyclohexanone	S
Isophorone	S
Other	
Water	VSS

S = Soluble, I = Insoluble, VSS = Very Slightly Soluble; * Testing also included DMG, DME-2 and DME-3

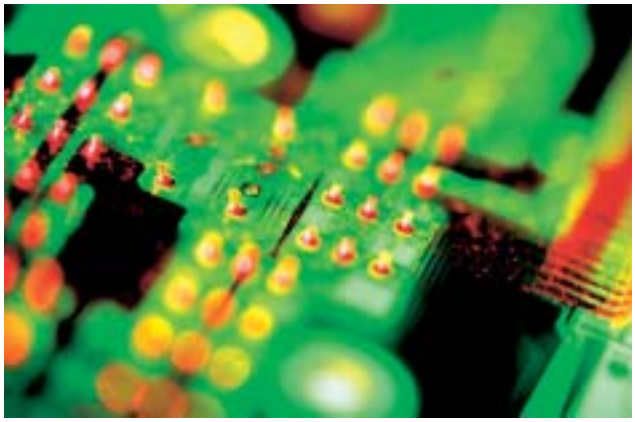
Hansen Solubility Parameters DME vs. Common Solvents (Graph 2)



Hansen Solubility Parameters[a] (MPa) 1/2 (Table 4)

	DMS	DMG	DMA	DME	DME-1	DME-2	DME-3
Non-Polar	16.4	16.4	16.4	16.4	16.2	16.4	16.4
Polar	5.3	4.7	4.2	4.8	4.7	4.6	4.3
Hydrogen Bonding	10.3	9.7	9.2	9.8	9.7	9.6	9.3

[a] Calculated from Hansen Parameter Group contributions, $(MPa)^{1/2}$ Ref. Alain F. M. Barton, CRC Handbook of Solubility Parameters and Other Cohesion Parameters, CRC Press Inc., pp. 82–87, 1988

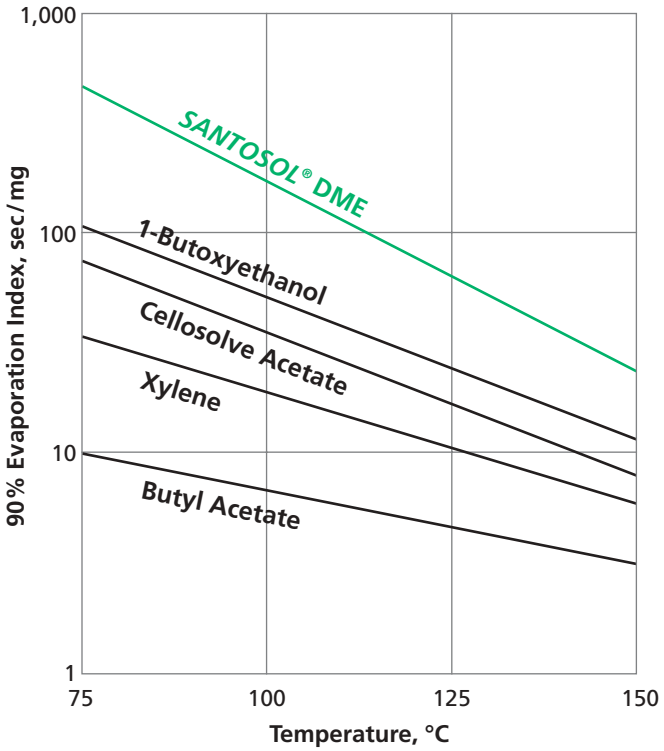


Selection Criteria
(continued)

Kauri-Butanol Values (Table 5)

DMS	DMG	DMA	DME	DME-1	DME-2	DME-3
30.1	43.7	58.7	41.4	41.4	49.7	60.9

Coating Solvents Evaporation vs. Temperature (Graph 3)



Solubility[1] of Coating Resins in *SANTOSOL*® Dimethyl Esters (Table 6)

Resin	DME-1/ DME	DME-2	DME-3
Epoxy			
BECKOPOX® EP 140	Clear Solution	Clear Solution	Clear Solution
BECKOPOX EP 301	Clear Solution	Clear Solution	Clear Solution
BECKOPOX EP 307	Clear Solution	Clear Solution	Clear Solution
Acrylic			
MODAFLOW® Resin	Clear Solution		
JONCRYL 500	Clear Solution	Clear Solution	Clear Solution
Polyester			
McWHORTER 5776	Clear Solution	Clear Solution	Clear Solution
McWHORTER 5770	Clear Solution	Clear Solution	Clear Solution
DYNAPOL LH 818-05	Clear Solution		
DYNAPOL L 411	Clear Solution		
Phenolics			
SANTOLINK® EP 560	Clear Solution	Clear Solution	Clear Solution
BTL 108	Clear Solution	Hazy	Hazy
Aminos			
CYMEL® 325	Clear Solution	Clear Solution	Clear Solution
CYMEL 301	Clear Solution	Clear Solution	Clear Solution
CYMEL 303	Clear Solution		
CYMEL 1133	Clear Solution		
CYMEL 202	Clear Solution		
Polyvinyl Butyral			
BUTVAR® B-72	VSS/Hazy[2]		
BUTVAR B-74	VSS/Hazy[2]		
BUTVAR B-90	VSS/Hazy[2]		
BUTVAR B-98	VSS/Hazy[2]		
BUTVAR B-76	Clear Solution		
BUTVAR B-79	Clear Solution		

VSS = Very Slightly Soluble, 1 = Solubility at 25 °C, 10 % Resin Solids, 2 = Clear Solution @ 80 °C

12 Applications

SANTOSOL® dimethyl esters are being used in an increasing number of industrial and commercial applications. The wide range of applications include:

Solvents

Coatings

- Coil Coatings
- Container Coatings
- Automotive Coatings
- Wire Enamel Coatings

Cleanup

- Paint/Coating Strippers
- Industrial Cleaners
- Waterborne Industrial Cleaners

Polymer and Chemical Intermediates

- Wet Strength Paper Resins
- Polyester Resins and Polyols
- Plasticizers
- Quinacridone Pigments

Chemical Grout

Foundry Binders

Solvents

Santosol dimethyl esters and blends with other solvents may be used to replace solvents, such as:

- methylene chloride
- isophorone
- glycol ethers and their acetates
- acetone
- cresylic acid
- N-methyl-2-pyrrolidone

SANTOSOL dimethyl esters are high boiling, low cost, low volatility, non-corrosive and have excellent solvency. Combined with the advantages of low toxicity and environ-mental impact, ***SANTOSOL*** dimethyl esters offer many advantages over more traditional solvents used in paint and coatings formulations.

Successful substitution of ***SANTOSOL*** dimethyl esters in solvent blends may be determined by Hansen solubility parameters for the various components. Resin behavior is evaluated in a variety of solvents utilizing the key parameters of hydrogen bonding, polar and non-polar interactions. Values for these three parameters may be plotted to illustrate which solvents or solvent blends have similar solubility characteristics. It is possible to select solvents, or combinations of solvents, having the required solubility within the solvent system chosen.

This allows the user to optimize the solvent(s) selection based on overall system efficiency, including costs, health hazards, solvency, viscosity, compatibility, environmental impact and handling requirements.

Coatings

■ Coil Coatings

The proper selection of solvents is a critical element in the formulation of coil primers and topcoats. The high bake temperatures and brief oven dwell times of the coil coating process demand a solvent balance which will preserve film integrity, appearance, and properties during cure. ***SANTOSOL***® dimethyl esters can be used to help maintain balanced evaporation rates to provide resistance to solvent popping under high throughput conditions and resistance to overbake defects. ***SANTOSOL*** DME-1 or DME can be used to effectively replace typical solvents such as isphorone, glycol ethers and others HAPS solvents thus enhancing the environmental sustainability of the coating system.

Gloss White Coil Appliance Top Coat Formulation

Part I (Dispersion)	Wt. %	Resin Solids
DYNAPOL LH 818-05 (Diluted in 7:3 ratio of Aromatic 150: Aromatic 200)	42.2	21.1
AEROSIL 200	0.2	
CL 310 Titanium Dioxide	27.5	
AROMATIC 200	4.2	
SANTOSOL DME or DME-1	8.3	

Mix under high speed agitation 10–20 minutes. Grind to Hegman 7-7.5.

Part II (Let Down)	Wt. %	Resin Solids
CYMEL® ***303***	5.5	5.5
Dilute: CAB 551-0.01 ***SANTOSOL*** DME or DME-1	 0.8 3.1	
MODAFLOW® ***2100*** (Diluted to 50% solids in xylene)	2.0	
K-SPERSE 152	0.2	
AROMATIC 200	2.0	
SANTOSOL DME or DME-1	4.0	

Cure Parameters	
Peak Metal	
Temperature (PMT)	450 °F (232 °C)
Oven Dwell Time	53 sec.
Dry film Thickness (DFT)	0.7–0.8 mils

Formulation Properties	
Melamine	80:20
Total Resin Solids	27 %
Total Solids	56 %
Total Solvent	44 %

Performance Properties	
MEK Resistance	200 double rubs
T-bend	0-1T
Impact Forward/ Reverse	70/70 in-lb (on Aluminum substrate)
Hardness (Tukon)	14.9

■ Container Coatings

SANTOSOL dimethyl esters may effectively replace isophorone, glycol ethers, glycol ether acetates and other HAPS solvents in can and container lining formulations. High solvency with low evaporation rates combine to allow good flow and levelling of the applied coating. It provides good coating flexibility and adhesion, important parameters in these applications.

SANTOSOL® DME-1 used in a typical container formulation follows:

Chromate free coil primer

Component	Wt. %
DUROFTAL® VPE 7186/ 60SNBMPAC	25.57
AROMATIC 200	2.66
EEP	2.91
SANTOSOL DME-1	2.95
1,6 hexanediol	1.31
Mix until dissolved	
AEROSOL 200	0.27
KRONOS 2310 TiO_2	15.69
Barium Sulfate	5.19
Aluminum Silicate, ASP Ultrafine	8.26
IRGACOR 252 LD	1.30
Grind to 7 Hegman with vertical bead mill	
DUROFTAL VPE 7186/60SNBMPAC	25.96
MODAFLOW® 2100	0.25
CYMEL® 303	2.00
CYMEL 325	1.22
2-Butoxyethanol	3.90
ADDITOL VXK 6395	0.57
Total	100.00

Cure Conditions	
Oven	560 °F (293 °C)
Peak metal temperature	450 ± 10 °F (232 °C)
Dwell	30 seconds
Film Build	0.2 mil (5 µm)
Performance Results	
MEK double rubs	–20
With PVDF topcoat (0.80 mil)	
T-bend	0T
Cross hatch tape test	no loss
MEK double rubs	200 +

QUV exposure on scribed panel passes 4000 hours (> 166 days) in tape pull adhesion test.

■ Automotive Coatings

SANTOSOL DME-1 may be utilized in a variety of automotive OEM and refinish coating applications and resin types. It may be used in surface primers to replace regulated solvents, such as certain glycol ethers, to provide desired flow and smoothness characteristics. In acrylic and alkyd top coats, ***SANTOSOL*** contributes to the smoothness and gloss of the finish. Wetout, leveling and reflow characteristics are enhanced when small accounts of DME-1 are included in the formulation.

■ Wire Enamel Coatings

SANTOSOL DME-1 is an excellent choice as a solvent for use in Butvar polyvinyl butyral, polyvinyl formal, polyurethane, polyester and polyestermide coating formulations. It may replace cresylic acid in total, in polyester and polyestermide systems. Higher total solids and lower viscosities are achievable using DME-1. Its non-corrosiveness benefits the user by reducing storage and handling liabilities.

Cleanup

■ Paint /Coating Strippers

SANTOSOL DME-1, DME-2 and DME-3 may be formulated as paint and coatings strippers, replacing the more commonly used methylene chloride compositions. Blends of ***SANTOSOL*** with other solvents, such as N-methyl-2-pyrrolidone can effectively remove various coating types, including lacquers, enamels and urethanes.

SANTOSOL®-based formulations may be used for removing buildup in spray booths, as well as most paint application equipment (spray nozzles, circulating lines and associated support equipment). Typical formulations will include thickeners, stabilizers for pH control and other ingredients. Proper formulation of ***SANTOSOL***-based paint strippers can offer advantages over methylene chloride based strippers, including:

- longer residence times without viscosity build
- reduced wood swelling and damage

Due to the differences between ***SANTOSOL*** vs. methylene chloride-based stripping mechanisms, ***SANTOSOL*** formulated strippers generally require up to twice the removal times. The small molecular size of methylene chloride allows it to rapidly penetrate and swell a coating to 3–4 times its normal volume. The pressure and tension due to the swelling release the coating from its substrate. Since the coatings are not actually dissolved by the methylene chloride, they are unlikely to re-adhere to the substrate.

SANTOSOL-based strippers dissolve the coating and, due to its low volatility, prevent the coating from re-adhering to the substrate before the solubilized coating is removed.

With the continued pressure to reduce the use of chlorinated solvents due to their ozone depleting and human health effects, there is a need to find suitable replacements for methylene chloride-based paint stripper formulations. Santosol dimethyl esters offer low cost, volatility and toxicity; are environmentally safe; and can be formulated into general purpose paint strippers.

A designed set of experiments was run to determine the optimal combination of three chosen solvents yielding the shortest strip time at the lowest raw material cost.

The solvents used were N-methyl pyrrolidone (NMP), tripropylene glycol methyl ether (TPM) and ***SANTOSOL*** DME-1. A total of 12 experiments were run, covering 10 compositions with three replicates of the center point. The compositions used are given in Table 7 and shown graphically in Graph 4, where the numbers on the design points correspond to the run order.

The stripper solutions were tested on three paint systems. Paint A was an air-dried polyurethane clear suitable for both interior and exterior use. It was applied in two coats on unprimed oak panels. Paint B was a force-dried yellow high-solids enamel which was applied over cleaned CRS panels at 0.8–1.0 mil dried film thickness (DFT). Paint C was force-dried red high-solids enamel, also applied over cleaned CRS panels at 0.8–1.0 DFT. All coatings were aged 10 days prior to testing.

Stripper solutions were applied to the coated panels and allowed to sit for a maxium of three hours. A 3° wide area was checked with a scraper every five minutes for the first 30 minutes, and then every 30 minutes up to the three-hour maxium. Results are shown in Tabel 7 as minutes to complete (>95 %) removal. Compositions with 200-minute times had good, but not complete, removal after three hours.

Applications
(continued)

Paint Stripper Solvent Mixture Design (Table 7)

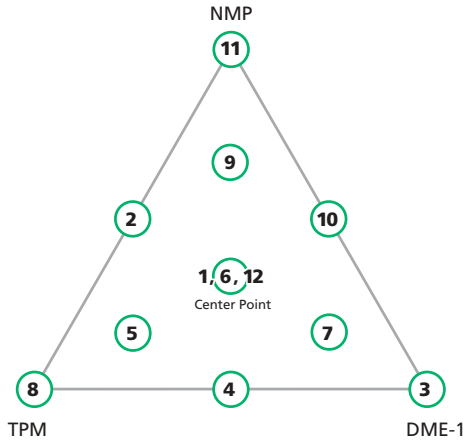
Run Order	Design Point	Weight NMP	Weight TPM	Weight DME-1	Cost of Mixture	Strip Time, Minutes		
						A	B	C
1	7	33.3	33.3	33.3	0.976	15	5	5
2	4	50.0	50.0	0.0	1.215	15	5	5
3	3	0.0	0.0	100.0	0.5	200	5	15
4	6	0.0	50.0	50.0	0.585	200	15	15
5	9	16.7	66.7	16.7	0.824	20	20	5
6	7	33.3	33.3	33.3	0.976	25	5	5
7	10	16.7	16.7	66.7	0.739	20	15	5
8	2	0.0	100.0	0.0	0.670	200	5	60
9	8	66.7	16.7	16.7	1.369	20	5	5
10	5	50.0	0.0	50.0	1.13	10	5	5
11	1	100.0	0.0	0.0	1.760	25	5	5
12	7	33.3	33.3	33.3	0.976	20	5	5

Paint A = Polyurethane on oak, Paint B = Yellow high-solids enamel, Paint C = Red high-solids enamel
Solvent mixtures also contained 1% by weight of Hercules Klucel H-PR thickener

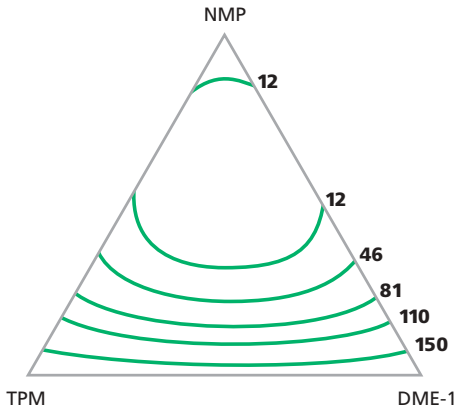
Strip times for paints A, B and C were fit to special cubic models. Contour plots from the models are shown in Graphics 5 – 7. Regions of lowest strip times are the most effective stripper compositions. As can be seen in Graph 5, mixtures of solvents are sometimes more effective than pure solvents. For all three paints, mixtures rich in DME-1 are effective strippers.

The cost of the stripper solutions is also of interest. Calculated costs in dollars/pound of the three solvents and all mixtures are given Table 7 and shown in Graph 8. Since both cost and effectiveness are important, models for both were combined and searched for compositions of low cost and high effectiveness. In Graph 9 – 11, the light areas are compositions which cost less than $ 1.00/pound and completely strip the paint in 40 minutes. Since DME-1 is the lowest-cost solvent in the mixtures, it follows that mixtures rich in DME-1 are cost-effective strippers.

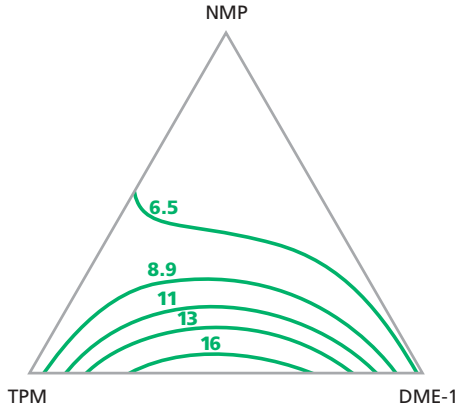
Paint Stripper Mixture Design (Graph 4)
Experimental points identified by run order



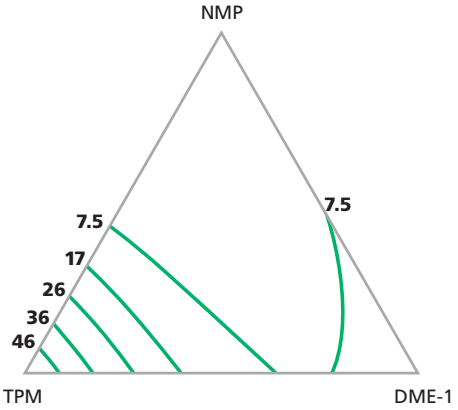
Mixture Strip Time (Graph 5)
Strip time in minutes for a polyurethande on oak



Mixture Strip Time (Graph 6)
Strip time in minutes for a yellow high-solids enamel

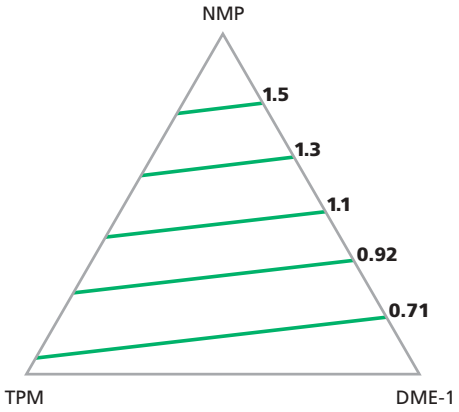


Mixture Strip Time (Graph 7)
Strip time in minutes for a red high-solids enamel

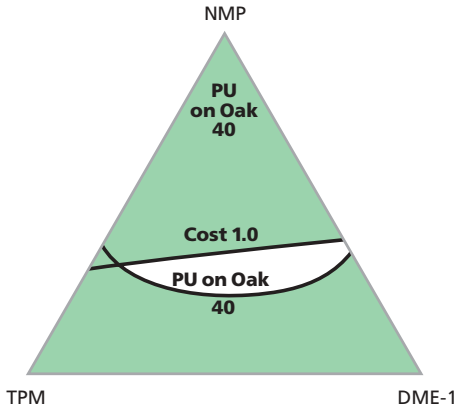


Applications
(continued)

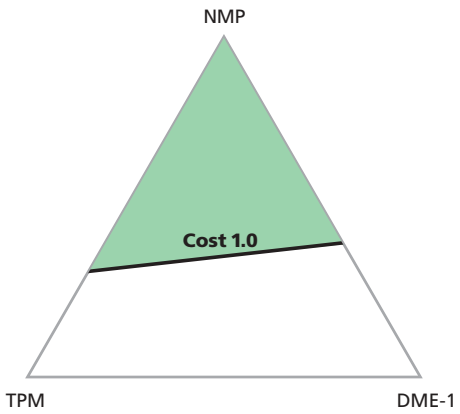
Paint Stripper Mixture Cost (Graph 8)
Dollars per pound



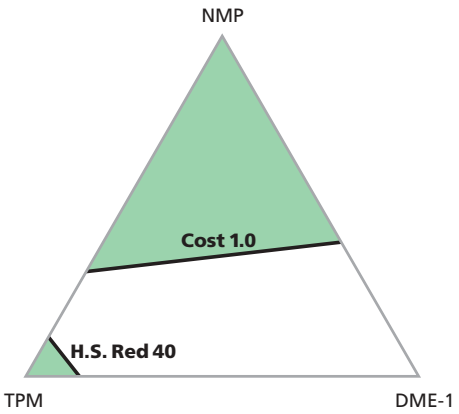
Paint Stripper Optimization (Graph 9)
Polyurethane



Paint Stripper Optimization (Graph 10)
Yellow high-solids enamel



Paint Stripper Optimization (Graph 11)
Red high-solids enamel



In summary, NMP, TPM and ***SANTOSOL***® DME-1 and their mixtures were evaluated as strippers of three different paints. Stripper effectiveness was evaluated over a three-four period and fitted to special cubic models. It was shown that sometimes mixtures are more effective than individual solvents, and that mixtures rich in ***SANTOSOL*** DME-1 are very effective. Since ***SANTOSOL*** DME-1 is also relatively low in cost, it is an attractive solvent for use in general-purpose paint strippers.

■ Industrial Cleaners

SANTOSOL® dimethyl esters and Santosol solvent blends may be effectively used for cleaning partially cured residues from equipment and work areas. ***SANTOSOL*** DME-1, both neat and in solvent blends, is an excel-lent choice for dissolving urethane, acrylic, epoxy, and polyester or alkyd resins. It also removes polyurethanes, unsaturated polyesters, and elastomers. The low volatility of ***SANTOSOL*** dimethyl ester based leaners prevents the solubilized coating or resin from re-adhering to the substrate.

Waterborne Industrial Cleaners
DME-1 may be combined with water using surfactants, emulsifiers, thickeners, emollients and other additives to formulate cleaning liquids, gels and pastes. ***SANTOSOL***-based cleaners can remove residue from a variety of substrates such as glass, metal, wood, and many plastics. Stains can be cleaned from carpets or textiles.

Waterborne Emulsion Industrial Cleaning Liquid

SANTOSOL DME-1 provides effective cleaning results when formulated into a water based emulsion at levels between 40 % and 60 %.

Premix A	Wt. %
Agitate until homogenous	
SANTOSOL DME-1	58.2
Sorbitan Monooleate	1.8

Premix B	Wt. %
Blend separately, under high shear	
Deionized Water	39.3
Alkyd ether sulfate, sodium salt	0.35
Ammonium lauryl sulfate	0.35
Total	100.00

Add Premix A to Premix B
Slowly add the DME-1 phase (3 – 5 % min.) to the water phase under high shear (6,000 rpm). Agitate an additional five minutes after all components are added. Maintain temperature below 90 °C to minimize evaporation.

Mixing Equipment:
Homogenizer or high shear mixer

Formulation Properties:
Consistency = Milky liquid
Viscosity @ 25 °C = 4 cps

Application:
Spray, brush, or dip tank
Let set 15 – 30 minutes
Rinse with water and/or wipe dry

Emulsified Industrial Cleaning Paste

An efficient water-based cleaning paste can be prepared from ***SANTOSOL*** DME-1 in levels ranging from 40 % to 60 %.

Premix A	Wt. %
Agitate until homogenous	
SANTOSOL DME-1	58.2
Sorbitan Monooelate	1.8

Premix B	Wt. %
Combine and mix in hand mixer	
Deionized Water	37.3
Alkyd ether sulfate, sodium salt	0.35
Ammonium lauryl sulfate	0.35
CARBOPOL ETD2691	2.0
Total	100.00

Add Premix A to Premix B
With hand mixer, slowly add the DME-1 phase (3–5%/min.) to the water phase. Agitate an additional 5 minutes after all components are added.

Mixing Equipment:
Wearing Blender of Hand Mixer

Formulation Properties:
Consistency: White Paste

Application:
Brush, roll or spatula
Let set 15–30 minutes
Rinse with water and/or wipe dry

Emulsified Industrial Cleaning Gel

An effective water-based cleaning gel can be formulated with ***SANTOSOL***® DME-1 and Kelzan Xanthan Gum.

Premix	Wt. %
Agitate 45 minutes at moderate high Shear (3000 rpm)	
Deionized Water	80.0
Keizan Xanthan Gum	0.7
Add slowly (3–5 min) under continous mixing ***SANTOSOL*** DME-1	19.3
Total	100.00

Blend in a Dispersator mixer (or equivalent). Ensure that the emulsion is maintained as an aqueous environment during the DME-1 addition. Agitate continuously for 10 additional minutes after all components are added.

Mixing Equipment:
Dispersator mixer

Formulation Properties:
Consistency: Hazy Gel

Application:

Brush or spray
Let set 15–30 minutes
Rinse with water and/or wipe dry

Waterborne Emulsion Industrial Cleaning Solution

A water-based solution with co-solvent is generally used in applications where a water-borne solution is preferred but the solvency of organic solvents is required.

Premix	Wt. %
Add the alcohol to ***SANTOSOL*** DME-1 and mix	
SANTOSOL DME-1	39.0
Isopropanol	22.0
Add and mix for five minutes	
Deionized Water	19.3
Total	100.00

Mixing Equipment:
Air mixer

Formulation Properties:
Consistency: Clear liquid

Application:
Spray, brush, or dip tank
Let set 15–30 minutes
Rinse with water and/or wipe dry

Polymer and Chemical Intermediates

■ Wet Strength Paper Resins

Glutarate rich fractions (DMG and DME-2) are employed as raw materials in the formation of wet strength paper resins. The ester is converted to its corresponding acid via methanol removal. Subsequent reactions produce water soluble cationic polymers which are then used to impart wet strength properties to paper.

■ Polyester Resins and Polyols

SANTOSOL® dimethyl esters are used in the manufacture of saturated and unsaturated polyester resins and for polyols used in various polyurethane applications.

■ Plasticizers

SANTOSOL dimethyl esters are used to provide economical sources of adipic, glutaric and succinic acids in reactions forming diester and polyester plasticizers. They may also be used as fugitive plasticizers where shorter term, temporary flexibility is needed and acceptable.

■ Quinacridone Pigments

SANTOSOL DMS (dimethyl succinate) may be used as a raw material in the manufacture of DMSS (dimethyl succinyl-succinate), which is further processed to produce quinacridone red pigments.

Chemical Grout

SANTOSOL dimethyl esters are used with sodium silicates in chemical grouting applications such as soil stabilization in excavation areas such as underground tunnels, dam and building construction and repair. Dimethyl esters, water and sodium silicate react to form "silica gel" which acts as a binder to solidify and stabilize the soil. By proper selection of ***SANTOSOL*** grade and dimethyl ester blend composition, setup times may be varied to achieve the desired timeframe for a broad range of temperatures.

Foundry Core Binders

SANTOSOL dimethyl esters are excellent solvents for use in phenolic or urethane resin-binding formulations. Improved tensile strength of cured mold shapes and increased pot life, combined with low cost and toxicity, make Santosol dimethyl esters a very good choice for this application.

22 Health, Safety and Handling

Exposure

As with any organic solvent, ***SANTOSOL***® dimethyl esters should be used with adequate ventilation, and direct skin contact exposure should be avoided by use of proper protective equipment. ***SANTOSOL*** dimethyl esters may cause eye and respiratory tract irritation. Use of appropriate protective clothing and chemical-resistant gloves is suggested. Where there is significant potential for eye contact, wear chemical goggles and have eye flushing equipment available. For additional information, consult the Material Safety Data Sheet for the Specific ***SANTOSOL*** product.

Toxity

Cytec Surface Specialties has conducted a series of toxity studies on ***SANTOSOL*** dimethyl esters. These and other studies conducted with the components of ***SANTOSOL*** have been referenced in a summary of toxicity effects of dimethyl esters, and is available upon requests. The three compo-nents of DME-1 and DME are included in the TSCA Chemical Inventory List.

Component	CAS. NO.	Formula
Dimethyl succinate	106 – 65 – 0	$C_6H_{10}O_4$
Dimethyl glutarate	1119 – 40 – 0	$C_7H_{12}O_4$
Dimethyl adipate	627 – 93 – 0	$C_8H_{14}O_4$

Biodegradability

All ***SANTOSOL*** dimethyl ester grades were tested in a modified SCAS test according to OECD guidelines test 302A and were found to have 100 % dissolved organic removal in 24 hours. This meets the OECD guidelines for inherently biodegradable and would be expected to be rapidly biodegradable in a domestic sewage treatment facility.

Storage

SANTOSOL dimethyl esters may be stored and handled without special precautions. They are stable when stored under conditions of normal heat and humidity and may be stored/used with mild steel containers and equipment. They are non-corrosive, are photochemically non-reactive (per California South Coast District Rule 102), and are not classified as hazardous materials by DOT. They are not flammable nor combustible under OSHA regulations.

Elastomers and Plastics Compatibility

It is important to select compatible materials for containers, seals, gaskets, etc., which may be exposed to ***SANTOSOL*** products. ***SANTOSOL*** is compatible with a variety of elastomers including neoprene, silicone, and ethylene propylene polymers. Tetrafluorethylene, as well as polyolefinics including polyethylene and polypropylene, are also compatible.

Use of buna-N rubber (NBR), fluoroelastomers and polyurethane types are not recommended, as these may swell or otherwise degrade.

Material	Supplier
AEROSIL 200 Fumed silica	Degussa
ADDITOL	Cytec Surface Specialties
Alkyl Ether Sulfate, Sodium Salt	Stepan Company
Aluminum silicate, ASP ultrafine	Engelhard
Ammonium Lauryl Sulfate	Stepan Company
AROMATIC 150, 200 Hydrocarbon solvents	ExxonMobil Corp.
BECKOPOX	Cytec Surface Specialties
Benzoguanamine Resin	BTL Industries
BTL 108 Phenolics	BTL Industries
BUTVAR Resins	Solutia Inc.
Butyl Cellosolve Acetate	Dow Chemical Co.
CAB 551-0-01 Cellulose acetate butyrate	Eastman Chemical Co.
CARBOPOL ETD 2691 Thickener	Noveon Inc.
CELLOSOLVE Acetate	Dow Chemical Co.
CL 310 Pigments/Ti02	Kronos
CYMEL	Cytec Surface Specialties
DUROFTAL	Cytec Surface Specialties
DYNAPOL L 411, L 490, LH 818-05 Polyester resins	Degussa

Material	Supplier
Ektasolve DB Solvents	Eastman Chemical Co.
JONCRYL 500 Acrylic resins	S.C. John Company
IRGACOR 252 LD Corrosion inhibitor	Ciba
Kelzan Xanthan gum	C.P. Kelco
KRONOS 2310 TiO_2	Kronos
K-SPERSE 152 Dispersing agents	King Industries
McWhorter 5770, 5776 Polyester coating resins	Hexicon Specialty Chemicals
Methyl Cellosolve	Dow Chemical Co.
MODAFLOW Resins	Cytec Surface Specialties
N-Methyl-2-Pyrrolidone (NMP)	BASF, International Specialty
PLUSOLIT H Polyester resin	Omya AG, KPI Co. LTD
SANTOLINK EP 560	Solutia Inc.
Sorbitan Monooleate Surfactant	ICI Americas (Uniqema)
Titanium Dioxide CL 310	Kronos
Tripropylene glycol methylether (TPM)	Ashland Chemical
Klucel H-PR thickener	Hercules Inc.

Ordering and Shipping Information

SANTOSOL® DMEs are available in tank truck quantities. Drum quantities are available through authorized distributors.

Dot Classification

DMEs are not classified as hazardous materials.

Freight Classification

Paint and Lacquer solvent.

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