



## DMSO vs. NMP

### Frequently Asked Questions

Solvents like Dimethyl Sulfoxide (DMSO) and *N*-Methylpyrrolidone (NMP) have important applications in the microelectronics industry, and are used in paint stripping and industrial cleaning applications.

Concerns about NMP have provoked some common questions about how to substitute the use of safer materials in these industries.

### Will DMSO work as a substitute for NMP?

**Table three** compares the physical properties of DMSO and NMP. Both solvents are very polar materials, with high boiling points and low vapor pressures. DMSO has a smaller molar volume. Both are totally water soluble.

Although it is difficult to predict exactly how solvents will perform when one is directly substituted for another in an application, in most cases DMSO and NMP will work very similarly. Formulation with suitable cosolvents / additives can often make up for any differences in cleaning performance.

**DMSO and NMP have very similar solvent properties, and work the same in many applications.**

### Is DMSO safer to use than NMP?

Yes. DMSO is considerably more safe to use than NMP, as shown in **table two**. Regardless of exposure type, DMSO has favorable safety data to support its use.

The main worry associated with NMP is its reproductive toxicity. This problem is driving regulatory action in both the EU and the US, and is restricting its use in some applications.

There is some concern that solvents like DMSO and NMP can penetrate skin. In fact, both solvents do penetrate skin to approximately the same degree (**figure 1**). The use of appropriate gloves is always a good idea when handling solvents. For DMSO, Ansell TNT® Blue disposable nitrile gloves (VWR catalog # 32889-888) are recommended.

**Although it has many solvent properties that resemble NMP, DMSO is safer to work with (oral, dermal, inhalation exposure).**

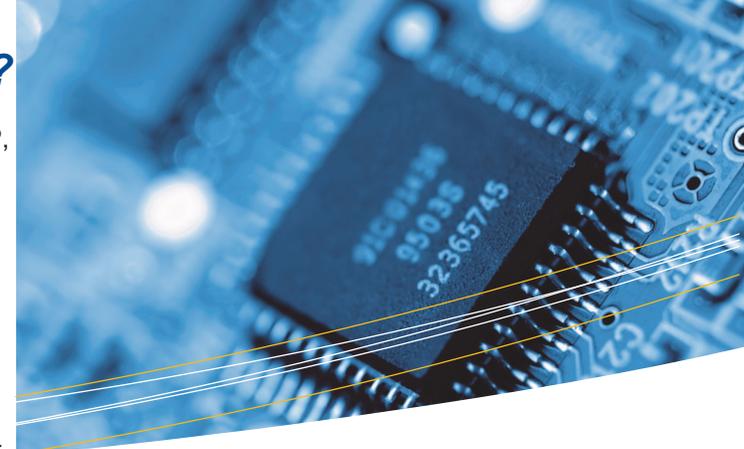
### How does regulatory treatment differ for DMSO and NMP?

In the US, products containing NMP must be labeled in the State of California as a developmental toxin under Proposition 65. DMSO is not "Prop 65" listed. There are reporting requirements for NMP in Massachusetts and Pennsylvania, which don't exist for DMSO.

NMP has SARA §313 reporting requirements with a reporting threshold of 1%, while DMSO does not have this requirement.

**Regulatory pressure is mounting on NMP in both the US and the EU.**

In the EU, it is expected that the 31st ATP (Directive 67/548/EEC) will mandate new labeling for NMP. NMP will be labeled as Toxic at levels >5%, which may pre-



A 'Green' Process-of-Record Solvent  
For the microelectronic industry?

The low toxicity, recyclability and environmental friendliness of DMSO suits the semiconductor industry's roadmap mandate for safer materials.

### How do their physical properties compare?

The basic physical properties of DMSO and NMP are nearly alike. Both have high flashpoints, low vapor pressures, and have comparable solvent parameters.

One difference worth noting is the relatively high freezing point of DMSO (18.5°C). When necessary, DMSO can be formulated to depress the mixture freezing point. Suitable drum-warming equipment is also readily available.

**Both solvents are high boiling, water miscible, and will effectively dissolve many polymers.**



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# Dimethyl Sulfoxide (DMSO) and N-Methylpyrrolidone (NMP)

## Properties at-a-glance

### Regulatory Data table one

US regulatory consideration	DMSO	NMP
Hazardous Air pollutant (HAP)	no	no
volatile organic compound (VOC)?	yes	yes
Prop 65 regulated?	no	yes
SARA §313 reportable?	no	yes
MA right-to-know regulated?	no	yes
PA right-to-know regulated?	no	yes
TSCA listed?	yes	yes

### Anticipated EU mandate: 31st ATP Directive

NMP (raw material)	T: R 36/37/38-61
NMP (formulated ≥ 5%)	T: R 61
NMP (formulated ≥ 10%)	T: R 36/37/38-61
Products containing ≥ 5% prohibited in DIY products	

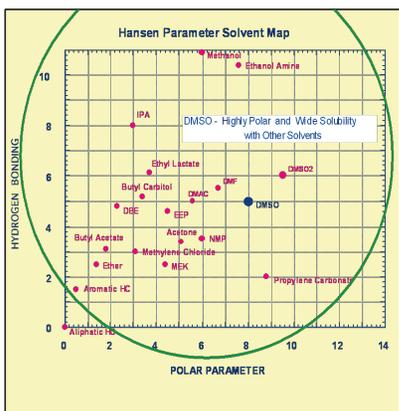
**DMSO has no labeling mandate in the EU.**

### Hansen Solubility Parameter Data

(cal/cc) <sup>1/2</sup>	DMSO	NMP
$\delta_d$	18.4	18
$\delta_p$	16.4	12.3
$\delta_h$	10.2	11.5

molar volume<sup>1</sup>

DMSO	NMP
71.3	96.5



### Safety Comparison table two

Toxicological Indicator	DMSO	NMP
Oral LD-50	14,500-28,300 mg / kg rat	3,914 mg/ kg rat
dermal LD-50	40,000 mg / kg rat	8,000 mg/ kg rabbit
Inhalation (rat)	none @ 2,900 mg / m <sup>3</sup>	NA
Reproductive toxin	no	yes
Proposition 65?	no	yes
ICH Residual Solvent Class	3	2

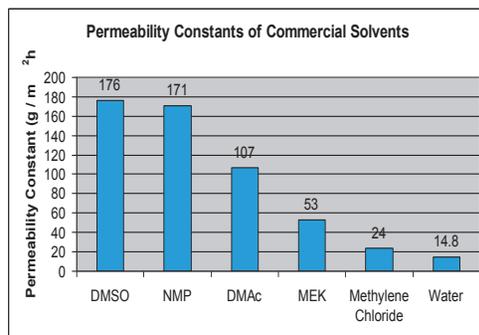


Figure 1.

Comparative Dermal penetration data

1. Adapted from Ursin, C.; Hansen, C, Van Dyk, J.; Jensen, P.; Christensen, I. Ebbehøj, J. *Am. Ind. Hyg. Assoc. J.* 56 (1995) p 651-660



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### Physical Properties table three

property	NMP	DMSO
CAS number	[872-50-4]	[67-68-4]
formula	C <sub>5</sub> H <sub>9</sub> NO	C <sub>2</sub> H <sub>6</sub> SO
MW	99.13	78.13
Solvent class	Dipolar Aprotic	Dipolar Aprotic
mp, °C	-24	18.55
bp, °C	202	189
vapor pressure, @25°C (mm Hg)	0.3	0.600
evaporation rate (BuOAc=1)	0.03	0.026
specific gravity, 25°C/25°C	1.033	1.0955 g/cm
viscosity, cP @ 25°C	1.67	2.0
flash point, °C (closed cup)	86	89
water solubility g/100g H <sub>2</sub> O at 25°C	100	100
Henry's Law Constant, (atm-m <sup>3</sup> /mole)	1.56E-08	991000 21C
Surface tension (dynes / cm) @ 20°C	40	43.53
log Kow	-0.54	-1.35
Hildebrand parameter (cal/cm <sup>3</sup> ) <sup>1/2</sup>	11.3	13.0
Autoignition temp (air)	270°C	300-302°C
Specific heat	0.465 cal/ g °C @ 50°C	0.47 cal/ g °C @ 29.5°C
Heat of combustion (cal / g)	7290	6054