Introduction to N-butylpyrrolidone

Replacing MOCs

January 2025 *Approved for external use*

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Regulation background

EPA regulation on NMP

The U.S. Environmental Protection Agency (EPA) is considering regulation that would impact making, processing and distributing n-methylpyrrolidone (NMP), a solvent used in many industries including paint and coatings. These rules would:

Ban NMP in some occupational uses

Require enhanced worker protection in other occupational uses

Impose concentration limits, consumer regulations and product labelling

Timeline:

- Proposal announced on June 14, 2024
- Estimated publication of final rule for NMP: 2025
- Effective date: 12-18 months depending on place in value chain

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NMP restricted under REACH

Annex XVII of REACH prohibits the use of CMR substances category 1A and 1B as substances and in mixtures for consumers.

Regulation 2018/588:

1. Shall not be placed on the market as a substance on its own or in mixtures in a concentration equal to or greater than 0,3 % after 9 May 2020 unless manufacturers, importers and downstream users have included in the relevant chemical safety reports and safety data sheets, Derived No-Effect Levels (DNELs) relating to exposure of workers of 14,4 mg/m^3 for exposure by inhalation and 4,8 mg/kg/day for dermal exposure.

2. Shall not be manufactured, or used, as a substance on its own or in mixtures in a concentration equal to or greater than 0,3 % after 9 May 2020 unless manufacturers and downstream users take the appropriate risk management measures and provide the appropriate operational conditions to ensure that exposure of workers is below the DNELs specified in paragraph 1.

3. By way of derogation from paragraphs 1 and 2, the obligations laid down therein shall apply from 9 May 2024 in relation to placing on the market for use, or use, as a solvent or reactant in the process of coating wires.

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Regulatory Summary

NMP is considered a CMR and is being restricted in Europe and has pending regulations in the US

N-butyl pyrrolidone (NBP) is not a CMR and is available for use in Europe. In the US/NA it is subject to a SNUR, but does not have pending regulations against its use.

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NBP is a powerful alternative

Overview

- Polar solvents like NMP (N-methyl-2-pyrrolidone), NEP (N-ethyl-2-pyrrolidone, and DMF (dimethyl formamide) are considered as a substance of very high concern (SVHC (EU))

- EPA (US) regulation is banning or limiting NMP in many applications, such as paints and coatings and removal of paints/coatings/adhesives

- Eastman's NBP is a powerful and versatile solvent for a variety of industries looking for alternatives to SVHC-listed solvents
  - In many applications, it can be used to replace NMP or NEP with little or no reformulation

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NBP vs NMP

NBP has similar or preferred properties to NMP

	NBP	NMP
CMR substance (SVHC listed)?	No	Yes
Boiling point (°C/°F)	241°C/ 465.8°F	204°C / 399°F
Surface Tension	33.8 mN/m	41 mN/m
Autoignition temperature (°C/°F)	212°C/413.6°F	245°C / 473°F
Evaporation Rate (n-Butylacetate = 1)	0.004	0.04
Flash Point (closed cup)	108°C/226.4°F	91°C / 196°F
Hansen solubility parameter @ 25 °C Dispersion($(MPa)^{1/2}$) Hydrogen bonding ($(MPa)^{1/2}$) Polar($(MPa)^{1/2}$) Total($(MPa)^{1/2}$)	 17.8 5.9 8.2 20.5	 18.0 7.2 12.3 22.9
Viscosity @ 25 °C (mPa s)	4.3	1.66
Water solubility	Completely Soluble	Completely Soluble

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Dipolar aprotic solvents comparison

NBP is an ideal replacement to the listed aprotic solvents

	NBP	NMP	NEP	DMSO	DMF	Acetonitrile	DMM
Boiling point (℃)	241	204	212	189	152	81	175
Flash point (℃)	107.7	91	90.5	87.2	57.8	-5.6	65
Vapor pressure (hPa, 25℃)	0.13	0.5	0.45	0.6	0.48	0.88	0.6
Odor [1]	◕	◕	◕	○	◑	◕	◕
Stability [2]	●	●	●	◑	●	○	●

1: solvents have neutral odor with exception of DMSO that smells like rotten cabbage and that DMF has more amine distinctive odor.
2: DMSO and Acetonitrile have stability issue at higher temperatures.

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NBP safety features

NBP vs NMP

Product	NMP	NBP
CAS No.	872-50-4	3470-98-2
Classification	Hazard pictograms :  Signal Word : Danger Hazard Statements : H227 Combustible liquid. H315 Causes skin irritation. H319 Causes serious eye irritation. H335 May cause respiratory irritation.	Hazard pictograms :  Signal word : Warning Hazard statements : H302 Harmful if swallowed. H315 Causes skin irritation. H319 Causes serious eye irritation.
SVHC	Yes	No
Boiling Point, °C	204	241
Flash Point, °C	91	108

- Signal word:
  - NBP: Warning
  - NMP: Danger
- Reproductive toxicity classification:
  - NBP: NO
  - NMP: Category 1B

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Toxicological evaluation

NBP does not have serious health hazard (CMR), acute toxicity, and hazardous to the environment label

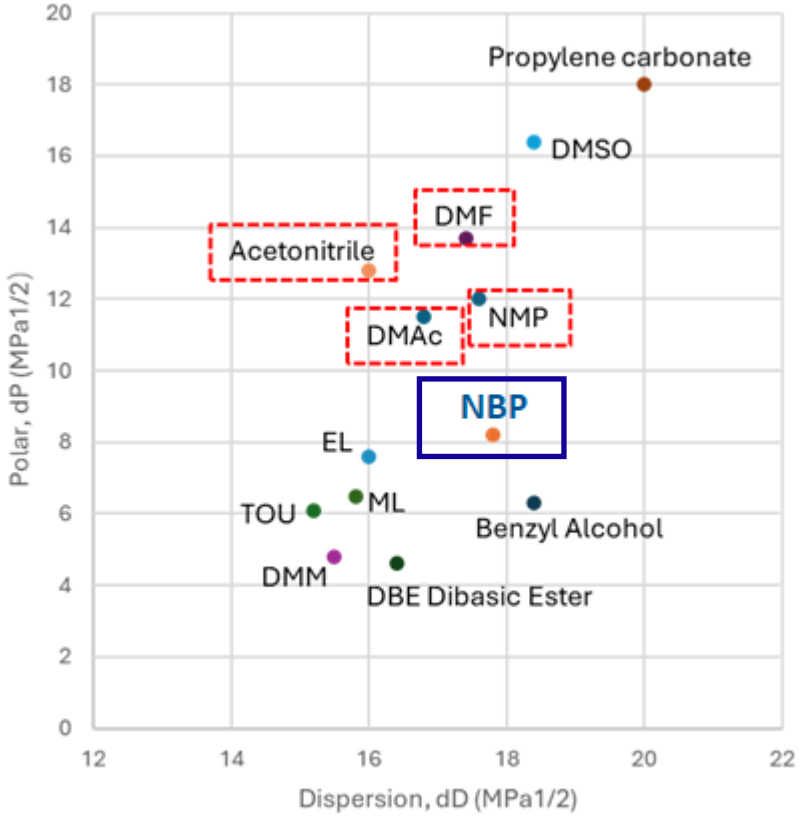
Test Number	Test Name	Classification	Test Number	Test Name	Classification
OECD 404	Acute Skin Irritation Test	No	OECD TGL 210	Fish Early Life Stage	No
OECD 405	Acute Eye Irritaion Test	No	OECD TGL 202	Acute Immobilization	No
OECD 408	Repeat Dose 90 day oral	No	OECD TGL 211	Daphnia Reproduction	No
OECD 414	Prenatal Developmental	No	OECD TGL 201	Freshwater algae	No
OECD 421	Reproductive/Developmental	No	OECD 423	Acute Oral	No
Ames	Mutagenicity Assay	No	OECD 403	Acute Inhalation	No
OECD 301D	Aqueous Aerobic Biodegradation test	No	OECD 402	Acute Dermal	No
OECD 302B	Inherent aqueous aerobic biodegradation test	No	OECD 404/405	Eye and Skin Irritant	Category 2
OECD TGL 203	Fish Acute	No	OECD 443	Extended One-Generation Reproductive Toxicity	Test is still ongoing

Compatibility

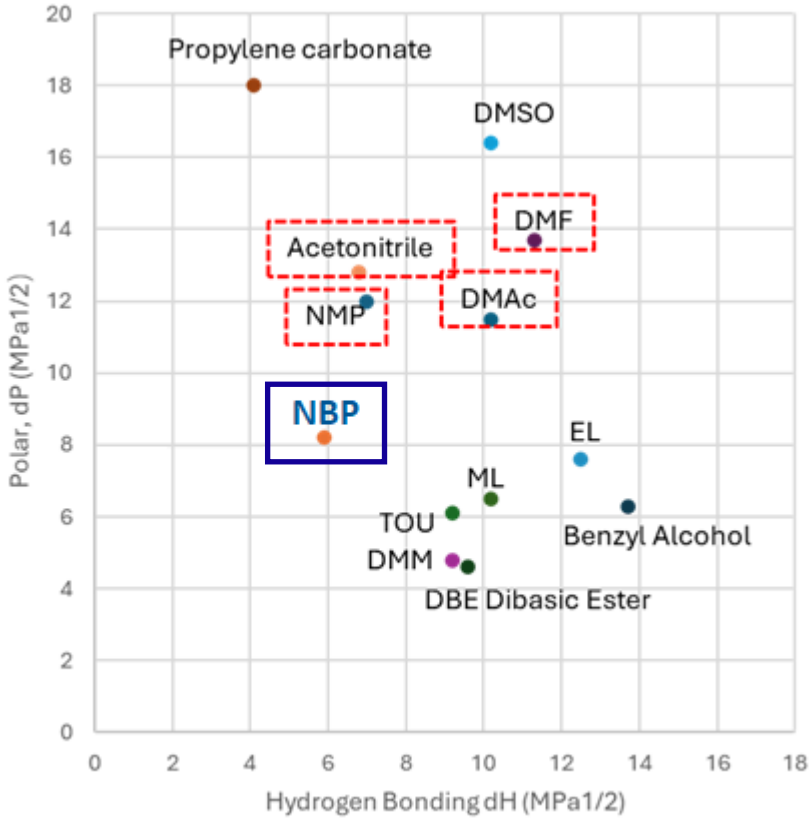
Hansen Solubility Parameter (HSP)

- HSP is an indication of solvency power to other resins
- HSP of NBP and NMP are close

Polar vs. dispersion



Polar vs. hydrogen bonding



Material of Concern (MOC)

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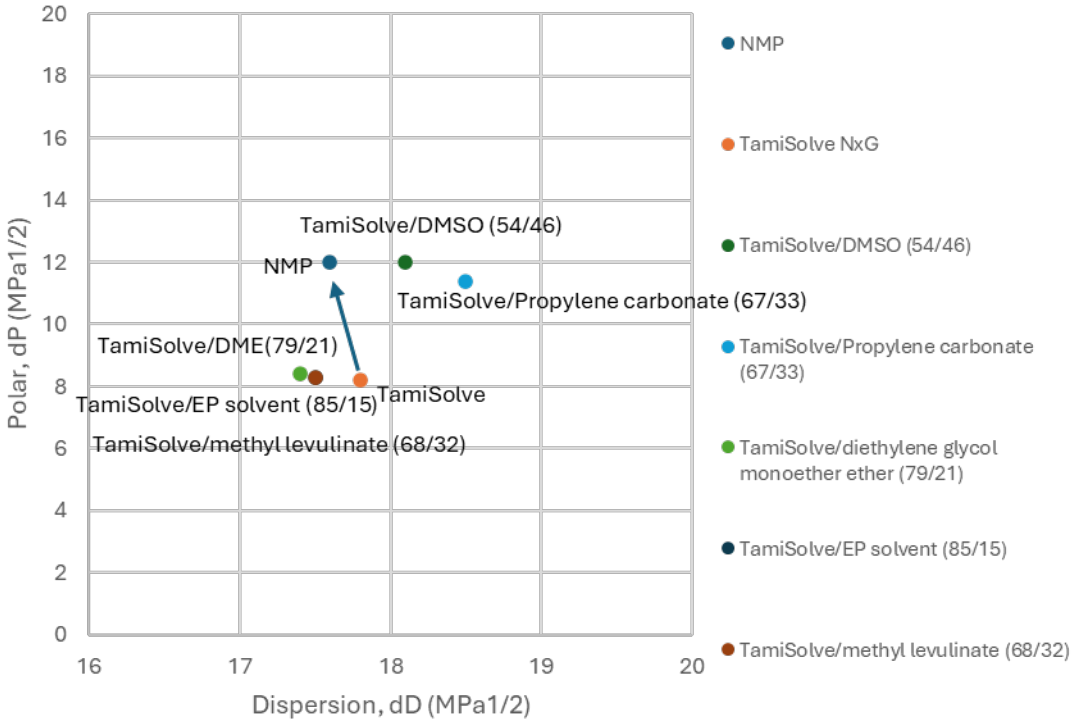
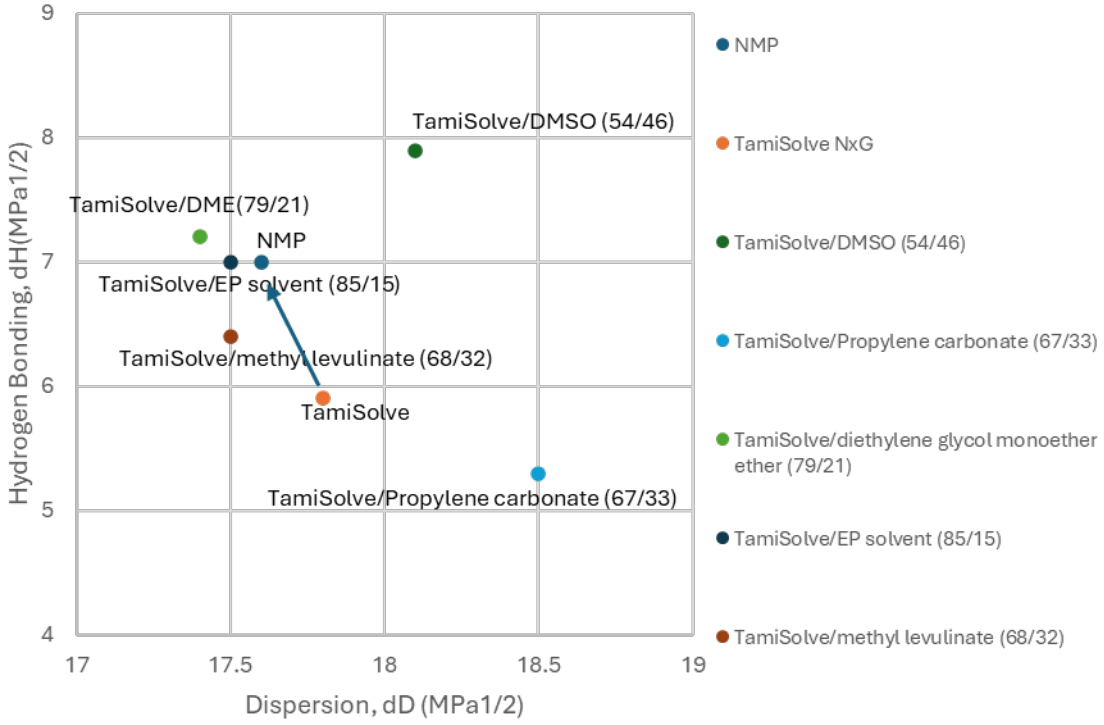
Hansen Solubility Parameter (HSP) – NBP blends

- Solvent blends with NBP bring HSP closer to NMP
- Bigger challenge is to bring dP closer. NBP/DMSO and NBP/Propylene carbonate work the best
- NBP/DME, NBP/EP solvent, NBP/methyl levulinate work the best to bring dH closer





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Dissolving of polymers

NBP can dissolve most binders used in coating, inks, and adhesives

Polymers	Soluble
Acrylics	Yes
Polystyrene	Yes
Poly(styrene-co-acrylonitrile)	Yes
Polyvinyl chloride	Yes
Polycarbonate	Yes
Polysulfone	Yes
Polyethersulphone	Yes
Polyimide	Yes
PVB	Yes
CA/CAP/CAB	Yes
PU/PUD	Yes

More polymers will be tested

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Application overview

Current applications

PUD synthesis and formulation

- Formulation flexibility
  - Free of NCO reactive contaminants and does not interfere PUD polymerization.
  - Excellent solvency for monomers and PUD prepolymers.
  - Reduced co-solvents for dispersibility and coalescence.
- PUD properties
  - Worked as both co-solvent and coalescent.
  - Improved film formation with possibility to reduce VOC level.
  - No permanent plasticizing effects.

Industrial cleaners & paint strippers

- Effective replacement for NMP in
  - Cleaning PUR/PIR, epoxy, polyester molds and tools
  - Industrial cleaning (bulk tanks)
  - Engine cleaning
- The high solvency power enhances performance of industrial cleaning formulations.
- Lower volatility is beneficial for reduced worker and environmental exposure.

Other applications

- Solvent for coatings formulations.
- Enamel wire coatings.
- Solvent for organic and polymer synthesis (cross-coupling reaction, polyimide, peptide, membrane et al.)
- Agrochemical formulations.

Inks

- Overprint varnishes
  - As a coalescing solvent or drying speed modifier in both solvent and water-based OPVs.
- Printed electronics
  - An effective solvent in metal-based conductive inks used for the printing of electronic circuitry.
- Packaging inks
  - Lower surface tension of water-based flexographic and gravure printing inks for better wetting and adhesion.
- Digital inks
  - Improved viscosity reduction, lower odor, and increased environmental benefits.
- Ink formulation
  - Excellent cosolvent
  - Lower volatility for reduced worker exposure.

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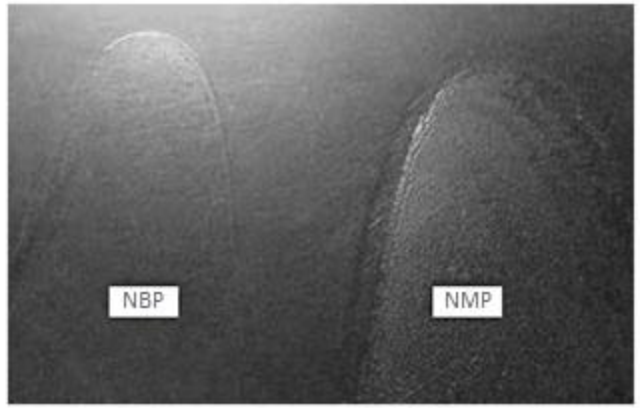
PUD coatings applications

PUD formulations containing NBP show improved coalescence and reduced dry-to-touch time

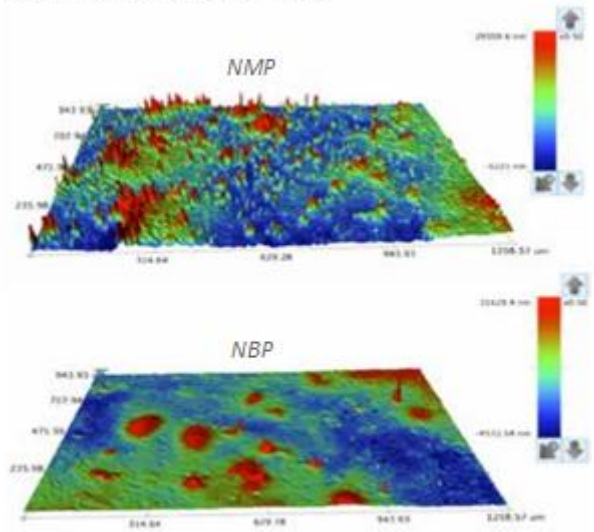
Improved coalescence*

Improved coalescence of PUD formulation with NBP.
(1 week cured at RT, 10 mil wet on Leneta paper)



Optical topography

(Bruker Contour GT optical profilometer)



* Hard aliphatic PUD - H12MDI/500BA/TMP/DMPA/HYD in ratio 1.70/0.67/0.030/0.30/0.7 (stoich. amounts)

Reduced dry-to-touch time*

Dual co-solvent coalescence

Co-solvent 1	Co-solvent 2	Dry-to-touch	Coalescence
3% NBP	3% glycol ether	12 min	Excellent
3% NMP	3% glycol ether	17 min	Acceptable
3% NEP	3% glycol ether	20 min	Acceptable - mudcracking

Table 1: Gardner dry time & coalescence of dual co-solvent PUD formulations

Single co-solvent coalescence

Co-solvent	Dry-to-touch	Dust free	Dry through
7.3% NBP	8 min	27 min	28 min
11.0% NMP	38 min	58 min	66 min
11.8% NEP	35 min	60 min	70 min

Table 2: Gardner dry time of PUD formulations with co-solvent added up to film coalescence level

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Case studies

Solvent for polyurethane container cleaning

Excellent solvency powder for PU cleaning

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Black graffiti removing

Similar to NMP, NBP is very effective in graffiti removing

Black graffiti was sprayed on top of steel and dried overnight. NMP or NBP was then applied for 15 mins and then wiped with a cloth.

NMP

NBP

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Adhesive removing

PU adhesive was easily removed after soaking with NMP or NBP

PU adhesive was applied to glass or wood substrates and cured according to product instruction. NMP or NBP was then applied for 15 mins and then separated with a stripper.

NMP NBP

NMP NBP

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Summary

Eastman N-butylpyrrolidone

Eastman can help you comply new regulations without compromising product quality. NBP offers effective alternatives to NMP and is supported by experts who can help find the right solution for you.

We provide:

N-butylpyrrolidone

- Safer alternative to NMP
- Commonly used to replace polar aprotic solvents like NMP
- In many applications, it can be used to replace NMP with little or no reformulation
- If reformulation is needed, Eastman can help
- Works well in a variety of applications:
  - PUD applications
  - Coatings
  - Paint strippers/removers
  - Ink applications
  - Many others

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Thank You!

Visit us at our booth!
#47

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Backup Slide

NBP – Status (US SNUR/EU REACH)

Regulatory:

- REACH listed
- TSCA listing working under a Consent Order; SNUR to publish
- Listed in the Phillipines, Taiwan, and Korea
- Working on China and Canada

Use in coatings

- Up to 20% by weight for coatings for microelectronics casting of polymer films in clean rooms / solvent based coatings
- Up to 18% by weight for water based coatings
- Up to 70% by weight for solvent based coatings
- Up to 15% by weight for industrial inks
- Up to 1% by weight for consumer coatings or professional coatings applied in a consumer environment
- Can only be used in Industrial applications

Use in cleaners and strippers

- Effective for replacing NMP and Methylene chloride in paint strippers
- Effective replacement for NMP in reactor and equipment cleaning solutions

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