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## Discussion and Comparison of Three Vapor Degreasing Alternatives

The purpose of this report is to briefly summarize and compare the efficacy of three popular vapor degreasing solvents: trichloroethylene, n-propyl bromide, and MicroCare CMS cleaning fluid.

### Background Information

Trichloroethylene (also called "TCE") is a colorless, volatile unsaturated aliphatic halogenated hydrocarbon. It is commonly used for cleaning of metals since the early 1930s. With its high boiling point, it found favor as a "vapor" degreasing solvent. It is an excellent cleaner for almost all types of contamination; however, it is quite aggressive.

Normal-propyl bromide (also called "nPB") was developed in the 1990s as a replacement vapor degreaser solvent with improved environmental characteristics. This chemical has been used in industrial degreasing, electronic defluxing, adhesives, coatings, inks, aerosols and other specialties. The cleaning power and drying rate of an nPB-based solvent matches 1,1,1 trichlorethane which was phased out due to its ozone depletion potential.. The US EPA has not permitted nPB to be used in aerosol or hand-wiping applications.

MicroCare CMS solvent is a proprietary cleaning fluid engineered as a mixture of two hydrofluorocarbon liquids, plus methanol and trans-1,2-dichloroethylene. It was designed to replace HCFC-141b and CFC-113 in their applications. It is used as a defluxer and as a precision industrial cleaning where enhanced solvency is required. It is milder than the other two cleaners, but has a number of important characteristics that make it an excellent choice in many applications.

The following pages provide more details regarding these products.

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## Comparison of Three Popular Vapor Degreasing Liquids

<i>Characteristic</i>	<b>TCE</b>	<b>nPB</b>	<b>MicroCare CMS</b>
<b>Technical Details</b>			
CAS Number	79-01-6	106-94-5 n-Propyl	See MSDS
Chemical Family	Chlorinated	Bromide (nPB)	HFC & trans
Appearance	Clear to Pale Blue Liquid	Clear to Pale Yellow Liquid	Clear Liquid
Boiling Point	87°C	71°C	36°C
Azeotrope	Not a mixture	Not a mixture	Yes
Specific Gravity @ 25°C	1.47	1.32	1.33
Kauri Butanol Value (Kb)	124	125	45 (est.)
Viscosity (cps) @ 25°C	0.53	0.49	0.58
Surface Tension (dynes/cm) @ 25°C	32	25.9	19.2
Vapor Pressure (mm Hg)	57.8	111	497
Evaporation Rate (TCA = 1)	<1	0.96	++>1
Percent Volatile	100%	100%	100%
Heat of Vaporization (cal/g @ BP)	50.1	58.8	54.0
Solubility in Water, %	0.11%	0.10%	<500 ppm
Solubility of Water in Solvent, %	0.40%	1.00%	<200ppm
<b>Health, Safety &amp; Environmental Data</b>			
Toxicity Rating (ppm, 8-Hr. ACGIH TLV)	50	10	260 (Calc.)
Flashpoint (TCC)/Rating	None/ Nonflam.	None/ Nonflam.	None/ Nonflam.
Ozone-Depletion Potential	Negligible	0.0006	Zero
Non-Exempt Organic Content (g/L)	1,470	1,322	590
Global Warming Potential (GWP)	140	0.31	639
NFPA Health:	Health 2; Fire: 1; Reactivity: 1	Health: 2; Fire: 1; Reactivity: 0	Health: 1; Fire: 0; Reactivity: 1

## Comparison of Three Vapor Degreasing Solvents

Characteristic	TCE	nPB	CMS
Cleaning Strength	Very strong degreaser, main focus is to clean metal parts	The cleaning power and drying rate of nPB is nearly equivalent to that of 1,1,1 trichloroethane	A highly effective defluxer and medium-strength degreaser
Wetting Index; a composite index of density, viscosity and surface tension. Higher scores indicate better cleaning (Water=31)	86	103	111
Material Compatibility	Aggressive solvent on elastomers and plastics. The cleaner is sensitive to white metals. Test carefully before deployment.	Aggressive solvent on elastomers and plastics. The cleaner is sensitive to white metals. Test carefully before deployment.	Generally considered plastic-safe, although testing is always recommended. No problems with any white metals
Ease of Use	Requires careful training of employees and good disciplines. Not suitable for aerosol or hand-wipe applications. Use only in engineered equipment meeting NESHAP standards. Requires weekly acid testing.	nPB requires rigorous training of employees and superior disciplines. Not suitable for aerosol or hand-wipe applications. Not suitable for use in older vapor degreasers without retrofit. Requires weekly acid testing	Used in engineered equipment to take advantage of recycling solvent over and over again. No acid testing required
Energy Consumption	Highest	Medium	Lowest
Aroma	Characteristic solvent aroma	nPB has a very pronounced and unpleasant aroma	Very light, ethereal aroma, barely noticeable
Global Warming	Manageable. Higher than nPB, lower than CMS, but probably not low enough to avoid new regulations coming in the next five years on GWP issues	nPB has the lowest GWP of any new solvent	It has a global warming factor that is higher than nPB and TCE, but in a properly designed system the emissive losses are so small as to not be a factor
Ozone Impact	Completely ozone-safe	Very low. Not listed as an Ozone-Depleting Material on the Montreal Protocol because the product was not in use in the 1980s	Completely ozone-safe

## Comparison of Three Vapor Degreasing Solvents

Smog ("VOC")	TCE is a volatile organic compound (VOC) and contributes to smog in the cities	nPB is a volatile organic compound (VOC) but has a half life of 11 days in the atmosphere, so it contributes little (if at all) the smog issue	MicroCare CMS has some ingredients which may contribute to smog
Stability	Water can be a problem in a vapor degreaser. If the parts being cleaned contain large quantities of water, the water can react with TCE and the system can "turn acid" (over several weeks or a month, for example). TCE is significantly MORE stable than nPB but less stable than CMS	Pure, untreated n-PB is inherently unstable and unsuitable for cleaning. It requires additives in the fluid to prevent the system from "turning acid." For example, if the parts being cleaned contain large quantities of water, the water can react with nPB and the system can "turn acid" relatively quickly (over a weekend, for example). nPB is the least stable of these three solvents	MicroCare CMS is very stable, does not react with water and will not turn acid. This minimizes maintenance and training issues
Waste disposal	TCE is regulated material in many countries, requiring extra subsystems on the vapor degreaser to control worker exposure and tracking of disposal	Needs proper disposal	Needs proper disposal
Boiling Point	In some applications, high-temperature cleaning fluids are used to simply melt insoluble contamination off the parts. The most common example is removing waxes. In this case, TCE is a very good choice because of the high boiling point	In some applications, high-temperature cleaning fluids are used to simply melt insoluble contamination off the parts. The most common example is removing waxes. In this case, nPB is a very good choice because of the high boiling point	Because CMS boils at a lower temperature, a degreaser using CMS will use significantly less energy
Versatility	Not approved for aerosol or hand-wiping applications	In the U.S., nPB is not permitted to be used in aerosol or hand-wiping applications due to the toxicity issue	Use anywhere, on anything

## Comparison of Three Vapor Degreasing Solvents

<p>Training &amp; Support</p>	<p>While all three of these products can be used safely in properly designed and maintained vapor degreasers, TCE must not to be used without proper training and product stewardship. It has relatively low toxicity ratings and this can lead to health risks in a poorly managed environment</p>	<p>While all three of these products can be used safely in properly designed and maintained vapor degreasers, nPB must not to be used without proper training and product stewardship. It has very low toxicity ratings and this can lead to health risks in a poorly managed environment</p>	<p>Requires training to avoid unnecessary solvent losses</p>
<p>Toxicity (TLV or PEL, 8-hour time-weighted average for a 30-year career. Lower scores are more toxic and dangerous; highest possible score is 1,000. IPA Alcohol = 400)</p>	<p>TLV=10. Suspected carcinogen. The health effects of trichloroethylene have been studied extensively. The International Agency for Research on Cancer (IARC) currently considers trichloroethylene to be "probably carcinogenic to humans" (Group 2A); other studies have produced different conclusions and there is no clear consensus</p>	<p>TLV = 10 ppm. It is currently being studied in the U.S. for potential long term health effects. Should be used in engineered system.</p>	<p>TLV=200. MicroCare CMS is roughly 20 times safer than nPB and four times safer than TCE</p>
<p>Cost</p>	<p>TCE is a commodity chemical produced in many countries around the world. TCE also is an intermediate product used in many chemical processes, such as making PVC. Because of this wide-spread availability, the cost-per-kilo of TCE is low</p>	<p>nPB is a commodity chemical produced in many countries around the world and in many grades or qualities. Because of this wide-spread availability, the cost-per-kilo of nPB is moderately low</p>	<p>MicroCare CMS is a specialty formulation produced specifically for the precision cleaning industry. Because of its unusual characteristics and narrow demand, the cost-per-kilo of CMS is higher than the other two choices.</p>

Sources:

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