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Eastman **OMNIA**™
high-performance solvent

Solvent comparison

Eastman Omnia™ high-performance solvent versus *d*-limonene in aqueous cleaning applications

Solvent selection for cleaning applications requires diligence. Today's focus on regulatory and sustainability improvement obligates those in the value chain to consider not only performance requirements but health and safety aspects as well. An argument that is gaining popularity is the source of the solvent material, whether it be petroleum or biobased. In this paper, we investigate the differences that exist between Eastman Omnia™ high-performance solvent and *d*-limonene. There are some notable differences between the two, including the chemistry of each molecule, the production feedstock, and HSE listings.

Table 1. Properties and listings

Solvent	Solvent family	Solvent type	Raw material feedstock	Evaporation rate *n*-BuOAc = 1	Density g/mL @ 20°C	Water solubility		LVP-VOC, Y/N	SCIL list rating[a]
						In water, wt% @ 20°C	Water in, wt% @ 20°C		
Omnia	Ester alcohol	Oxygenated	Petroleum	0.01	0.971	3.90	10.30	Y	●
d-limonene	Terpene	Hydrocarbon	Citrus oil	0.20	0.841	Ins.	Ins.	N	▲

[a]*https://www.epa.gov/saferchoice/safer-ingredients*

Emulsification

There are many factors that influence solvent selection; one of the first being the end-use environment of the formulation. The continuous phase can be organic, carbon containing, or aqueous, which simply means water. This requires the formulator to make a decision on the level of miscibility the solvent has within the continuous phase. If there is low or no miscibility between the solvent and continuous phase, surfactants will be needed to emulsify the two to make a homogeneous single-phase solution. Emulsifiers, often called surfactants, come in four different types based on the counterion charge associated with the head portion of the compound.

Table 2. Surfactant information

Surfactant type	Charge	Common example
Nonionic[a]	None	Alcohol ethoxylate
Anionic	(–) Negative	Alkyl ether sulfate
Cationic	(+) Positive	Quaternary, or "quat"
Amphoteric	(–) Negative & (+) positive[b]	Sodium alkanoate

[a]*Nonionic surfactants are differentiated by HLB (hydrophilic-lipophilic balance), which is a scale ranging from 1–20. 1 being very lipophilic (fat loving), and 20 being very hydrophilic (water loving).* [b]*Zwitterionic—having both a positive and negative charge depending on the acidity or alkalinity of the solution*

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Making a clear, stable emulsion is dependent on the surfactant choice, HLB, continuous phase, and solvent miscibility in that phase. Both Eastman Omnia™ high-performance solvent and *d*-limonene, individually and blended, were placed in an emulsion, and the amount of surfactant needed to achieve stability was compared.

Table 3. Nonionic/amphoteric-containing emulsions

Component	Formulation		
	A	B	C
Omnia, %	4	0.83	—
d-limonene, %	—	0.83	0.64
Nonionic surfactant,[a] %	2	0.83	0.40
Anionic surfactant,[b] %	***2***	***27.1***	***36.4***
Water, %	92	70.4	62.6
Clear, Y/N	Y	Y	Y
Multiplier[c]	***1***	***13.5***	***18.2***

[a]Alcohol ethoxylate [b]Sodium lauriminodipropionate [c]Amount of amphoteric surfactant added, relative to Formulation A, to achieve clarity

When creating a stable emulsion using a nonionic/amphoteric surfactant pair, Omnia shows an advantage in the amount of surfactant needed to make a clear and single-phase formulation. This also shows a reduction in surfactant usage as Omnia is blended into *d*-limonene formulations. The amount of amphoteric surfactant needed to emulsify the *d*-limonene-containing solution increases exponentially with no Omnia present. The trend continues for the nonionic/anionic-containing formulations, seen in Table 4, although not as severe.

Table 4. Nonionic/anionic-containing emulsions

Component	Formulation		
	D	E	F
Omnia, %	4	1.05	—
d-limonene, %	—	1.05	1.80
Nonionic surfactant,[a] %	2	1.05	0.90
Anionic surfactant,[b] %	***2***	***14.32***	***16.20***
Water, %	92	82.53	81.1
Clear, Y/N	Y	Y	Y
Multiplier[c]	***1***	***7.2***	***8.1***

[a]Alcohol ethoxylate [b]Alkyl lauryl sulfate [c]Amount of anionic surfactant added, relative to Formulation D, to achieve clarity

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Performance evaluation

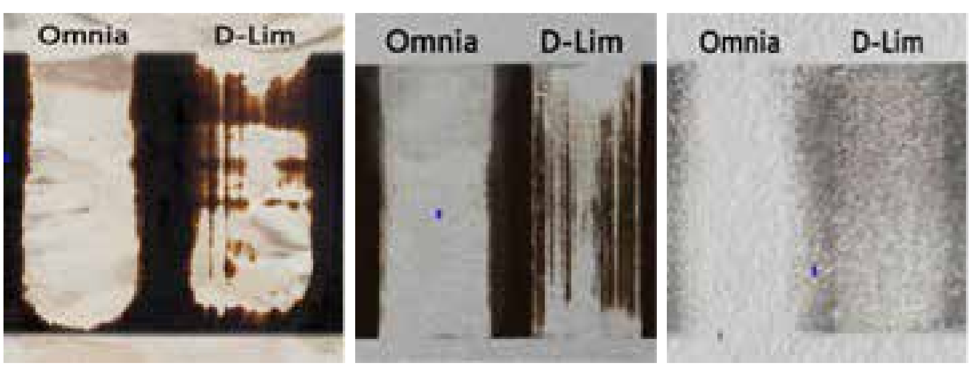
Cleaning efficacy can be evaluated using different methods, from abrasive scrubbing to sit and soak. We make use of two such methods to test the performance of different formulations. The presence of different energy inputs and testing environments provides a more balanced testing approach.

Scrub test method

Figure 1. Augmented MEK double-rub scrub machine
(For more information, visit **www.eastman.com/Brands/Eastman_Omnia/Pages/Performance.aspx.**)

Using this method, we can assess differences on porous and nonporous substrates like vinyl tile, painted wallboard, and aluminum. These substrates can be soiled with anything from a tarry soil to soap scum, greasy soil, or ink. The test records the number of scrubs to visual cleanliness, with the lower number equaling higher performance and a 1000 scrub maximum.

Figure 2. Scrub cleaning performance comparing Omnia to *d*-limonene on various soil substrate combinations[a]



Soil	Tarry soil[b]	Greasy soil[c]	Soap scum[d]
Substrate	Waxed vinyl tile	Aluminum	Painted wallboard

[a]Cleaning formulation contents: Solvent—2%, nonionic surfactant—1.5%, anionic surfactant—1.5%, chelator—0.25%, pH adjuster—0.1%, water—95.25% [b]Proprietary mixture—similar to an auto body undercoating [c]DCC-17/ASTM 4488D Soil [d]ASTM 5343-06

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The Omnia-based formulation was scrubbed to visual cleanliness, and the *d*-limonene-based formulation was tested to the same number of scrubs. However, if the *d*-limonene-based formulation had posted lower scrub numbers (better performance), that difference would have been noted. In all three soil/substrate combinations, the Omnia-based formulation outperformed the *d*-limonene-based formulation.

Ultrasonic sit-and-soak test method

Figure 3. Ultrasonic bath with petri testing dishes (left); DCC-17 greasy soil panel (right)

This technique is designed for nonporous substrates and typically used in conjunction with greasy soil. Performance data is based on gravimetric analysis of soil removed from an aluminum panel. The values are shown in weight percent (wt%) of the soil removed. Each evaluation is performed in duplicate to reduce variability. The test works by fully submerging the soiled portion of the panel in the cleaning solution, applying ultrasonic energy to the cleaning solution for 2 minutes, removing the panels, and allowing them to dry before recording the (postclean) weight.

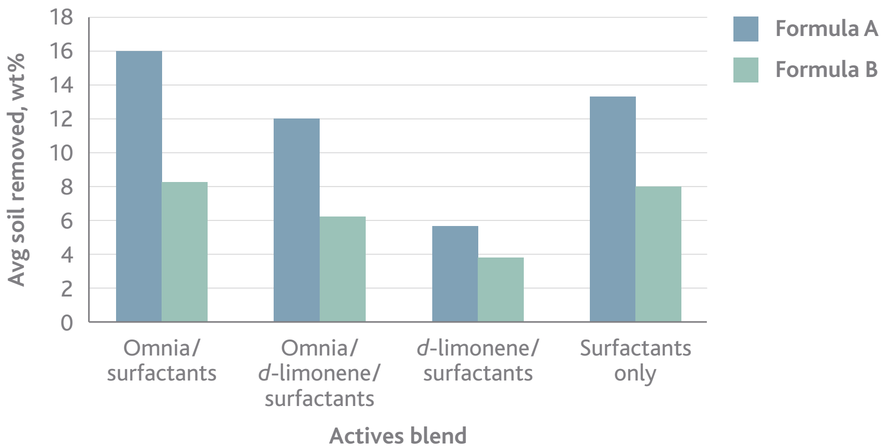
Table 5. Degreasing formulations comparing Omnia to *d*-limonene using different solvent blends and surfactant combinations

	Formula A				Formula B			
Component	Omnia/ surfactant	Omnia/ *d*-limonene/ surfactant	*d*-limonene/ surfactant	Surfactant only	Omnia/ surfactant	Omnia/ *d*-limonene/ surfactant	*d*-limonene/ surfactant	Surfactant only
Omnia, %	4	2	—	—	4	2	—	—
d-limonene, %	—	2	4	—	—	2	4	—
Nonionic surfactant, %	2	2	2	4	2	2	2	4
Amphoteric surfactant, %	2	2	2	4	—	—	—	—
Anionic surfactant, %	—	—	—	—	2	2	2	4
Water, %	92	92	92	92	92	92	92	92
pH	4.5	4.5	4.5	4.5	5.6	5.6	5.6	5.6
Stable[a]	Y	*N*	*N*	Y	Y	*N*	*N*	Y

[a] *Stable is defined as clear, single-phase solution not exhibiting cloudiness, biphasing, sedimentation, or flocculation.*

The degreasing formulations were tested using the ultrasonic method to yield the results seen in Figure 4.

Figure 4. Degreasing performance evaluation comparing Omnia to *d*-limonene in two different cleaning formulations



The results show that the nonionic/amphoteric-containing formulation consistently outperforms the nonionic/anionic-containing formulation. The results also show that the addition of Eastman Omnia™ high-performance solvent increases the efficacy of the formulation no matter the combination of other actives. Using Omnia will enable better cleaning with less total surfactants and can increase efficacy when blended with a cosolvent like *d*-limonene.

Conclusion

Many variables can impact solvent selection for cleaning formulations. As seen from Eastman's internal testing, Omnia shows many advantages over *d*-limonene, including higher performance at equal use levels, greater emulsion stability with less surfactant, and performance across a range of soils and substrates. This can translate into value addition and product differentiation for the formulator.

Some other potential benefits of using Omnia rather than *d*-limonene include less GHS labeling requirements due to lower irritation risk and combustibility versus the flammable *d*-limonene. Along with that, there is source reliability which Eastman provides to the customer. This alleviates the fear of volume restraints or price volatility. The application, end-user expectations, and regulatory compliance should all be weighed when selecting a solvent for a cleaning formulation, but this information should be useful in making an informed decision with regards to aqueous emulsions.

For more information, visit **www.eastman.com/omnia**.

All results provided were generated from Eastman internal testing. Customers will need to perform their evaluation and use proper judgment to ensure the right solvent selection for their specific application.

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