

Galaster™ and Galasolv™

our bio-solvents solutions



NATURAL SOLVENTS

Galactic has developed a wide range of bio-solvents with different solvency properties, high flash points and slow evaporation rates.

All our products are derived from natural ingredients and aim to replace (parts of) traditional solvents, providing distinct advantages for your formulations and labelling declarations. Galactic offers high performance alternatives to conventional crude-oil based solvents.

ENHANCING THE GENIUS OF NATURE



Galactic has acquired valuable expertise in biotechnology since its creation 20 years ago. The company develops natural solutions for application in the food, feed, personal & health care, and industrial markets. Specialised in food safety, nutrition and green chemistry, Galactic offers environment - and health-friendly alternatives including lactic acid, lactates and many other innovative product-based solutions. In collaboration with our clients and scientific partners, we meet the challenges of nature to share together its unlimited potential with a view to a more sustainable future.





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I. INTRODUCTION

Since 1994 Galactic has become one of the world's greatest leaders in biotechnology serving the food, feed, personal & health care, and industrial markets. Based on its valuable experience in the fermentation of lactic acid and other derivatives, Galactic continuously develops sustainable, innovative and health-friendly solutions in the field of food safety, nutrition and green chemistry. In particular, Galactic provides an extensive range of solutions for application in the bio-solvents industry.

The global solvents market continues to grow and as such gives rise to the atmospheric release of toxic emissions which causes a serious environmental hazard. Thus, in light of growing regulatory restrictions and environmental concerns over the use of traditional petroleum-based solvents emitting pollution, the demand for manufacturing green solvents is set to intensify. To comply with environmental legislation and the increasing demand for eco-friendly solvents manufacturers are focusing on the design and development of biological sources which are much less volatile and can dramatically reduce the amount of pollution released into the atmosphere.

MARKET DRIVERS

At Galactic, we focus on four principal pillars in our quest to develop a highly effective range of bio-solvents, namely:

- ✔ Green
- ✔ Clean
- ✔ Safe
- ✔ Performing

The lactate esters produced by Galactic through the natural fermentation of sugar or corn means that our solvents range is bio-sourced and thus sustainable compared to most conventional petroleum-based solvents. As we are committed to sourcing environmentally friendly raw materials, the alcohol that we use in the production of esters may also be bio-sourced. Consequently, our solvents have the advantage of being biodegradable. These two aspects combined result in a lower CO₂ footprint when compared to crude-oil traditional solvents.

Galactic's solvent range represents an attractive alternative to many established solvents, some of which have become increasingly regulated for environmental and health impact. Substances such as cyclohexanone, cresols and glycol ether and their acetates are examples of solvents which can be substituted. As VOC levels become increasingly more restrictive, we offer effective solvents with high boiling points providing a solution for lower VOC levels in applications such as coatings, inks, varnishes, surface cleaning, and others.

Our products are safe to handle, store and use. They pose no risk when stored under normal conditions and do not require special conditions for handling. They are also safe for the environment since they are biodegradable and do not release pollution into the atmosphere.

The bio-solvents range that we offer our clients is highly performing. It is in line with, or even better than, traditional solvents and available at a reasonable cost. This range is particularly attractive for those who are concerned with and interested in green chemistry.



II. GALACTIC'S SOLUTIONS

1. PRODUCT RANGE: GALASTER™ AND GALASOLV™

Galactic has developed a range of bio-solvents in order to provide alternatives to traditional solvents. We offer pure lactate esters: Galaster™, and blends: Galasolv™. Some of the advantages of our range of bio-solvents include high flash points and slow evaporation rates. In some cases they are fully soluble in water and for the most part are fully sustainable.

Galaster™ is composed mainly of the following products, all of which are based on lactates:

- Galaster BL™: butyl-lactate
- Galaster EHL™: 2-ethyl-hexyl-lactate
- Galaster IAL™: iso-amyl-lactate
- Galaster IPL™: iso-propyl-lactate
- Galaster NPL™: n-propyl-lactate
- Galaster IPL™: iso-propyl-lactate
- Galaster EL™: ethyl-lactate
- Galaster IBL™: iso-butyl-lactate
- Galaster ML™: methyl-lactate
- Galaster OL™: octyl-lactate

Galasolv™ is our blend range and is also based on lactate esters. These blends have improved properties such as:

- Galasolv NF62™: non-flammability, i.e. higher flash point for ethyl-lactate
- Galasolv EL78ST™: a solution against hydrolysis of ethyl-lactate in water

We continuously develop and create new blends for our clients for a wide range of applications. The following table aims to recapitulate the main products we offer, with a brief description of their specifications. Other product descriptions are available on request.

Table 1: Galactic's bio-solvents product range overview

	Composition (single/blend)	Purity content (% w/w)	Acid content (% w/w)	Water content (% w/w)	Colour (Hazen)
Galaster ML97™	Single	Min. 97	0.2	0.3	Max. 50
Galaster EL98™ *	Single	Min. 98	0.1	0.2	Max. 30
Galaster IPL98™	Single	Min. 98	0.25	0.5	Max. 50
Galaster NPL98.5™	Single	Min. 98.5	0.1	0.1	Max. 20
Galaster BL97™	Single	Min. 97	0.1	0.3	Max. 50
Galaster IAL98™	Single	Min. 98	0.1	0.3	Max. 25
Galaster EHL95™	Single	Min. 95	0.1	0.3	Max. 50
Galaster OL96™	Single	Min. 96	0.1	0.3	Max. 50
Galasolv NF62™	Blend	Min. 97	0.1	0.2	Max. 30

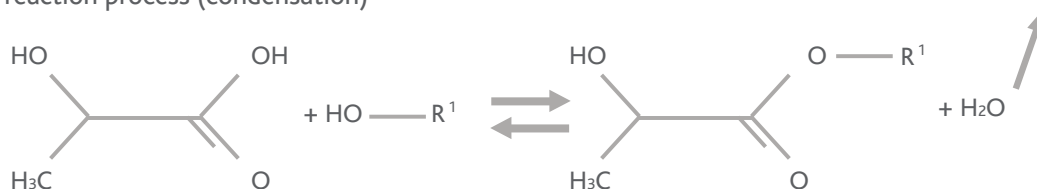
*Galaster™ (ethyl lactate) - different quality grades are available for applications in food, industry, and electronics.



2. BASIC CHEMISTRY

A. REACTION

Galactic's bio-solvents are produced by reacting alcohol with lactic acid during the esterification reaction process (condensation)

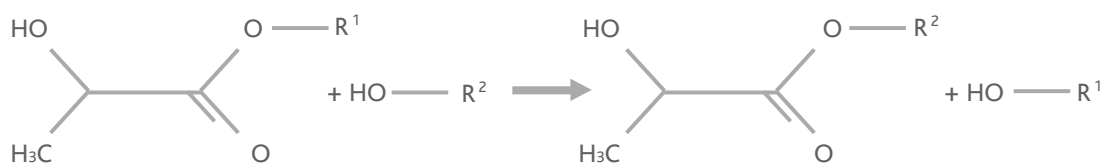


Where R¹ is an alkyl, an iso or sec alkyl.

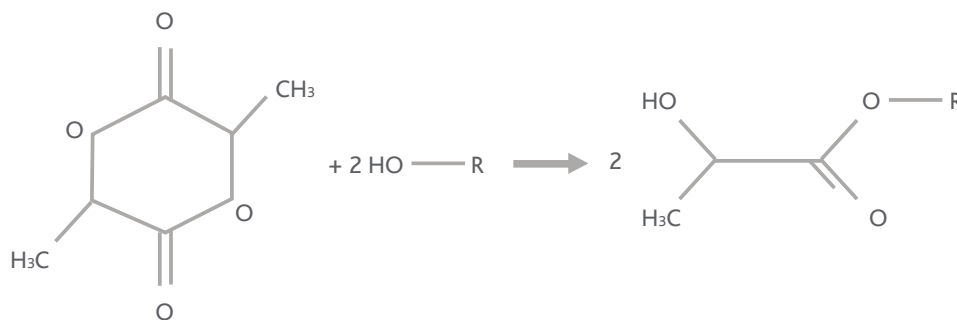
Careful control of the esterification and separation processes allows our compounds to be produced with low levels of water, alcohol, acid content and slight colouring. Other synthesis processes are also carried out by Galactic to produce Galaster™ and Galasolv™ solutions.

We also conduct trans-esterification using:

a. Another lactate ester (generally methyl or ethyl lactate)



b. Lactide (cyclic dimer of lactic acid)



Galaster™ can serve for a wide variety of chemical reactions.

B. CLASSIFICATION

All our Galaster™ solvents share the following properties:

1. Organic solvent

2. Protic and polar solvent

- Protic: OH function free – the hydrogen atom is able to form a hydrogen bond
- Polar: when longer-chain alcohols are used for synthesis the solvent is more likely to be non polar; this explains why Galaster EHL™ is not soluble in water (unlike Galaster EL™)

3. Oxygenated solvent

- Ester alcohols



3. CHEMICAL PROPERTIES

Galaster™ bio-solvents are sensitive to hydrolysis. As esterification is a reversible reaction, an ethyl lactate is always susceptible to reversion into lactic acid and alcohol. It is the principle reason why water is removed during distillation and synthesis. It holds true that Galaster™ solutions which are soluble in water will be sensitive to hydrolysis in the presence of water.

The graph below demonstrates how various concentrations of ethyl lactate hydrolyse in water:

Figure 1: Hydrolysis of Ethyl Lactate in function of concentration and time at 25°C

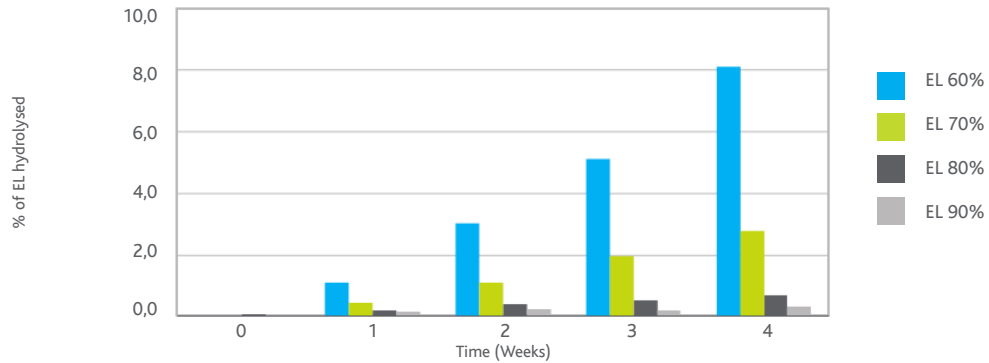


Figure 2: Hydrolysis of Ethyl Lactate in function of concentration and time at 25°C

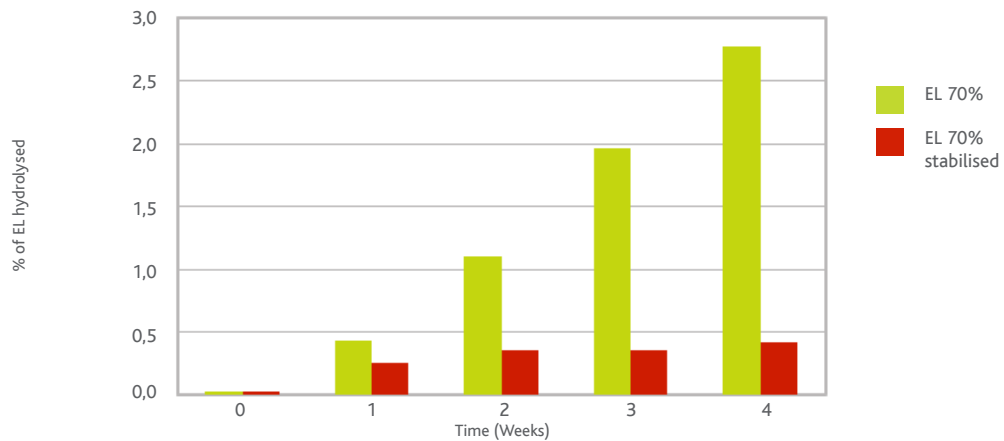
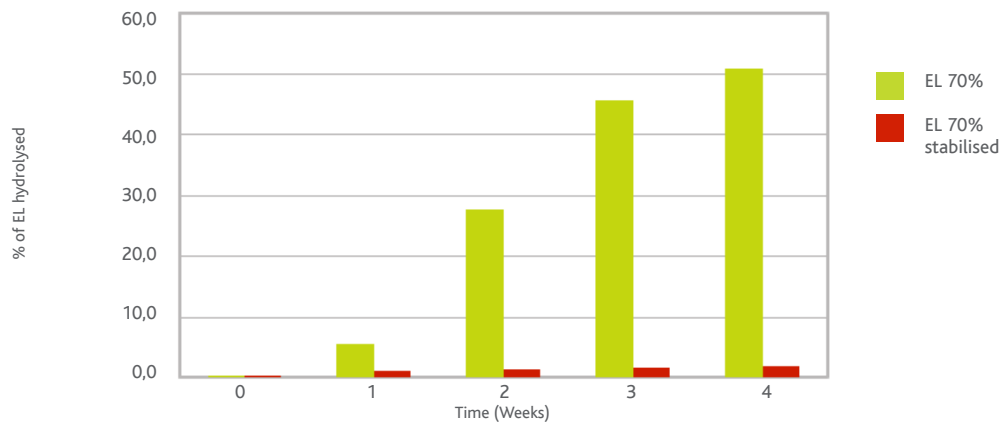


Figure 3: Hydrolysis of Ethyl Lactate in function of concentration and time at 40°C





As a result of this, Galactic has developed a solution to slow down the speed of hydrolysis by adding a specific stabiliser. Galactic offers a blend called Galasolv EL78ST™ with better hydrolysis resistance where water needs to be added for a particular reason (eg. handling, storage, use...).

4. PHYSICAL PROPERTIES

Table 2: Physical properties of Galactic's bio-solvents

Solvent	MW	Hansen Solubility parameters				Hildebrand	Density	Flash Point	Boiling Point	Vapour Pressure	Partition Coefficient Log P	Water Solubility	Sustainability
	g/mol	(MPa) ^{1/2}				g/cm ³	°C	°C	KPa (20°C)	Log ([Octanol]/[Water])	g/100 ml	%	
		δd	δp	δh	δ								
Galaster ML97™	104.1	17.6	8.59	12.95	23.48	1.090	57	144	0.34	-0.53	Miscible	100	
Galaster EL98™	118.1	16.7	6.45	11.6	21.33	1.030	60.5	153	0.22	0.06	Miscible	100	
Galaster NPL98,5™	132.2	16.3	6.80	10.77	20.68	1.024	69	170	0.11	0.39	Soluble	55 or 100	
Galaster IPL 98™	132.2	15.8	6.81	10.77	20.30	0.991	60	157	0.17	0.39	Soluble	55 or 100	
Galaster BL97™	146.2	15.9	4.60	10.49	19.60	0.980	79	187	0.03	1.10	4.5	49 or 100	
Galaster IBL98™	146.2	15.64	4.4	10.55	19.37	0.979	76	182	0.05	1.10	5.1	49 or 100	
Galaster IAL98,5™	160	15.8	3.70	9.9	19.01	0.961	85	202	0.02	1.62	0.3	100	
Galaster EHL95™	202.3	16.0	2.15	8.27	18.14	0.940	113	246	0.002	3.17	0.03	36	
Galaster OL96™	202.3	16.37	2.16	8.28	18.47	0.943	126	258	0.002	3.17	0.03	36	
Galasolv NF62™	118.7	16.7	6.41	11.58	21.31	1.030	61.5	unknown	0.18	unknown	Miscible	100	

A. SOLUBILITY AND SOLVENCY

Our product range is well-suited as an attractive alternative to many established solvents some of which have become increasingly regulated for environmental and health impact.

Hansen solubility parameters are key numerical characteristics of the solvency power of any given solvent. It predicts if one material will dissolve another one to form a solution.

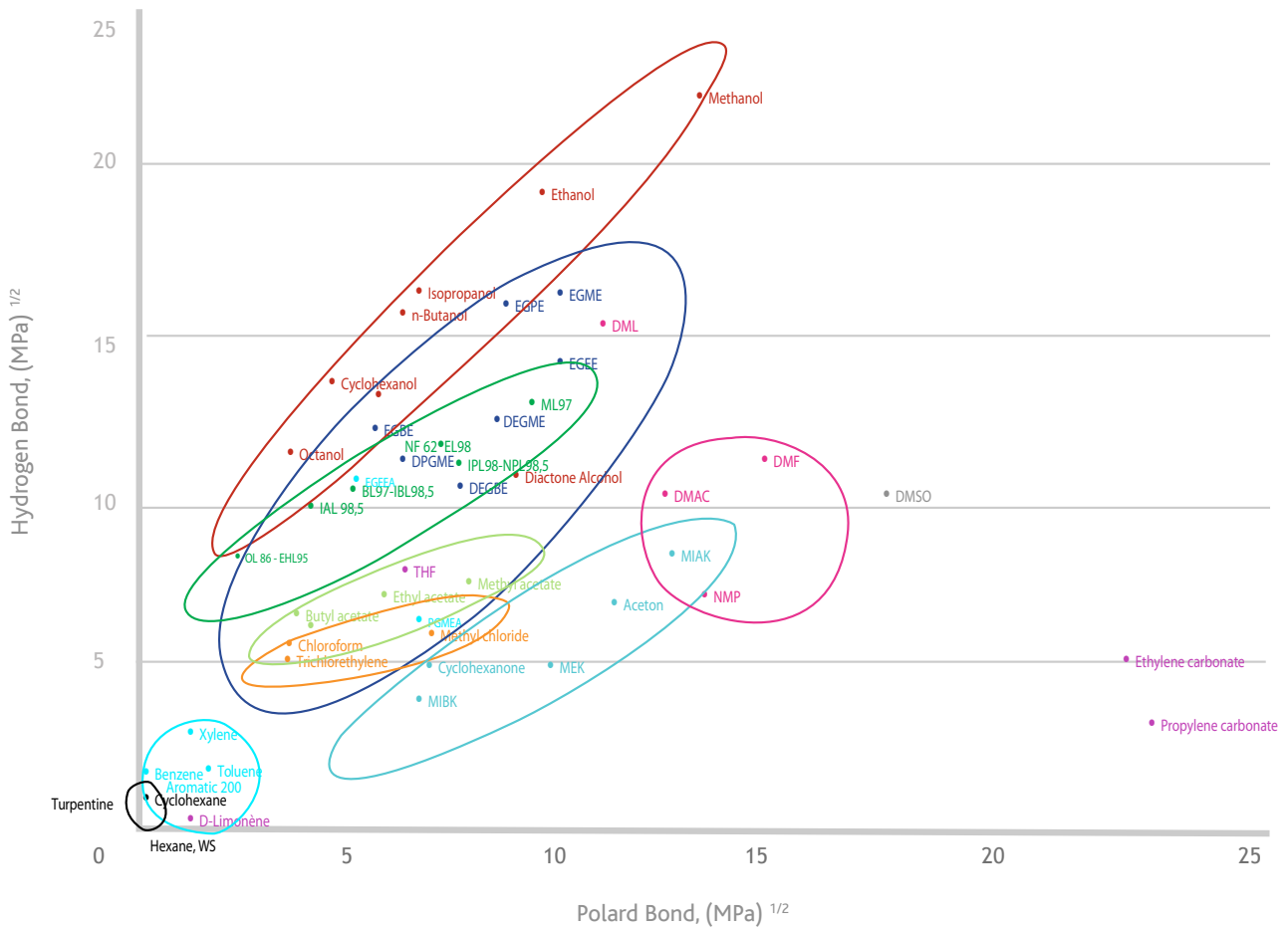
The graph herewith shows the position of Galaster™ solutions in contrast to other traditional petroleum-based solvents. Galaster™ can advantageously replace toxic halogenated hydrocarbons, chlorinated solvents, glycol ether and their acetates but are also able to assume the same functionality as traditional alcohol and esters, even ketones.



B. SOLUBILITY OF GALASTER™ SOLUTIONS IN VARIOUS SOLVENTS

Figure 4: Hansen solubility parameters of Galaster™ compared to common solvents

Hansen Solubility Parameters: Galaster™ vs Common Solvents



• Alcohol	• Ether Glycol & Acetate	• Keton
• Acetate	• Amide	• Aromatics
• Aliphatics	• Chlorinated Solvent	• Limonene
• Ether, Ester, Cyclic	• Organo Sulfuric	• Galaster
• Galamid DML		



Galasters™ are miscible in many common solvent types, including alcohols, ketones, acetates, ether and most hydrocarbons.

Table 3: Solubility of Galasters™ solutions in various solvents

SOLVENT	SOLUBILITY	SOLVENT	SOLUBILITY
Alcohols		Ketones	
Methanol	S	Acetone	S
Ethanol	S	Methyl Ethyl Ketone	S
n-Propanol	S	Methyl Isobutyl Ketone	S
Isopropanol	S	Methyl Isoamyl Ketone	S
n-Butanol	S	Cyclohexanone	S
n-Pentanol	S	Isophorone	S
Isoamyl alcohol	S	Chlorinated solvents	
2-Ethyl-1-hexanol	S	Ethylene dichloride	S
Octan-1-ol	S	Methyl chloride	S
Octan-2-ol	S	Chloroforme	S
Cyclohexanol	S	Trichloréthylène	S
Esters		Aromatic hydrocarbons	
Methyl acetate	S	Xylène	S
Ethyl acetate	S	Toluene	S
n-Butyl acetate	S	m-Crésol	S
Diméthyl succinate - DMS	S	Tetrahydrofuran	S
Propylène carbonate - PC	S	Alliphatic hydrocarbons	
Glycol Ethers and Acetates		Cyclohexane	S
2-Ethoxyethanol - EGEE - Cellosolve - Ethyl glycol	S	Heptane	S
2-n-Butoxyethanol - EGBE - Butyl cellosolve - Butyl glycol	S	Hexane	S
1-Methoxyl-2-propanol- PGME - Propylene glycol methyl ether - Dowanol PM	S	Octane	S
Diethylene glycol monoethyl ether - DEGEE - Ethyl diglycol	S	Amides	
1,2-Diméthoxyéthane - EG2ME - Ethylene glycol dimethyl ether - Dimethyl glycol	S	Dimethyl acetamide - DMAC	S
2-Ethoxyethyl acetate - EGEEA - Cellosolve acetate - Ethyl glycol acetate	S	Dimethyl formamide - DMF	S
2-n-Butoxyethyl acetate - EGBEA - Butyl cellosolve acetate - Butyl glycol acetate	S	N-Methyl pirolidone - NMP	S
1,2-Propanediol monomethyl ether acetate - PGMEA - Dowanol PMA	S	Dimethylsulfovide - DMSO	S
2-(2-n-Butoxyéthyl)éthyl acetate - DEGBEA - Butyl carbitol acetate	S		

S = Soluble, I = Insoluble
 Testing made on Galaster EL98™ and Galaster EHL95™. For water solubility: see physical properties table.

C. SOLUBILITY OF RESINS IN GALASTER™ BIO-SOLVENTS

Galasters™ are efficient as standalone solvents or in solvent blends. Studies have been conducted in collaboration with world leaders in the field as indicated in the table below; it demonstrates a synthesis of the analyses carried out. Further detailed information is available on request from our technical department with the usual confidentiality caveats applying.

See Appendix I for the table: Dissolution of resins with Galactic's bio-solvents.

D. KAURI-BUTANOL INDEX

The Kauri-butanol value ("Kb value") is a standard measure (ASTM D1133) of the power of solvents regarding their ability to remove stains such as gums or rubber resins.

The higher the index value the more powerful the solvent is. Values around 20 indicate a poor solvent and values of approximately 105 indicate powerful solvents.



Table 4: Kauri-butanol values

Solvents	Value*	Prognosis
Galasolv NF62™	>164	Excellent
Methyl chloride	136	Excellent
Trichloroethylene	130	Excellent
Perchloroethylene	93	Good
1,1,1- trichloroethane	107	Excellent
N hexane	27	Poor
White Spirit	31-33	Poor
CFC 113	31	Poor
Toluene	84	Good
NMP	>300	Excellent

We can see that Galasolv NF62™ is a better performant than chlorinated solvents and hydrocarbonated solvents.

Due to their high polarity, our products are highly efficient in surface cleaning operations to remove contaminants.

* Where values up to 20 reflect poor solvency and values >100 indicate excellent solvency.

E. EVAPORATION RATE

Solvents can be classified in three different categories in accordance with their evaporation rate values:

- Slow drying; more than 30 minutes ($le >15$ or $lab <0,2$)
- Medium drying; between 1 to 30 minutes ($3 <le <15$ or $0.2 <lab <1$)
- Fast drying; less than 1 minute ($le <3$ or $lab >2$)

DIN 53170 is the standard used for testing, using either diethyl ether (le) or butyl acetate (lab) as a reference.

Table 5: Evaporation rate

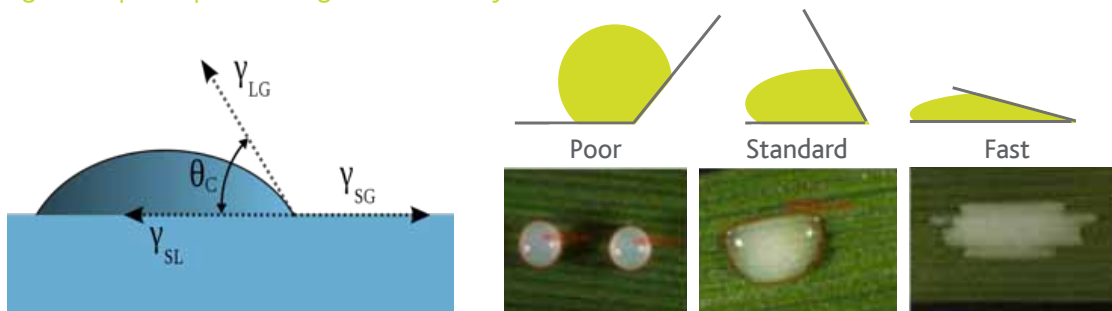
Solvents	lab	le	Results (rate)
EL 98	0.22		Slow
BL 97	0.035		Slow
Ethyl acetate		2.9	Fast
MEK		2.7	Fast
Ethanol		8.3	Medium
Toluene		6.1	Medium
NMP		360	Slow

In general our products have low evaporation rates compared to other alternatives: this makes them highly suitable for drying applications, such as print and varnishes.

F. WETTABILITY – SURFACE TENSION

Surface tension is measured by the degree of angle contact made between the solvent drop and the substrate.

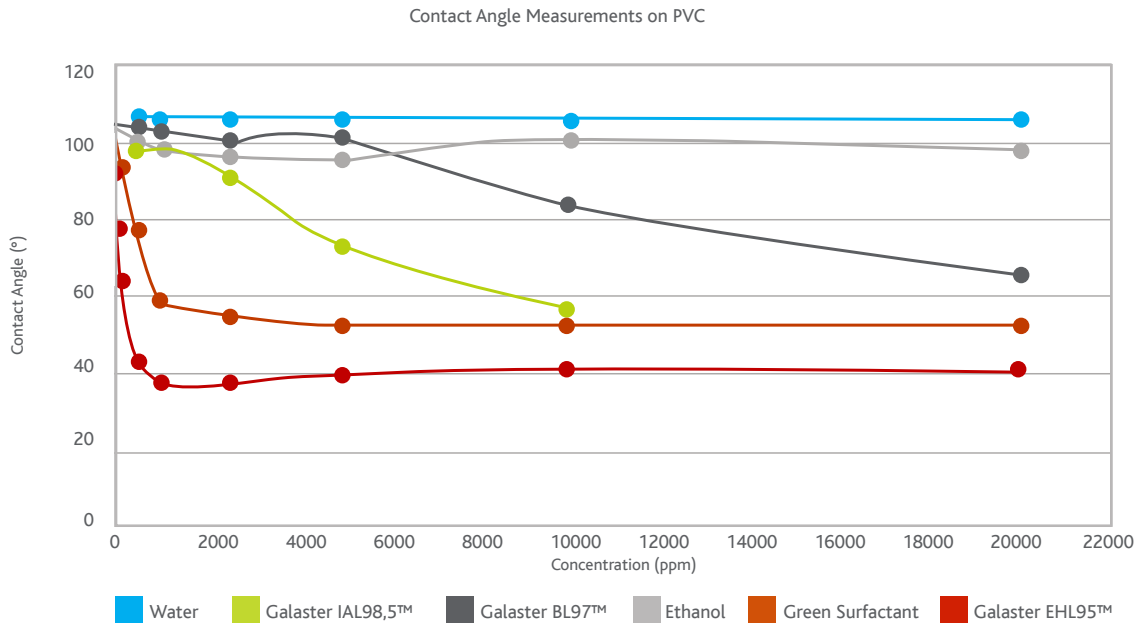
Figure 5: Liquid drop contact angle and wettability illustration



The method consists in measuring the angle made by the tangent to the liquid drop's profile and the substrate. Wettability is considered to be good if the angle is less than 90°.



Figure 6: surface tension or wettability of Galaster™ bio-solvents on a PVC substrate



Note: the concentration refers to one which is a solvent in water.

Galaster EHL95™ demonstrates very efficient wettability properties with a concentration less than 0,5%. The contact angle is similar to that which we get with surfactants. This is the reason why it is used in agrochemistry to improve the efficiency of the active ingredient for the wetting of the leaf.

Galaster IAL98™ and GalasterBL97™, being less efficient than Galaster EHL95™, require higher concentrations to attain the same effect.

G. VOC – NON VOC – DIRECTIVE 1999/13/EC AND 2004/42/EC

Volatile organic compounds (VOC) are organic chemicals that have a high vapour pressure at ordinary room temperature. Their high vapour pressure results from a low boiling point which causes a number of molecules to evaporate from the liquid form of the compound.

In the European Union, VOC compounds are classified in accordance with two specifications:

For decorative paints: Directive 2004/42/EC

- VOC is an organic compound having a boiling point less than 250°C at 101.3 kpa

For general purposes: Solvent Emissions Directive 1999/13/EC

- VOC is an organic compound having a vapour pressure at 20°C of 0.01 kPa or more

Galaster™ products are generally considered to be very low VOC because of their high boiling point. Galaster EHL95™ and Galaster OL96™ are considered as non-VOC under Directive 1999/13/EC as they have a vapour pressure below 0,01 at 20°C (see table 2: physical properties of Galactic's bio-solvents). Even Galaster OL96™ is considered non-VOC under 2004/42/EC for decorative painting.



H. SOLUBILITY IN WATER (LOG P)

Galaster™ bio-solvents include a range of solvents which are fully soluble, partially non-soluble or not at all soluble in water depending on the alcohol particle size.

The log P values demonstrate this characteristic (see table 2: physical properties of Galactic's bio-solvents).

Log P, also called distribution coefficient octanol-water, measures the difference in solubility of a compound in octanol and water. It measures hydrophilic ("affinity for water") or hydrophobic ("repelling or incapable of dissolving in water") (lipophilic) properties.

If Log P is 0 or above, the compound is more highly soluble in octanol than in water meaning it is hydrophobic (showing lipophilic properties) and the converse also holds true.

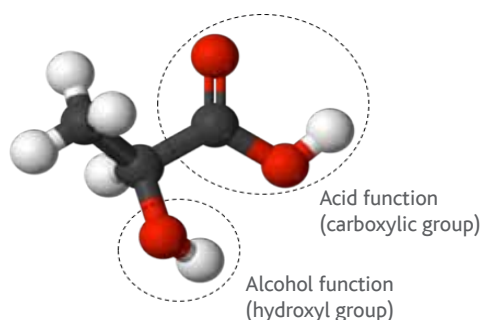
If the value of Log P = 0, then the compound is equally soluble in water as it is in solvent.

Solubility is a key factor for selecting the right Galaster™ or Galasolv™ product, especially in water-based applications and for coalescing aids in particular.

I. ADVANCED DEVELOPMENTS AND TAILOR MADE SOLVENTS

Galactic's aim is to develop natural solutions based on lactic acid to replace existing harmful products. With our long R&D history and focus, we have built a strong competitive edge in Lactochemistry®.

Figure 7: Lactic acid molecule



Lactic acid is one of the key bio-based building blocks of the future. Thanks to its hydroxyl and acid functions, available in liquid or solid form, lactic acid is the base that makes hundreds of chemical reactions possible (esterifications, condensation, oxidations, reductions, substitutions...).

A dedicated team of experts with strong experience and knowledge in process design, product development and formulation chemistry provide solutions to enhance the innovation process. Galactic offers standard products but also tailor-made formulations and products at above market standards, the right product for your application and the development of unique products or blends to achieve the right properties.



III. KEY APPLICATIONS OF GALACTIC'S BIO-SOLVENTS

Galactic's product range is being used in an increasing number of industrial and commercial applications.

1. AGROCHEMISTRY



Galasters™ are used as solvents and adjuvants in agrochemical products. They may also be used as chirally pure material for synthesising specific active ingredients (AIs) used in agrochemical products. Galasters™ are typically used as alternatives to conventional solvents to dissolve active ingredients in oil phase formulations. Solvents improve the wetting of the AI on the leaf surface as we have demonstrated earlier. Based on the type of formulation, Galasters™ are used as alternatives

for soluble concentrations and emulsifiable concentrations (eg. Galaster EHL™). Our bio-solvents are highly effective because of their high solvency rate and high boiling point resulting in prolonged contact with weeds, pests, etc.

2. METAL AND SURFACE CLEANING

Metal cleaning is principally the removing of the toughest non soluble contaminants such as oils, greases, carbon, inks, waxes, dyes and industrial grime or indeed metal filings such as solder flux from metal parts.



Users can select the most suitable Galactic solvent in function of their specific needs and local legislation. Typical applications occur in the aerospace, railroad, metal tubing and automotive industries and indeed any other industry where parts and pieces of metal and plastic etc. are cleaned.

Surface cleaning uses a large variety of traditional solvents including: chlorinated solvents, HCFC's, modified alcohol solvents and hydrocarbonated solvents. Our Galaster™ and Galasolv™ ranges can replace all these solvents effectively as they have the

distinct advantage of being green, non-toxic, safe and efficient (see table 4: kauri-butanol values). Our Galasters™ are used in different solvent metal cleaning processes including cold-cleaning, vapour degreasing both in enclosed and open cleaning systems. In these types of cleaning systems, Galasters™ can be used in combination with ultrasonic transducers or re-circulated power flow. Cleaning is generally done in several stages.

Galaster EL98™ is a suitable cleaner for printing presses. Because it is highly soluble in water and solvents, it can be used to clean "Offset Printing" presses regardless of the type of ink that is used (waterborne or solvent-borne). Galaster EL™ can be used as an alternative to chlorinated and low aromatic solvents. Ethyl lactate also appears to be a suitable alternative to ethylene glycol-based glycol ethers, such as 2-Ethoxyethyl acetate, as it has a very similar evaporation rate compared to other propylene glycol-based glycol ethers.



Table 6: Ethyl lactate versus ethyl glycol acetate

	Ethyl Lactate	Ethyl Glycol Acetate
Solubility :		
Hansen Parameters		
Disperse (Mpa ^{1/2})	16.7	16
Polar (Mpa ^{1/2})	6.45	4.7
Hydrogen (Mpa ^{1/2})	11.6	10.6
Others Properties :		
Boiling Point	154°C	156°C
Evaporation Rate	0.21	0.19

Galasters™ are known to be an excellent paint stripper and graffiti remover. Methylene chloride, NMP (1-methylpyrrolidone) and many other traditional solvents are widely used in paint stripping formulations. Those petroleum-based solvents are dangerous and toxic for the environment so should be replaced where feasible. Galaster EL98™ or Galasolv NF62™ are the most suitable alternatives used in combination with other green solvents such as d – limonene, and ethyl soyate, and on occasion traditional solvents like DMSO. The indicative concentration level for Galaster EL98™ in formulations is between 40-60%. For more information, our R&D team may provide you with advice specific to your requirements.

3. ELECTRONICS



The Galaster™ product line in the electronics industry has many beneficial applications. It can be used as a high purity solvent in positive photosensitive resins (photolithographic processes), as an edge bead remover and as a cleaning solvent in semiconductor and printed circuit board manufacturing. By way of example positive photosensitive resins, made with Galaster EL™, are used for manufacturing micro-electronic components such as; semi-conductor chips, printed circuit boards and flat panels. Since Galaster EL™ shares similar properties to glycol ethers, it can therefore be used as an alternative.

Table 7: Galaster™ properties for electronic applications

Properties	Unit	Galaster EL™	2-ethoxyethyl acetate (EEGEA)	1-methoxy 2 propyl acetate (PGMEA)
Solubility Parameters (Hansen)				
Dispersion bond	Mpa ^{1/2}	16.7	16	16.1
Polar bond	Mpa ^{1/2}	6.45	4.7	6.1
Hydrogen bond	Mpa ^{1/2}	11.6	10.6	6.45
Boiling Point	°C	154	156	146
Evaporation rate	N-butanol acetate = 1	0.21	0.19	0.33

Galasters™ can also be used instead of CFC 113 to remove residues and soldering flux from circuit boards.



4. SOLVENTS

A. RESINS IN COATINGS, INKS, VARNISHES, WIRE COATINGS



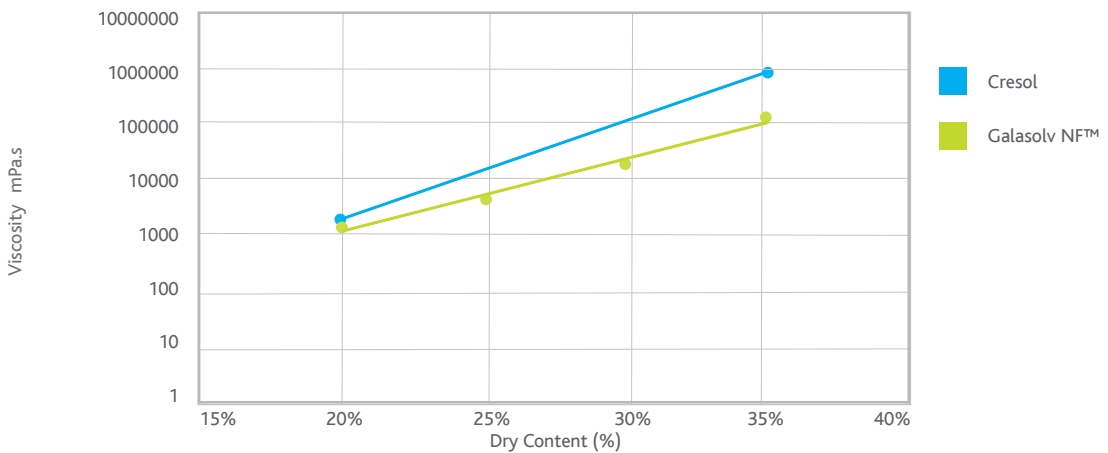
Galactic proposes a wide range of solvents, to replace traditional crude oil based ones, which demonstrate effective performance-related properties for solvent based formulations in coatings, inks, varnishes, and adhesives applications. Replacement of traditional solvents may be determined with the help of Hansen solubility parameters.

Due to their high polarity, Galasters™ and Galasolvs™ are adapted to dissolve many types of resins to produce solvent based solutions eg. Acrylic resins, Phenolic resins, Phenoxy resins, Cellulose resins (see Appendix I for a demonstration of the capability of our Galaster™ solvents range).

Successful substitutions have already been demonstrated. Hereunder, are some examples:

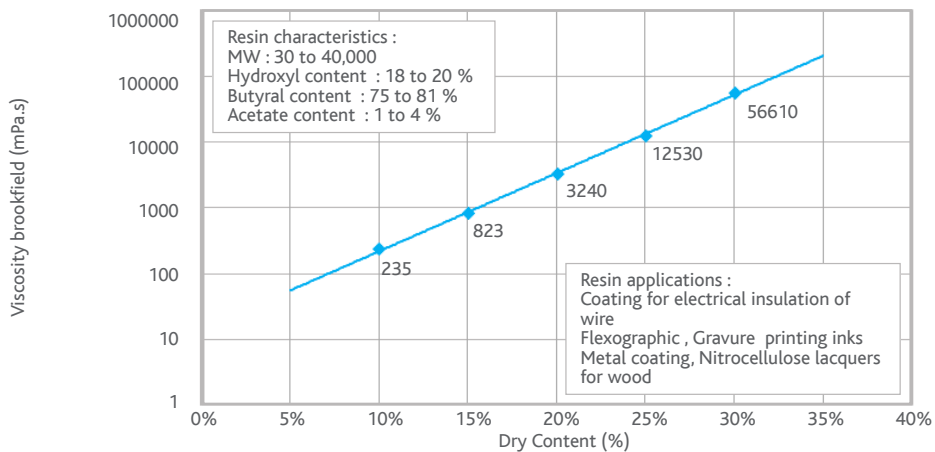
- Replacement of Cresol to dissolve Phenoxy resins in a wire coating application (insulation of first level)

Figure 8: Solubility of Inchemrez PKH phenoxy resin in Galasolv NF™ versus m-Cresol



- Dissolution of Polyvinyl Butyral resins in metal coating, wire coating or finished wood

Figure 9: Dissolution of Polyvinyl Butyral resin in Galaster EL 98™





- Dissolution of acrylic resins , VC/VA copolymer for varnishes or inks

Figure 10: Solubility of VC/VA (13%) copolymer resin in Galaster's bio-solvents

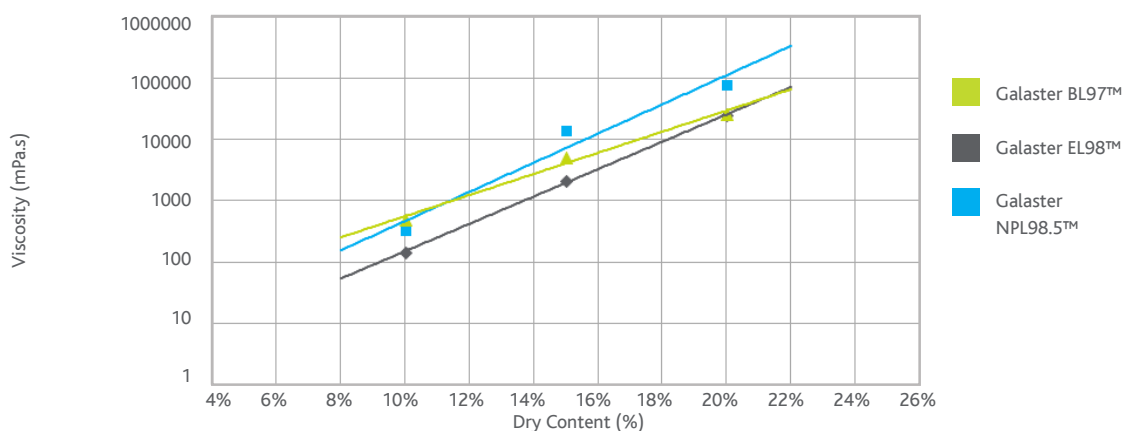
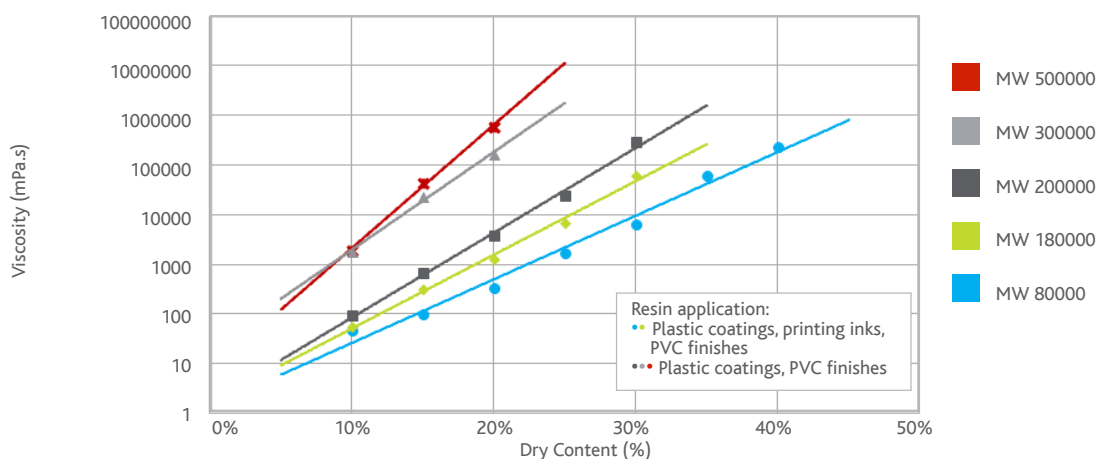


Figure 11: Solubility of Methyl Methacrylate (MMA) resins in Galaster EL 98™



Note: Viscosity in function of concentration for resins of different MW.

Further to Appendix I, and for reasons of viscosity, we recommend Galaster EL98™ or the non-flammable Galasolv NF62™ for use in this application. You can also use a solvent with a higher boiling point such as Galaster NPL 98.5™ or BL97™.

For other technical uses, our research team is at your disposal.



B. ADDITIVES IN COATINGS

Galasters™ can be used as additives to improve the properties of formulations in terms of their wettability. They can also be used as an evaporation control agent for solvent-based formulations and as coalescing agent for water-based formulations.

As explained in the above paragraph, we recommend using Galaster EHL 95™ to improve wettability. As Galasters™ are slow evaporation-rate solvents (high boiling points solvents) they are interesting to use in coating formulations to increase drying time and thus provide an effective replacement for glycol ethers.

Another application for Galasters™ makes use of to their ability to act as a coalescing agent. Galactic, in collaboration with the CORI Institute, has proved that some of our products can be used as effective coalescing agents to replace traditional solutions (eg. Glycol ether, Texanol,...). Galaster EHL 95™, BL 97™ and OL 96™ show similar or even better properties than these alternative conventional coalescing agents. Galaster OL 96™ is also classified as non-VOC in decorative paints (2004/42/EC) making it a very interesting alternative.

Hereunder, some results of trial tests performed at the CORI Institute:

Figure 12: CORI Institute tests for coalescing aids Galaster EHL™ and BL™

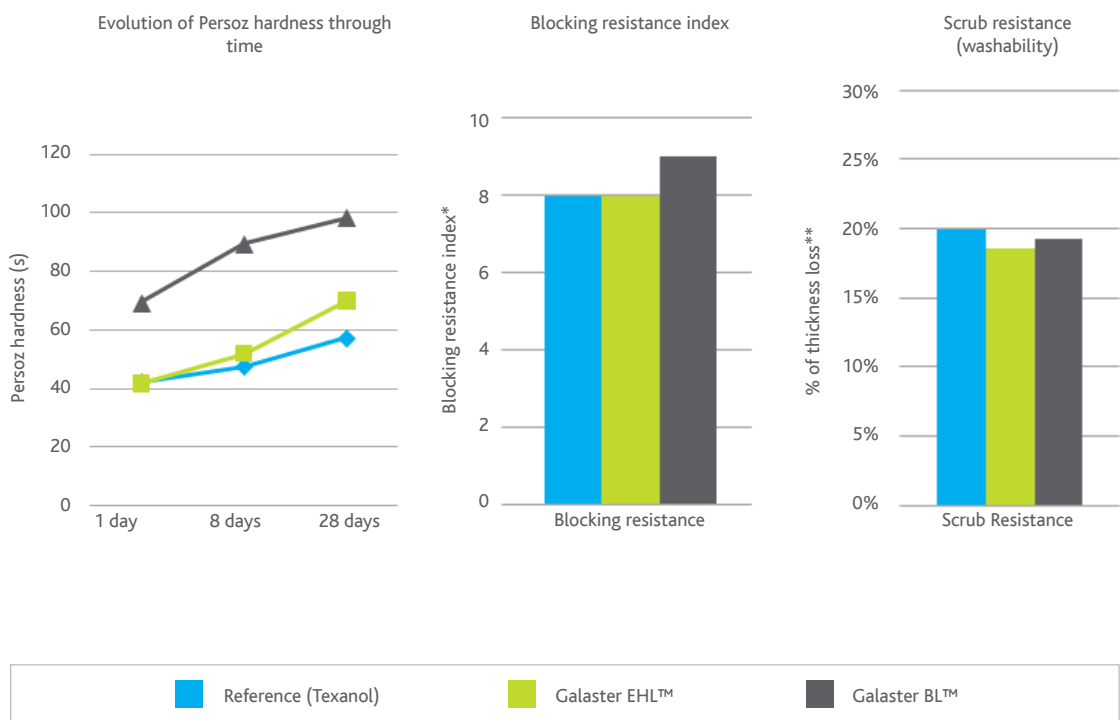




Table 8: CORI Institute tests for coalescing aids Galaster OL™

Persoz Hardness - ISO 1522				
Drying Time 20°C and 50% RH	Texanol Tin Plate Steel	Galaster OL96™ Tin Plate Steel	Texanol Leneta Sheet	Galaster OL96™ Leneta Sheet
1 day	20 sec	19 sec	-	-
7 days	27 sec	25 sec	-	-
14 days	33 sec	35 sec	-	-
2 months	-	-	46 sec	47 sec

Paints	Film Formation - Drying Time - ASTM D5895		Scrub Resistance - ISO 11998	
	Drying Time (min)		Loss in coating mass	Loss in film thickness
	23°C / 50% RH	= 8°C / 40-60% RH	(g/m ²)	(µm)
Texanol	30 ± 2	63 ± 0	11.45	5.37
Galaster OL96™	32 ± 1	47 ± 1	9.86	4.46

Table 9: Summary of key applications for Galaster™ and Galasolv™ solutions

			Galaster ML97™	Galaster EL™ (various grades)	Galaster NPL98.5™	Galaster BL97™	Galasolv IAL98™	Galaster EHL95™	Galaster OL96™	Galasolv NIF62™
Agrochemistry								++		
Cleaning	Paint stripper and graffiti remover			++						++
	Metal surface cleaning	Open system		+	+	+		+		++
		Closed system		++						
Electronics				++						
Solvents	Solvent for resins in inks, varnishes, coatings, adhesives	For polar resins	+	++	++	++		+		++
		For hydrocarbon resins						++		
	Additives in inks, varnishes, coatings, adhesives	Wetting/levelling				+	++	++		
		Evaporation control	++	++	++	++		++		++
	Coalescing agent				+		+	++		

For any further questions on our products and how to introduce them in your applications, please contact us.



IV. OTHER BENEFITS

1. HEALTH AND SAFETY

From a health perspective, our Galasolv™ and Galaster™ ranges are safe for end-users and workers to apply. They are non-harmful to health with generally high boiling points, offer improved safety due to their non-flammability and are deemed to have a low/eco toxicological profile.

2. ENVIRONMENT

When we consider how hazardous existing petroleum-based solvents are then it presents the ideal opportunity to invest in research to produce a solvent that is as equally effective as the traditional ones but that is sourced naturally and is biodegradable. Many of the current solvents on the market are toxic for the environment because they are Volatile Organic Compounds (VOC). By using either our Galaster™ or Galasolv™ ranges we offer formulations that have the same effectiveness as commercial formulations and which also have favourable impacts on the environment as they are low VOC.

3. COST-EFFECTIVENESS

At the heart of Galactic's business is the production of natural lactic acid through the fermentation of corn or sugar. Unlike the cost of traditional alternatives to the solutions we provide, our price-range is quite stable by comparison because it is not susceptible to influence by crude oil prices. In addition, because of the very nature of the products we provide, there is less cost involved in their storage, handling and recycling. We follow the motto of "less is more" and so create highly efficient products which don't require our customers to invest in the same volumes as they would do with traditional substitutes. Naturally, this ensures our clients make important cost savings and part of why they consider our line of tailor-made formulations to products which don't require our customers to invest in the same volumes as they would do with traditional substitutes. Naturally, this ensures our clients make important cost savings and part of why they consider our line of tailor-made formulations to be above market standards.





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APPENDIX I : DISSOLUTION OF RESINS WITH GALACTIC'S BIO-SOLVENTS

Resins	Type	A	B	C	D	E	F	Suppliers
Acrylic	MMA	S - NR	CS to NS	CS	CS	CS	S - NR	Degalan Evonik, Elvacite Lucite Degalan Evonik, Elvacite Lucite Degalan Evonik, Elvacite Lucite Elvacite Lucite Degalan Evonik, Elvacite Lucite, Neocryle DSM Neo Resins + Neocryle DSM Neo Resins + Neocryle DSM Neo Resins +
	IBMA	S - NR	CS	CS	CS	CS	S - NR	
	EMA	S - NR	CS	CS	CS	CS	S - NR	
	NBMA	NS	CS	CS	CS	CS	NS	
	MMA/BMA	S - NR	CS	CS	CS	CS	S - NR	
	MMA/EMA	S - NR	CS	CS	CS	CS	S - NR	
	BMA/Styren	S - NR	CS	CS	CS	CS	S - NR	
Cellulose Esters	Cellulose acetate	NS	NS	CS	CS	S - NR	S - NR	CA Eastman CAB Eastman CAP Eastman
	Cellulose acetate butyrate	NS	CS	CS	CS	CS	CS	
	Cellulose acetate propionate	CS	CS	CS	CS	CS	CS	
Polyvinyl chloride copolymers	VA/VC copolymer	NS	CS	CS	CS	CS	NS	SolVin solvay, Vinnol Wacker
Polyvinyl acetate homopolymer	VA homopolymer	NS	CS	CS	CS	CS	NS	Vinnapas Wacker
Polyvinyl butyral	All types	CS	CS	CS	CS	CS	CS	Mowital Kuraray, Butvar Solutia
Phenoxy		S - NR	CS	CS	CS	CS	S - NR	Inchemrez Inchem
Phenolic resins	Alkyl phenol							Durez Sumimoto (solution in butanol) Bakelite Europe Durez Sumimoto Bakelite Europe Durez Sumimoto Bakelite Europe Durez Sumimoto Bakelite Europe Bakelite Hexion Specialty chemicals Bakelite Hexion Specialty chemicals Bakelite Hexion Specialty chemicals Bakelite Hexion Specialty chemicals
	Terpene Phenolic resins	S - NR	CS	CS	CS	CS	NS	
	Modified Novolac Phenolic resin	S - NR	CS	CS	CS	CS	CS	
	Phenolic	S - NR	CS	CS	CS	CS	CS	
	Phenolic Novolac	S - NR	CS	CS	CS	CS	CS	
	Alkylphenolic Novolac	S - NR	CS	CS	CS	CS	CS	
	Alkylphenolic Resol	S - NR	CS	CS	CS	CS	CS	
	Phenolic resol, etherified Cresol resol							
Epoxy resin	Epoxy Novolac resin based on Epichlorohydrin/bisphenol A	NS	CS	CS	CS	CS	CS	D.E.N Dow Plastics
	Epoxy resin based Epichlorohydrine/bisphenol A (High Epoxy content)	S - NR	CS	CS	CS	CS	CS	D.E.R Liquid Dow Plastics
	Epoxy resin based Epichlorohydrine/bisphenol A (Low Epoxy content)	S - NR	CS	CS	CS	CS	CS	D.E.R Solid Dow Plastics
Polyterpene resin	Alpha pinene	CS	NS	NS	NS	NS	NS	Piccolyte A Pinova
	Beta pinene	CS	NS	NS	NS	NS	NS	Piccolyte C Pinova
	D-limonene	CS	NS	NS	NS	NS	NS	Piccolyte S Pinova
Rosin resin	Wood rosin partially hydrogenated	MS	not tested	MS	MS	not tested	not tested	Staybelite Pinova Foral Pinova Foral Pinova
	Wood rosin highly hydrogenated	MS	not tested	MS	MS	not tested	not tested	
	Glycerol ester of highly hydrogenated gum rosin	CS	not tested	CS	CS	not tested	not tested	

Comparison at same level of concentration : Gel is considered as non soluble at low concentration solubility is good. Solubility depends on the molecular size of the resins.

CS/MS
S - NR
NS

Thinnable

Good solubility (CS clear : transparent solution, MS : milky solution)

Soluble but not recommended (higher viscosity, gel)

Not soluble

Since 1994 Galactic has become one of the world's greatest leaders in biotechnology serving the food, feed, personal & health care, and industrial markets. Based on its valuable experience in the fermentation of lactic acid and other derivatives, Galactic continuously develops sustainable, innovative and health-friendly solutions in the field of food safety, nutrition and green chemistry. With headquarters in Belgium, production facilities in the United States (Milwaukee), China (Bengbu) and Europe (Escanaffles), and sales offices in Belgium (Brussels), Japan (Tokyo) and Brazil (Curitiba), Galactic employs more than 300 people worldwide and is active in almost 65 countries.



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