TBF ENVIRONMENTAL
LEADERS IN LOW-VOC SOLVENT SOLUTIONS

Advantages of KradaSol™

Purpose

This document summarizes the enhanced safety and performance attributes of TBF Environmental's KradaSol product as a replacement for Hexanes and other organic solvents that are used for dissolution in addition to other purposes. KradaSol can also be used as a replacement for primary solvents or co-solvents such as Xylene, Toluene, Cyclohexane, Perchloroethylene (Perc) and Methyl Amyl Ketone (MAK).

Factors to consider

When evaluating the safety and quality of the KradaSol product versus other solvents, the following factors must be considered:

- Environmental considerations - toxicity and regulatory controls
- Safety - reduced hazard to the environment and workers
- Performance - comparable physicochemical characteristics to Hexanes and other solvents that may be replaced with KradaSol

Environmental considerations

The following table details the environmental comparison between KradaSol, Hexanes, Xylene, Toluene, Cyclohexane, Perchloroethylene (Perc) and Methyl Amyl Ketone (MAK):

	KradaSol	Hexanes	Xylene	Toluene	Cyclohexane	Perc	MAK
VOC Content: US EPA (outside SCAQMD)	**0**	100%	100%	100%	100%	100%	100%
VOC Content: SCAQMD	**2.2* g/L**	100%	100%	100%	100%	100%	100%
Maximum Incremental Reactivity (MIR, g O_3 / g organics)	**0.062**	1.45	7.49	3.97	1.46	0.04	2.80

*ASTM Test Method 313-91. South Coast Air Quality Management District (SCAQMD) considers <5 g/L VOC content to be "zero VOC".
KradaSol is 100% comprised of solvents considered to be VOC-exempt by the EPA, CEPA, NPRI and SCAQMD and as such is considered zero VOC.

KradaSol is far less toxic to the environment than conventional organic solvent alternatives. Hexanes, Xylene, Toluene, Cyclohexane, Perchloroethylene and Methyl Amyl Ketone are all emitters of Volatile Organic Compounds (VOCs), which can engage in photochemical reactions in the atmosphere to form ground-level ozone and smog precursors, and are harmful to the environment. By contrast, KradaSol is comprised of 100% VOC-exempt material.

MIR is a quantifiable measure of relative ground-level ozone impacts of VOCs. A lower MIR value indicates less negative impact on the environment. KradaSol has a very low Maximum Incremental Reactivity (MIR) value when compared to Hexanes, Xylene, Toluene, Cyclohexane and Methyl Amyl Ketone.

Safety

The following table details the safety considerations comparisons between KradaSol, Hexanes, Xylene, Toluene, Cyclohexane, Perchloroethylene (Perc) and Methyl Amyl Ketone (MAK):

	KradaSol	Hexanes	Xylene	Toluene	Cyclohexane	Perc	MAK
Flash Point (°C)	**20.7**	-26	28.3	6.7	-20	-	39
Oral LD_{50} (rat) (mg/kg)	**5000 - 13,000**	25,000	3520	> 5580	12,705	3005	2630
U.S. ACGIH TLV (8-hour TWA)	**> 200 ppm**	50 ppm	100 ppm	20 ppm	100 ppm	25 ppm	50 ppm

The flash point of KradaSol is higher than that of Hexanes, Toluene and Cyclohexane. The higher flash point demonstrates KradaSol is less flammable and consequently safer solvent for transport, handling and use.

Safety - continued

LD_{50} values can be used to determine the toxicity of a chemical. LD_{50} is the lethal amount of a material, given all at once, which causes the death of 50% (one half) of a group test population. The LD_{50} is one way to measure the short-term poisoning potential (acute toxicity) of a material. The greater the LD_{50} value the less toxicity of the product. The oral LD_{50} (rat) for the components in KradaSol range from 5000 to 13,000 mg/kg, which provides a range that has less acute oral toxicity than Xylene, Perchloroethylene and Methyl Amyl Ketone.

Threshold Limit Values (TLV) are restrictions enforced by the American Conference of Governmental Industrial Hygienists (ACGIH) that quantify in parts-per-million (ppm) the maximum allowable exposure for a certain chemical over an 8-hour time weighted average (TWA). The ingredient in KradaSol that has the lowest TLV is listed at 200 ppm, which is higher than the allowable exposures for all other solvents listed.

In addition to the safety considerations listed above, many of the solvents described herein contain other safety hazards and toxic effects to humans. These are summarized in the table below:

Solvent	Other Safety Hazards
KradaSol	**None known**
Hexanes	Aspiration Hazard, Mutagen, Teratogen, Reproductive Hazard, Developmental Toxicity
Xylene	Aspiration Hazard, Developmental Effects, May contain Ethylbenzene (Suspected Carcinogen)
Toluene	Aspiration Hazard, Teratogen, Reproductive Hazard
Cyclohexane	Aspiration Hazard
Perchloroethylene	Probable Carcinogen

Exposure to Hexanes, Xylene, Toluene, Cyclohexane and Perchloroethylene are associated with various hazards, while the ingredients in the KradaSol formulation do not contain any of the hazards listed in the table above. This makes KradaSol a preferable solvent with regards to worker safety and hazardous potential.

Physical properties

The following table summarizes various physical properties of KradaSol compared to various other solvents.

	KradaSol	Hexanes	Xylene	Toluene	Cyclohexane	Perc	MAK
Evaporation Rate (n-Butyl Acetate = 1)	**1.4**	8.3	0.7	1.6	0.4	2.1	0.4
Viscosity (cP)	**0.69**	0.31	0.81	0.55	1	0.89	0.81
Hansen Solubility Parameters $(MPa)^{1/2}$	**14.9**	14.9	17.9	18.2	16.8	19.3	17.6
Dispersion (δ_D)	**13.5**	14.9	17.6	18.0	16.8	18.4	16.2
Polarity (δ_P)	**5.7**	0	1.0	1.4	0	5.7	5.7
Hydrogen Bonding (δ_H)	**3.1**	0	3.1	2.0	0.2	0	4.1

KradaSol has a comparable evaporation rate to Xylene, Toluene, and Perchloroethylene. It also has similar viscosity and solubility profiles compared to Xylenes, Toluene, Cyclohexane, Perc and MAK.

In addition to the Hansen Solubility Parameters, the Kauri Butanol value (K_B, not shown) for KradaSol is 49.2, while Hexanes has a value of 30. This indicates that KradaSol has greater solvency compared to Hexanes and can perform more efficiently as a dissolution agent.

Conclusion

As demonstrated above, KradaSol is the only zero-VOC solvent with an excellent environmental, and performance profile that is less toxic than many current solvent alternatives for use as a dissolution solvent as well as many other applications, as a replacement for Hexanes and various other solvents.

References

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