



Product Handbook

Indorama Ventures Oxides Australia Pty Limited

INDORAMA
VENTURES
Integrated Oxides & Derivatives

> *Empowering potential.*

Indorama Ventures

Proudly manufacturing in Australia since 1964

Indorama Ventures is a manufacturer of ethylene oxide, ethylene oxide derivatives and other differentiated chemicals, operating in Australia for over 50 years. Our long history of supplying quality products into key industries including agriculture, automotive, home care, cleaning, coatings, energy and mining chemicals has made us a trusted chemical supplier in the Australian, Asia Pacific and Global market.

In Australia, our manufacturing facility is located in Botany, NSW and leads the Asia Pacific region for production of ethylene oxide and derivatives. Indorama Ventures is the only manufacturer of ethylene oxide in Australia. Ethylene oxide is reacted with a variety of locally and globally sourced materials resulting in over 250 specialised products, namely surfactants, glycols and glycol ethers, that remain pivotal to the function of both Australian industries and those abroad.

We are committed to sustainably providing quality products and services that meet our customer needs by ensuring we operate safely and in accordance with applicable statutory, regulatory and environmental requirements. We strive to provide consistent and flexible supply options, and as a local manufacturer, maintain the benefit of being responsive to the dynamic needs of industry.

Our Australian commercial, R&D and production teams harness their combined experience to provide both passionate and dedicated service and support, whilst continuing to innovate by developing new products and applications, improving existing product lines and finding new and improved ways to service our customers' needs.

Indorama Ventures is ISO9001 and Roundtable on Sustainable Palm Oil (RSPO) accredited.



Product Integrity

Most ethylene oxide derivatives, including surfactants, are hygroscopic. If moisture content is critical to the end-use application, then silica gel or alumina traps should be attached to tank breathers or drum vents.

All alkylene oxide derivatives are ultimately susceptible to oxidative degradation. Such degradation is accelerated by aeration, UV light and heat, and will result in discolouration, a decrease in pH, an increase in acidity and possibly the development of a faintly aldehydic odour. Although, in general, this does not change the bulk properties of the surfactant, oxidative degradation may well cause the product to drift outside of pH, acidity or colour specifications.

Alkylphenol ethoxylates are the least susceptible to oxidative degradation, followed by the fatty alcohol ethoxylates. Block copolymer surfactants and polyethylene glycols are relatively sensitive, particularly to excessive heat. Polyoxyethylene fatty acid derivatives are complex equilibrium mixtures of esters and polyglycols. It is possible for subtle compositional changes to occur over time, particularly when the product is stored above its melting point to facilitate ease of handling. Usually an assay of acid value, saponification value and hydroxyl value will indicate if significant change has occurred.

Indorama Ventures recommends the following storage and handling practices to maximize effective storage life:

- Store products indoors and away from local heat sources.
- Partial use of solid products by melting and re-melting is discouraged because it will hasten oxidative breakdown and may lead to 'zone refining' of the product. Dividing material into smaller lots proportional to the application's batch size will reduce the need to repeatedly reheat it.
- Partially used bags of flaked goods should be resealed or transferred to sealed containers in order to reduce moisture absorption and oxidation.
- It is advised to store solid products above their melting point for extended periods, unless the tank is well padded with nitrogen.

It is also recommended that solid products are melted and then mixed thoroughly prior to their use to ensure product homogeneity.

Indorama Ventures cannot control the storage and use conditions of its products, making it difficult to prescribe absolute shelf-life values. Shelf life is affected by storage and handling conditions. Surfactant and polyol products are chemically stable provided the product is stored in the original unopened airtight container (steel drums or IBCs that are impermeable to oxygen), out of the direct sunlight and under shelter from the weather. Under these conditions surfactant and polyol products will remain useable for at least two years. After this time, it is recommended that product should be retested for conformance against the published specification.

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Safety in Use

A comprehensive Safety Data Sheet (SDS) is available on request from Indorama Ventures sales offices. The SDS, which conform to the requirements of the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) are frequently reviewed and updated. It is strongly recommended that the SDS is reviewed prior to the use of any surfactant product. Suitable protective clothing, including gloves and appropriate eye protection must be worn when handling these materials.

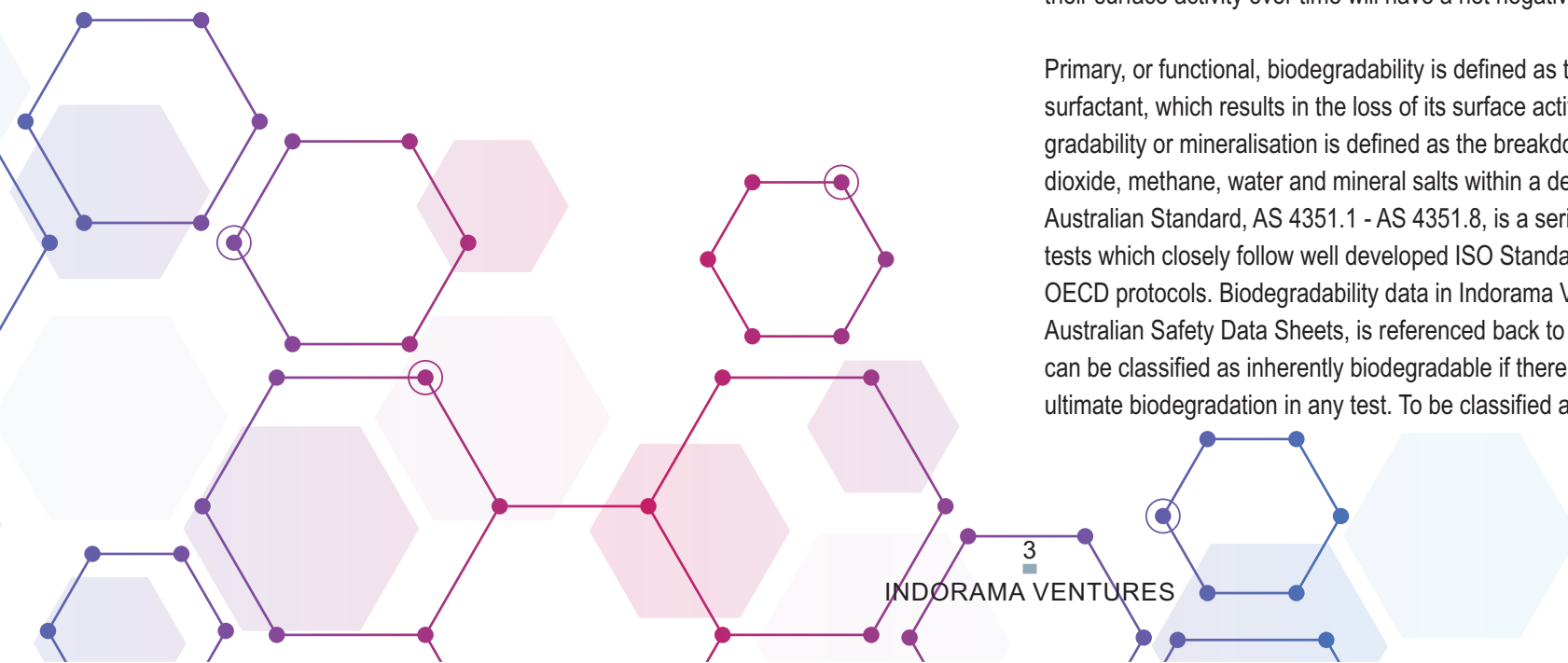
Indorama Ventures SDS also indicate a products dangerous goods classification for road and rail, shipping and air transportation. Some products have been assigned Class 9, UN 3082, Environmentally Hazardous Substance, Liquid, N.O.S. classification based on their potential adverse effect on marine life.

Environmental Impact and Sustainability

There are two properties of a surfactant which are of prime importance in assessing the environmental impact of a surfactant - its biodegradability and its toxicity.

The surface active properties of a surfactant, such as foaming, wetting and interfacial tension depression are what makes it useful in its domestic or industrial application. These very same properties are highly undesirable when the surfactant enters the aquatic environment. The interfacial tension depression effects and wetting effects are probably the prime cause of the significant aquatic toxicity of surfactants. Such toxicity is a function of both concentration and chemical composition. Concentration can be controlled by effluent management, but chemical composition has a broader significance. Surfactants which are very rapidly biodegraded can be claimed to be toxic only for a short time and therefore show minimal environmental impact, whereas surfactants which degrade slowly and retain a high percentage of their surface activity over time will have a net negative impact on the environment.

Primary, or functional, biodegradability is defined as the initial breakdown of the surfactant, which results in the loss of its surface active properties. Ultimate biodegradability or mineralisation is defined as the breakdown of the product to carbon dioxide, methane, water and mineral salts within a defined time period. The current Australian Standard, AS 4351.1 - AS 4351.8, is a series of ultimate biodegradation tests which closely follow well developed ISO Standards and their corresponding OECD protocols. Biodegradability data in Indorama Ventures literature, including the Australian Safety Data Sheets, is referenced back to these standards. Surfactants can be classified as inherently biodegradable if there is clear evidence of primary or ultimate biodegradation in any test. To be classified as readily biodegradable, the



SUSTAINABILITY

surfactant must pass rigorous biodegradation test criteria which indicated that it will rapidly and completely degrade in an aquatic environment under aerobic conditions.

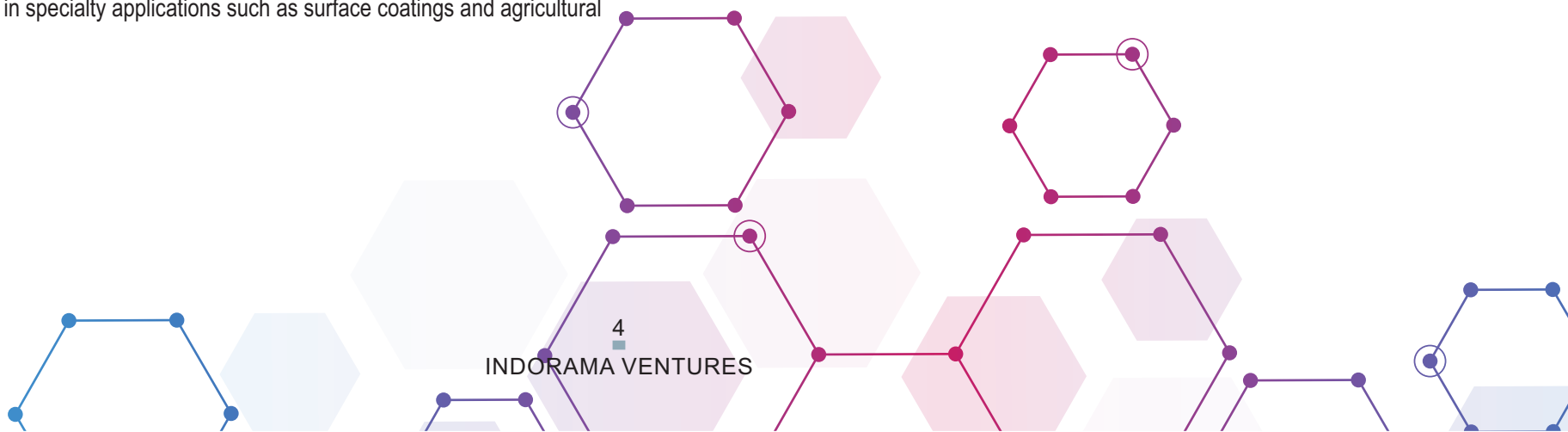
The relative biodegradability of nonionic surfactants is governed primarily by the structure of the hydrophobe and secondarily to the amount and type of alkylene oxide in the molecule. A general ranking below, based on hydrophobe types, illustrates the gradient towards readily biodegradable nonionic surfactants.

- Branched chain alkylphenol ethoxylates.
- Linear alkylphenol ethoxylates.
- Branched chain fatty alcohol ethoxylates.
- Oxo hybrid fatty alcohol ethoxylates.
- Linear fatty alcohol ethoxylates.
- Fatty acid esters.

There is ample evidence to show that biodegradation of a surfactant leads to a complete loss of any toxic effects. However, incomplete biodegradation or the formation of recalcitrant metabolites as a co-product of partial degradation must be regarded as potentially hazardous to the environment in the longer term. Surfactants which degrade slowly, but do ultimately degrade, and which have inherently low aquatic and mammalian toxicity represent an alternative route to minimal environmental impact, especially in specialty applications such as surface coatings and agricultural chemicals.

Both branched and linear chain alkylphenols, and their one and two mole ethoxylates have shown to possess the ability to mimic natural oestrogen hormones. This is often referred to as the endocrine disruptor effect. Potential adverse health implications in both humans and wildlife exposed to endocrine disruptor chemicals have been demonstrated and reported in the literature. Regulatory agencies worldwide have conducted extensive reviews of alkylphenols and alkylphenol ethoxylates due to concerns on their environmental impact. Some countries and authorities have introduced regulations that severely restrict their use.

The broader environmental impacts of surfactants can also be examined, where sustainability of raw material sourcing, production, carbon footprint and 'life cycle' analyses are key considerations. In general, whilst surfactants are manufactured industrially and often using petrochemical feedstocks, all efforts are made to ensure that products are based upon and manufactured using the best available and socially acceptable raw materials and manufacturing processes. These are in accordance with applicable regulatory and environmental compliance and using best manufacturing practices. In most cases, consideration is given to raw material feedstocks which demonstrate heightened awareness for sustainability such as in the case of RSPO certified fatty raw materials.



Surfactants

Alkanolamines

Oxygenated Solvents

Polyglycols and Alkoxy-Polyethers

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Surfactants

Indorama Ventures surfactants (surface active agents) are used in household and institutional cleaning products such as laundry powders and liquids, auto and manual dishwash, hard surface cleaners and disinfectants; personal care products such as those for skin and hair shampoos, shower gels and bath products; crop care products in agriculture; emulsion polymerisation processes for paints, coatings and adhesives; rheology control and aeration agents for concrete and plasterboard; flocculants, dispersants and flotation aids in mineral extraction processes; metalworking lubricants and related engineering process aids; foundry sands and pharmaceuticals.



“Without surfactants we would be completely helpless in facing 90% of industry’s problems.”

PIERRE GILLES DE GENNES
Nobel Prize winner for Physics



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SURFACTANTS



CHEMISTRY OF NONIONIC SURFACTANTS

Nonionic surfactants are usually the reaction product of an alkylene oxide, typically ethylene oxide, with an alcohol, alkylphenol, alkylamine, fatty acid or other appropriate compound having at least one active hydrogen atom. For most practical surfactants the most common alcohols, amines and acids have a carbon chain length in the range C8 - C18 and the most common alkylphenols are nonylphenol and octylphenol. Products for specialised applications may include propylene oxide in addition to ethylene oxide. A great many other nonionic surfactants can be formed by reaction of ethylene oxide with natural vegetable oils or esters of multifunctional compounds such as sorbitol.

Ethoxylation of alcohols and alkylphenols is achieved by the base catalysed addition of ethylene oxide under strictly controlled conditions of temperature and pressure. Simplistically, the reaction is a two-stage process involving the formation of an alkoxide anion which facilitates nucleophilic attack at the oxirane ring carbon atom to form an oxyethylated alkoxide anion, which in turn undergoes rapid reaction with additional ethylene oxide. In most reactions a long polyether chain is formed with repeating oxyethylene units. The relative reactivity of the alkoxide anion and the oxyethylated alkoxide anion is such that an alcohol ethoxylate produced by base catalysis may well contain unreacted alcohol, whereas an alkylphenol ethoxylate made under the same conditions will not contain unreacted initiator. Initiators in which the reactive site is sterically hindered will also tend to contain unreacted initiator. All nonionic surfactants contain a distribution of species with different molecular weights, due to different numbers of oxyethylene units in the polyether chains. Use of specialised, proprietary, catalysts can reduce or eliminate the amount of unreacted initiator and narrow the distribution of molecular weights. Increasing pressure and/or temperature increases the rate of polymerisation. Excessive temperature can induce depolymerisation, degradation and monomer isomerisation reactions.

The mole ratio of initiator or “hydrophobe” to ethylene oxide and the molecular weight and structure of the hydrophobe are the key factors which govern the performance characteristics of a nonionic surfactant.

The ability to control these structural elements during design and manufacture, provides the scope for performance optimisation with nonionic surfactants which is simply not attainable with common anionic and cationic surfactants.

The terminal hydroxyl group of the polyether chain is reactive and exhibits most of the conventional chemical characteristics of an alcohol. Accordingly, it is possible to make derivatives of nonionic surfactants by reacting them with higher alkylene oxides, or by sulphating, phosphorylating or carboxylating them. Ethoxylates or propoxylates of fatty amines can be quaternised to produce novel cationic surfactants.

The reaction products of ethylene oxide with fatty acids require separate discussion. They can be produced either by the direct reaction of the fatty acid with ethylene oxide using an alkaline catalyst, or by the esterification of the fatty acid with polyethylene glycol using an acidic catalyst. Both processes involve a number of ester interchange reactions, but ultimately produce similar products. Polyglycol monoesters, polyglycol diesters and unreacted polyethylene glycol coexist in a ratio of approximately 2:1:1. Special processing techniques or the use of other catalysts can influence this ratio to some extent. Indorama Ventures oleoesters are produced by the direct ethoxylation route.

Alkylpolysaccharides are nonionic surfactants which do not contain ethylene oxide. They are formed by the condensation of an alcohol with D-glucose, in the presence of a catalyst. Both the alkoxy group chain length and number of glucose units influence the solution properties of alkylpolysaccharide surfactants.

NONIONIC SURFACTANTS RANGE

Indorama Ventures surfactant products carry several different Tradenames which, in general, identify them with the major market sectors for which they were developed. The core range is the TERIC® product group, and its naming scheme will be detailed later in this section. Other Tradenames, used for the effect chemicals and specialty surfactants, are listed below.

Trademark	Brand Description
ALKADET® series	Alkyl polysaccharides for high caustic concentration cleaners and cleaning of dairy and food processing equipment
BIONIC®	Biodegradable nonionic detergent specifically optimised for high efficiency scouring and processing of natural textiles and raw fibres
COOL-RAD™	Formulated automotive engine coolants for general purpose applications
DI-GLYSOLV®	Glycol ether (di-ether of the parent alcohol)
ECOTERIC® E series	Emollients for use in personal care formulations
ECOTERIC® T series	Sorbitan ester ethoxylates or polysorbates
ETHOXINOL®	Formulated brake fluids of glycols, corrosion inhibitors and antioxidants For general purpose applications
GLYSOLV®	Solvent having applications within the surface coatings industry, in hard surface cleaners and agrochemical applications
GLYCOOL®	Formulated automotive engine coolants to suit specific OEMs as well as general purpose requirements
HBF™	Formulated brake fluids of glycols, corrosion inhibitors and antioxidants for specific OEMs and general purpose applications
HYDRAPOL®	Textile industry processing aids, including a diverse range of woolscouring detergents, carding combing and spinning lubricants, carbonising assistants, antistatic agents and specialty low foam wetting agents Also includes the RP series of high performance surfactants for all industrial processes involving spreading, penetrating, wetting and cleaning applications
POLYFROTH®	Flotation frothers developed for use in mineral beneficiation processes
POLYMAX®	Dispersants and depressants specifically developed for use in minerals beneficiation processes

Trademark	Brand Description
POLYSIL®	Coagulants for use in mining and related industries for the coagulation of silica and other fine particles
OXAMIN®	Alkyl dimethyl amine oxides, for domestic and industrial cleaning formulations
RADIHIB™	Fully formulated water-based corrosion inhibitor concentrate
RBF™	High performance racing brake fluid specifically designed for motor sport
SURFONIC®	Specialty wetting agents, emulsifiers and dispersants from Indorama Ventures North American nonionic surfactants range
SURFONIC® AG	Specialty solvents for agrochemical applications
TERIC®	The core range of commodity and specialty nonionic surfactants, comprising a series of ethoxylates of alcohols, fatty acids, fatty amines, alkylphenols, EO/PO block copolymers
TERMIX®	Specialty tank-added adjuvants and compatibilisers for agrochemical applications
TERMUL®	Specialty emulsifiers for industrial and agrochemical use The range includes both single component and formulated specialties
TERSPERSE®	Monomeric and polymeric dispersants, anionic and nonionic, for use in agricultural chemicals, surface coatings, pigment systems, ceramics, minerals processing and other industrial processes
TERWET®	Specialty wetting agents, including both single component and formulated specialties for agrochemical, textile and general industrial applications
TRI-GLYSOLV®	Glycol ether (tri-ether of the parent alcohol)
UNIDRI®	Dewatering aid for mineral processing applications
UNIFROTH®	Blend of butyl ethers of polyethylene glycols for use in frother formulations for mineral processing applications

CHEMISTRY OF IONIC SURFACTANTS

Anionic Surfactants

The Indorama Ventures range of anionic surfactants is composed of alkyl ether and alkylphenol ether sulphates and phosphates.

The hydrophobic portion of most anionic surfactants is typically a carbon chain with length in the range C8-C18. The counter-ion has a significant influence on the solubility of the compound and on its physical form.

Although sodium and potassium are most commonly used, other common counter-ions include those derived from ammonia, diethanolamine and triethanolamine. Alkyl ether sulphates can be produced by the reaction of sulphamic acid with an alkyl ether compound.

Alkyl and alkyl ether phosphates are produced by reacting polyphosphoric acid or phosphorus pentoxide with an alcohol or an alkyl ether compound. The choice of phosphating agent employed, ratio of reactants and reaction conditions, will afford products of different chemical composition and hence physical solution properties. Most commercial phosphates are mixtures of mono-esters, di-esters, residual unreacted nonionic surfactant or parent hydrophobe and free phosphoric acid. As a generalisation, phosphorus pentoxide is capable of generating products with a higher di-ester content relative to the polyphosphoric acid route.

IONIC SURFACTANTS RANGE

In addition to the large and diverse range of nonionic surfactants, Indorama Ventures supplies a selected range of ionic surface-active agents. This range includes conventional formulation auxiliaries for detergent and emulsion system development as well as more specialised derivatised alkoxyates targeting niche applications in resins, coatings and emulsions systems. A general description of these products is given below.

Trademark	Brand Description
ALKANATE® P series	A range of alkyl phosphate esters, alkylphenol ether phosphate esters and alkyl ether esters, some in free acid form and some in the form of their sodium, potassium or ammonium salts
ALKANATE® W series	A range of alkylphenoxy ether sulphates, in sodium salt or ammonium salt form, at various active levels These products are the sulphate esters of the higher ethoxylates, typically used in surface coatings formulations and for emulsion polymerisation
TERMUL®AIS series	Anionic surfactants for agrochemical applications

NOMENCLATURE SYSTEM FOR TERIC® SURFACTANTS

The TERIC® line of nonionic surfactants comprises two separate groups, the traditional effect chemicals and a range of specialty surfactants. The effect chemicals are named in a way which clearly indicates their composition, thereby facilitating ease of selection by the end user. The specialty surfactants are generally grouped by end effect or common surfactant property and are named according to these groups. The structure of the effect surfactants naming scheme is as follows.

A letter identifies the basic chemical class of the surfactant hydrophobe, thus:

A	Alcohols
M	Alkylamines
N	Nonylphenol
PE	ABA block copolymer
X	Octylphenol

A numeric prefix to the letter which identifies the basic chemical class indicates the average carbon chain length of the hydrophobe. This is mostly used for the alkylamines and the fatty alcohols, thus:

9	C ₉₋₁₁ synthetic linear primary alcohol
10	C ₁₀₋₁₂ linear primary alcohols, natural or synthetic
12	C ₁₂₋₁₄ linear primary alcohols, natural or synthetic
13	C ₁₃ iso-tridecanol
16	C ₁₆₋₁₈ linear primary alcohol or an oleyl amine
17	C ₁₆₋₁₈ linear primary alcohol or alkylamine in which the C ₁₈ component is mono-unsaturated

Block Copolymers

The TERIC® PE surfactant range comprises conventional ABA block copolymers, in which a polypropylene glycol central block is the hydrophobe and polyethylene glycol is the hydrophile. The SURFONIC® POA surfactant range are reverse block copolymers, in which the central block is polyethylene glycol.

NOMENCLATURE SYSTEM FOR TERIC® SURFACTANTS

TERIC® Specialty Surfactants

The TERIC® specialty surfactants are identified by a three-digit product name. The range consists of a diverse group of alkoxylates which have been developed in response to our identification of more technically demanding opportunities in the specialty chemicals segment of the market. Some TERIC® specialty surfactants are formulated products and others are highly specific alkoxylates. The following table shows the general alignment of product name and end-use functionality or industry.

Product Code	Description
160 – 199	Low foam wetting agents and detergents
300 – 349	Industrial process aids
400 – 459	Mineral beneficiation surfactants
460 – 499	Surfactants for paints and coatings
520 – 599	Domestic and industrial cleaning surfactants

Nomenclature Variants in the TERIC® Surfactant Range

- The TERIC® BL product group comprises alcohol-based detergents which have been modified to lower their pour point by changing the chemistry of the alkoxylate chain.
- TERIC® LA products are alcohol ethoxylates which have had their pour point reduced by the addition of a limited amount of water and a specialty hydrotrope.
- The “N” suffix, when used with an alcohol ethoxylate name, indicates that the hydrophobe is exclusively a natural alcohol.
- The extension “MB” at the end of a name indicates that the hydrophobe has been sourced according to the Roundtable on Sustainable Palm Oil (RSPO) Mass Balance Supply Chain Certification Standard.
- USP suffix indicates the product conforms to United States Pharmacopeia.

TYPICAL PROPERTIES AND SOLUTION PROPERTIES

Interpretation of Physical and Chemical Data

The typical properties and solution properties of many of the Indorama Ventures surfactant products are shown in the tables on the following pages of this handbook. The information given below defines the contents of the fields in the tables, in order to assist users in selecting the most appropriate product for their needs.

Water Content

Free water and water of hydration is measured by titration with Karl Fischer reagent, using electrometric endpoint detection. The test method is defined by ISO 4317 or ASTM E203. Results are reported as percentage weight / weight (w/w).

Colour

The colour of light coloured liquids is measured by comparison to glass colour standards or a spectrophotometric colourimeter, which are based on the platinum-cobalt scale. The values are variously called Hazen units, APHA units or Pt-Co units. The test method is defined by ISO 2211 and ASTM D1209.

The colour of the more strongly coloured liquids is measured against the Gardner scale, using glass colour standards or a spectrophotometric colourimeter conforming to ASTM D1544.

Cloud Point

Aqueous solutions of amphipathic ethylene oxide derivatives become heterogeneous when the temperature is raised, as hydrogen bonds between the water and the ether oxygen atoms are broken. The temperature at which this phenomenon occurs is directly related to the number of oxyethylene units in the polyether chain and is called the cloud point. For surfactants with a very low aqueous cloud point, a solvent-water solution may be used, and for surfactants with a very high aqueous cloud point, an electrolyte solution may be used.

To conduct the test, an aqueous solution, or modified aqueous solution, containing the nonionic surfactant (at 1% w/w unless otherwise stated) is heated until it clouds. The solution is then cooled slowly and the temperature at which it clarifies is recorded as the cloud point. The test method is defined by ISO 1065 or ASTM D2024.

pH Value

For nonionic surfactants the pH value measures the degree of neutralisation of the alkoxylation catalyst.

The pH is measured using a glass pH electrode with a temperature compensation connected to a pH meter on a sample diluted in either water or a water-solvent mixture. Results are quoted in pH units and against a diluted concentration quoted as percentage weight / weight.

Viscosity

Viscosity is generally measured by a Brookfield viscometer, at varying temperatures dictated by the homogeneity of the test surfactant. Results are quoted in centipoise. In situations where a more precise viscosity value is required, the kinematic technique is used, and results are usually quoted in mm²/sec.

TYPICAL PROPERTIES AND SOLUTION PROPERTIES

Interpretation of Solution Properties Data

Solution properties data provides an insight to the surfactant behaviour of the product and as such is a powerful selection tool for the skilled applications technologist and for formulators. The three most basic and practical solution property parameters are surface tension depression, wetting ability and foaming propensity. Unless indicated otherwise, solution properties data is measured using 0.1% aqueous solution at 20°C.

Surface Tension

The surface tension of a solution is a measure of the relative surface activity of the surfactant in that solution.

It may alternatively be described as the interfacial tension at the air/liquid interface. Its units are millinewtons / metre (mN/m). It is measured by the Wilhelmy plate technique, on aqueous solutions at standard concentrations and at a standard temperature.

Wetting Ability

The displacement or immersionsal wetting ability of an aqueous solution of surfactant is measured by the Draves-Shapiro technique. This test measures the time taken to displace the entrapped air from a standard woven cotton tape. The shorter the time taken, the more effective the wetting agent. Draves-Shapiro wetting ability results are quoted in the 'Tape Wetting' column and its units are seconds.

Foaming

Foam height measurement by the Ross Miles technique provides a guide to the foaming ability of the surfactant solution and to the stability of the foam produced. Aqueous solutions of the surfactant at a standard concentration and temperature are used to generate a volume of foam in a column of standard dimensions. The initial foam height, (I) provides an indication of the foaming ability of the surfactant. The final foam height (F) measured five minutes later, provides an indication of the stability of the foam produced. If the difference between (I) and (F) is small, the foam produced is very stable, and conversely if the difference is great then the foam produced is unstable. A dynamic foam test is used to evaluate low foaming surfactants, especially those used in machine dish wash and industrial cleaning applications.

SOLUBILITY CHARACTERISTICS OF NONIONIC SURFACTANTS

The accompanying data tables provide solubility information for a range of solvents with varying polarity. The abbreviations used to describe solubility behaviour are as follows:

d	dispersible	ps	partly soluble
i	insoluble	s	soluble

In general, fatty alcohol ethoxylates and alkylphenol ethoxylates containing more than 58% ethylene oxide in the molecule will be fully soluble in water and those containing less than 42% ethylene oxide will be soluble in paraffinic solvents and insoluble in water. Surfactants which fall between these limits will have limited solubility in paraffinic solvents but will be readily soluble in more polar organic solvents and will generally form stable dispersions in water.

The solubility characteristics of polyoxyethylene (POE) fatty acid esters will deviate from these generalised trends because of their significant diester content. Because the diester is almost twice as hydrophobic as the monoester and also constitutes approximately 25% of the product, practical POE fatty acid esters tend to be less water soluble, per degree of ethoxylation, than the corresponding alcohol ethoxylates or alkylphenol ethoxylates. In many cases the water solubility appears to be concentration dependent, in that at low concentrations the product is only dispersible in water but becomes soluble as the concentration increases. This can be interpreted as the difference in solubility between the monoester and the diester, or more strictly the diester being solubilised by the monoester and solvated by the polyglycol. Conversely, polyoxyethylene fatty acid esters appear disproportionately more soluble in solvents.

Aqueous solutions of polyoxyethylene-based nonionic surfactants show an inverse temperature-solubility relationship, which is the basis of their cloud point phenomenon. This means that solutions heated to temperatures significantly above their cloud point will phase separate, and those which are just above their cloud point temperature will be hazy or turbid. Anionic surfactants do not show the inverse solubility characteristic, and the addition of an anionic to a nonionic surfactant can reduce or even eliminate the cloud point effect. Hydrotropes, particularly anionic hydrotropes, will also greatly modify the cloud point behaviour of the typical nonionic surfactant in solution.

The solubility of all polyoxyethylene-derived nonionic surfactants is suppressed by most electrolytes and by alkalinity. Where stable solutions of surfactants are required in strong electrolytes or in strongly alkaline environments, alkylpolysaccharides will be found to be the preferred surfactant. It is possible to hydrotrope conventional nonionics into these aggressive environments using alkylpolysaccharides. Conventional hydrotropes such as sodium xylene sulphonate are moderately effective in these situations, but derivatized nonionics such as the alkyl ether phosphates and alkyl ether carboxylates will be found to be very effective and, further, will contribute significantly to the overall surfactant performance of the system.

Concentrated solutions of many nonionic surfactants in water can form gels. From a practical standpoint, troublesome gels can be avoided by attention to the method of dilution. Dilute solutions are best prepared by adding the surfactant to water, slowly and with some form of continuous mixing. Highly concentrated solutions should always be prepared by adding the surfactant to the water, slowly and with continuous mixing. If a convenient heat source is available, adding the water to the surfactant heated to a temperature greater than the melting point of the gel will avoid gel formation. Once formed, gels can be broken by heat or by addition of polar solvents such as glycol ethers or lower alcohols.

INDORAMA VENTURES PRODUCT DATA SHEETS

Indorama Ventures product data sheets list both sales specification parameters as well as typical properties of individual products.

Specifications

By definition, a specification is any parameter which is measured quantitatively during the manufacturing process and is directly controllable by that process. Current specifications are not shown in this brochure, but some of the common specification parameters are listed. A current specification may be obtained by contacting the Indorama Ventures sales offices, listed on the back page of this handbook.

Product specifications are controlled documents meeting the audited requirements of ISO 9001.

Note: The chemical, physical and solution property values presented in this handbook do not constitute specifications. Refer to the individual Product Data Sheets for the current product specifications.

Typical Properties

Common physical properties which are reasonably constant and usually characteristic of each individual product. They are not used to control manufacture and are not measured on a batch to batch basis. They do not constitute specification.

Detergent Alcohol Ethoxylates

Physical and Chemical Properties

Solution Properties

TERIC® Surfactant	Moles EO	Water %w/w	Colour Pt-Co max	Cloud Point °C	pH 1% Solution	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
												Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
12A2N	2	< 0.1	30	n/a	6.0-8.0	6.0	2	0.908	25	-	-	-	-	d	s	s	s
12A3N	3	< 0.1	30	n/a	5.5-7.5	7.1	3	0.928	31	-	-	-	-	d	s	s	s
12A4N	4	< 0.3	30	n/a	5.5-7.5	9.8	6	0.953	41	-	-	-	-	d	s	d	d
12A4N-MB	4	< 0.3	30	n/a	5.5-7.5	9.8	6	0.953	41	-	-	-	-	d	s	d	d
12A6N	6	< 0.3	30	n/a	5.5-7.5	11.2	12	0.974 ¹	42 ¹	28	4	10.2	9.8	s	s	d	d
12A7N	7	< 0.1	50	49-52	5.5-7.5	12.1	18	0.975	33	30	8	9.1	8.8	s	s	i	i
12A8N	8	< 0.5	30	54-62	5.5-7.5	12.6	18	0.985 ¹	49 ¹	32	5	11.5	10.7	s	s	i	i
12A9N	9	< 0.5	30	80-85	5.5-7.5	13.6	23	0.994 ²	64 ¹	35	9	11.6	10.5	s	s	i	i
12A12N	12	< 0.3	30	90-95	5.5-7.5	14.4	24	1.004 ²	27 ²	35	12	13.1	12.0	s	s	i	i
12A23N	23	< 0.5	50 ³	n/a	5.5-7.5	16.6	44	1.055 ²	71 ²	43	82	14.2	11.3	s	s	i	i

1. Measured at 25°C

2. Measured at 50°C

3. Measured at 60°C

Tridecanol Ethoxylates

Physical and Chemical Properties

Solution Properties

TERIC® Surfactant	Moles EO	Water %w/w	Colour Pt-Co max	Cloud Point °C	pH 1% Solution	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
												Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
13A7	7	< 0.3	100	n/a	5.5-7.5	11.8	< 0	0.984	80	-	-	-	-	d	s	ps	d
13A9	9	4-5	100	60-65	6.0-8.0	13.3	< 0	1.018	142	28	2	12.5	11.0	s	s	i	i
309	12	14-16	100	73-77 ¹	5.0-8.0	14.7	< 0	1.041 ²	180 ²	30	10	14.5	12.5	s	s	i	i

1. Measured as 1% w/w surfactant in 5% w/w aqueous NaCl solution

2. Measured at 25°C

Cetyl-Oleyl Alcohol Ethoxylates

Physical and Chemical Properties

Solution Properties

TERIC® Surfactant	Moles EO	Water %w/w	Colour Pt-Co max	Cloud Point °C	pH 1% Solution	HLB	Pour Point °C	Specific Gravity @ 50°C	Viscosity cP @ 50°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
												Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
17A8	8	< 0.5	150	-	6.0-8.0	11.6	17	0.963	35	31	25	9.6	8.5	s	s	i	i
17A10	10	< 0.5	150	70-75	6.0-8.0	12.7	24	0.973	43	33	27	10.8	10.1	s	s	i	i

Specialty Alcohol Ethoxylates

Physical and Chemical Properties

Solution Properties

TERIC® Surfactant	Moles EO	Water %w/w	Colour Pt-Co max	Cloud Point °C	pH 1% Solution	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
												Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
10A5N	5	< 0.2	50	33-38	5.5-8.0	11.6	6	0.974 ¹	32 ¹	26	2	15.3	15.1	s	s	s	s
10A6N	6	< 0.2	50	51-55	5.5-8.0	12.4	10	0.989 ¹	38 ¹	28	3	14.5	13.5	s	s	i	i
10A6N-MB	6	< 0.2	50	51-55	5.5-8.0	12.4	10	0.989 ¹	38 ¹	28	3	14.5	13.5	s	s	i	i
10A8N	8	< 0.2	50	78-83	5.5-8.0	13.7	19	1.001 ²	20 ²	31	7	15.0	14.5	s	s	i	i
552	7	< 0.3	50	55-56	6.0-7.5	12.0	21	0.945 ³	55 ¹	29	11	11.0	10.0	s	s	i	i
LA4N	4	9-10	30	n/a	5.5-7.5	9.8	1	0.960	45	-	-	-	-	d	s	s	s
LA8N	8	12-13	50	55-65	5.5-7.5	12.6	12	1.002	100	27	8	11.1	10.8	s	s	i	i
LA8N-MB	8	12-13	50	55-65	5.5-7.5	12.6	12	1.002	100	27	8	11.1	10.8	s	s	i	i

1. Measured at 25°C

2. Measured at 50°C

3. Measured at 70°C

Specialty Alcohol Alkoxylates

Physical and Chemical Properties

Solution Properties

TERIC® Surfactant	Moles EO	Water %w/w	Colour Pt-Co max	Cloud Point °C	pH 1% Solution	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
												Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
BL8	-	< 0.5	250	57-61	6.0-8.0	13.7	< 0	1.003	63	30	3	13.1	3.2	s	s	i	i
BL12	-	< 0.5	250	57-61	6.0-8.0	13.7	3	1.004	61	30	4	14.0	4.5	s	s	i	i

Physical and Chemical Properties

Solution Properties

HYDRAPO® Surfactant	Water %w/w	Colour Pt-Co max	Cloud Point °C	pH 1% Solution	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
											Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
RP40	< 0.2	50	~45 ¹	5.5-8.0	7.8	-10	0.949	29	27	5	1.7	0.8	d	s	s	s
RP50	< 0.2	50	~56 ¹	5.5-8.0	10.2	0	0.964	38	28	3	3.1	0.8	d	s	s	s
RP80	< 0.2	50	~65 ¹	5.5-8.0	12.0	8	0.974	43	28	2	9.5	2.5	s	s	s	s
RP90	< 0.2	50	50-55	5.5-8.0	13.0	16	0.993	156	28	2	12.0	3.0	s	s	s	s
RP90L	14-16	50	50-55	5.5-8.0	13.0	-10	1.014	100	28	2	12.0	3.0	s	s	s	d
RP120	< 0.2	50	79-84	5.5-8.0	14.7	22	0.986 ²	20 ²	30	6	12.5	3.0	s	s	s	s

1. Measured on a 20% w/w solution of the surfactant in 25% w/v aqueous butyl diglycol

2. Measured at 50°C

Octylphenol Ethoxylates

Physical and Chemical Properties

Solution Properties

TERIC® Surfactant	Moles EO	Water %w/w	Colour Pt-Co max	Cloud Point °C	pH 1% Solution	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
												Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
X5	5	< 0.5	100	-	6.0-8.0	10.4	< 0	1.046	465	-	-	-	-	d	s	s	s
X8	8	< 0.5	100	45-49	6.0-8.0	12.6	< 0	1.060	402	30	2	11.0	10.5	s	s	i	i
X10	10	< 0.5	100	63-67	6.0-8.0	13.6	7	1.062	393	32	3	13.0	12.0	s	s	i	i
X40L	40	< 30.0	250	> 100	5.5-7.0	17.6	5	1.097	1750	36	146	12.0	12.0	s	s	i	i

Nonylphenol Ethoxylates

Physical and Chemical Properties

Solution Properties

TERIC® Surfactant	Moles EO	Water %w/w	Colour Pt-Co max	Cloud Point °C	pH 1% Solution	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
												Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
N2	2.0	< 0.5	100	-	6.0-8.0	5.7	< 0	1.001	620	-	-	-	-	d	s	s	d
N5	5.5	< 0.3	100	-	6.0-8.0	10.5	< 0	1.035	355	-	-	-	-	d	s	s	s
N6	6.5	< 0.3	150	64-67 ¹	6.0-8.0	10.9	< 0	1.046	340	-	-	-	-	d	s	s	d/s
N8	8.5	< 0.3	100	30-34	6.0-8.0	12.3	< 0	1.056	350	29	4	6.7	6.2	s	s	i	i
N9	9.0	< 0.3	100	50-55	6.0-8.0	12.8	< 0	1.060	330	31	4	10.6	9.3	s	s	i	i
N10	10.0	< 0.3	100	65-69	6.0-8.0	13.3	5	1.063	360	31	5	12.6	10.8	s	s	i	i
N11	11.0	< 0.5	100	72-76	5.5-7.5	13.7	7	1.069	410	35	9	12.6	11.5	s	s	i	i
N12	12.0	< 0.3	100	79-84	6.0-8.0	13.9	11	1.045 ²	67 ²	35	9	13.0	11.9	s	s	i	i
N13	13.0	< 0.3	100	87-91	6.0-8.0	14.4	14	1.049 ²	75 ²	35	16	12.3	11.2	s	s	i	i
N15	15.0	< 0.3	100	92-96	6.0-8.0	15.0	21	1.051 ²	82 ²	33	14	14.2	13.6	s	s	i	i
N20	20.0	< 0.5	100	> 100	6.0-8.0	16.0	30	1.061 ²	100 ²	42	25	13.9	12.1	s	s	i	i
N30	30.0	< 0.5	150	> 100	6.0-8.0	17.2	40	1.066 ²	150 ²	43	69	14.0	13.3	s	s	i	i
N30L	30.0	30-31	100	> 100	6.0-8.0	17.2	2	1.095	1750	43	69	14.0	13.0	s	s	i	i
N40LP	40.0	30-31	100	> 100	6.0-8.0	1.0	5	1.099	1750	41	140	13.0	8.0	s	s	i	i

1. Measured by addition of 20g of surfactant in 100g of 25% weight / volume (w/v) solution of diethylene glycol butyl ether (DEGBE) in water

2. Measured at 50°C

Block Copolymer Surfactants

Physical and Chemical Properties

Solution Properties

TERIC® Surfactant	Moles EO	Water %w/w	Colour Pt-Co max	Cloud Point °C	pH 1% Solution	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
												Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
PE61	6	< 0.5	50	16-18 ¹	5.0-7.5 ²	3.0	< 0	1.017	388	39.0	51	3.0	0.0	i	s	ps	i
PE62	17	< 0.5	80	22-24 ¹	5.0-8.0	7.0	< 0	1.032	440	42.1	60	3.5	0.0	s	s	i	i
PE64	25	< 0.5	100	58-61 ¹	5.0-8.0	15.0	8	1.051	450	43.2	85	3.0	0.0	s	s	i	i
PE75	60	< 0.5	250	79-85	5.0-7.5	16.5	32	1.060 ³	240 ³	38.1	67	4.5	0.7	s	s	i	i

1. Measured on 10% aqueous solution

2. Measured on 2.5% aqueous solution

3. Measured at 60°C

Physical and Chemical Properties

Solution Properties

SURFONIC® Surfactant	Water %w/w	Colour Pt-Co max	Cloud Point °C	pH 1% Solution	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
											Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
POA-17R2	< 0.4	100	33-38	5.5-7.5	8.0	< 0	1.030	205	43.2	117	3.0	0.0	s	s	i	i
POA-17R4	< 0.3	80	44-48	5.5-7.5	7.0-12.0	< 15	1.050 ¹	254 ²	44.9	217	4.7	0.0	s	s	i	i

1. Measured at 25°C

2. Measured at 37.8°C

Alkylamine Ethoxylates

Physical and Chemical Properties

Solution Properties

TERIC® Surfactant	Moles EO	Water %w/w	Colour Gardner max	Cloud Point °C	pH 1% Solution	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
												Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
16M2	2	< 0.5	10	n/a	8.0-11.0	9.5	-15	0.906	190	-	-	-	-	i	s	s	s
16M5	5	< 0.5	-	n/a	9.0-11.0	10.5	-16 ¹	0.954	182	29.7	-	-	-	ps	s	s	s
16M15	15	< 0.5	-	> 100	9.0-11.0	13.8	< 5	1.034	300	38.8	50	12.2	9.7	s	s	i	i
17M5	5	< 0.5	12	-	9.0-10.5 ²	10.0	11 ¹	0.950	177	-	-	-	-	ps	s	s	s
17M8	8	< 0.5	-	78	9.0-11.0	11.0	1 ¹	0.978	210	32.9	18	8.5	7.5	s	s	s	i

1. Melting point °C

2. Measured on 5% w/w aqueous solution

Oleo Surfactants

Physical and Chemical Properties

Solution Properties

ECOTERIC® Surfactant	Composition	Water %w/w	HLB	Pour Point °C	Specific Gravity @ 50°C	Viscosity cP @ 25°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
									Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
E	PPG-15 stearyl ether	< 0.7	-	< 0	0.95	90	-	-	-	-	i	s	s	s
T20	POE (20) sorbitan mono-laurate	~3.0	16.7	10	1.10	550 ¹	34.1	53	5.3	0.3	s	s	i	i
T80	POE (20) sorbitan mono-oleate	~3.0	15.0	< 0	1.07	550 ³	36.0	104	6.0	5.3	s	s	i	i
T80 USP ²	POE (20) sorbitan mono-oleate	~3.0	15.0	< 0	1.07	550 ³	36.0	104	6.0	5.3	s	s	i	i
T85	POE (20) sorbitan tri-oleate	~5.0	11.0	10	1.03	350	37.2	90	1.1	0.9	d	s	s	i

1. Measured at 20°C

2. Meets the United States Pharmacopoeia standard requirements for Polysorbate 80

3. Units in cS at 25°C

Biodegradable Detergent, Emulsifier and Solubiliser – Methyl Ester Ethoxylates

Physical and Chemical Properties

Solution Properties

TERIC® Surfactant	Water %w/w	Colour Pt-Co max	Cloud Point °C	pH 1% Solution	HLB	Melting Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
											Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
ME240-60	< 1.0	200	56-61	5.0-7.0	13.1	~9	1.052 ¹	100 ¹	32.5	22	7.5	6.5	s	s	i	i

1. Measured at 25°C

TERIC® ME240-60 surfactant is the product of ethoxylated fatty acid esters derived from coconut oil. It combines low aquatic toxicity and low irritancy with powerful emulsification and detergent properties. It is totally non-gelling in water and substantially cuts the gel properties of other surfactants. It is very useful in the preparation of mild, low hazard and concentrated formulations.

Low Foam Nonionic Wetting Agents and Detergents

Physical and Chemical Properties

Solution Properties

TERIC® Surfactant	Water %w/w	Colour Pt-Co max	Cloud Point °C	pH 1% Solution	HLB	Melting Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility			
											Initial	Final	Water	Alcohol	Kerosene	Paraffin Oil
161	< 0.50	100	33-36	5.5-7.5	12.3	< 0	1.034	340	33.4	6	8.0	0.3	s	s	i	i
164	< 0.25	100	39	6.0-8.0	10.8	1-4	0.988	68	30.6	4	9.8	1.5	s	s	s	i
168	< 0.50	100	28-37	6.0-8.0	11.1	< -10	0.991	70	29.0	3	4.5	0.5	s	s	s	i
169	< 0.50	100	37-45	5.0-7.0	12.7	< 0 ¹	1.000	115	28.0	3	8.5	0.6	s	s	s	i
568	< 0.50	200	30-34	6.0-8.0	11.0	< -10 ¹	0.992 ²	65 ²	29.0	2	4.0	0.3	s	s	s	i
569	< 0.50	100	37-41	5.5-8.0	12.0	< 0 ¹	1.010	135	28.9	6	5.0	0.4	s	s	s	i

1. Pour point °C

2. Measured at 25°C

Specialty Surfactants for Agrochemicals

Anionic Emulsifiers

Physical and Chemical Properties

TERMUL® Surfactant	Active Content %w/w	Flash Point °C	Specific Gravity @ 25°C	Pour Point °C	Appearance @ 25°C	Typical Application
AIS 70/13	69.5	38	1.020	-6	Liquid	Primary anionic emulsifier for emulsifiable concentrates (EC)
AIS 70/2E	57.0	63	0.990	< 0 ¹	Liquid	Primary anionic emulsifier for EC
3230 ²	100.0	> 100	1.050 ³	-8	Liquid	Primary anionic emulsifier for EC

1. Melting point °C

2. APE-based

3. Temperature not defined

Ethoxylated Castor Oil

Physical and Chemical Properties

TERMUL® Surfactant	Moles EO	HLB	Specific Gravity @ 25°C	Pour Point °C	Appearance @ 25°C	Typical Application
3512	12	7.3	1.010 ¹	< -10	Liquid ¹	Low HLB emulsifier for oil-based EC, particularly suited to vegetable oils
2507	32	12.0	1.050	16	Liquid	Nonionic emulsifier for EC
1284	36	12.6	1.050	20	Semi-solid	Primary nonionic emulsifier for EC
3540	40	13.0	1.060	28	Semi-solid	Primary nonionic emulsifier for EC
1285	54	14.4	1.050	36	Semi-solid	Primary nonionic emulsifier for EC

1. Measured at 20°C

Tristyrylphenol Ethoxylates

Physical and Chemical Properties

TERMUL® Surfactant	Moles EO	HLB	Specific Gravity @ 25°C	Pour Point °C	Appearance @ 25°C	Typical Application
3130	10	10.5	1.100	< 0	Liquid	Nonionic emulsifier for EC
3150	16	12.5	1.100	11	Liquid	Nonionic emulsifier for EC, dispersant for suspension concentrates (SC)

Alcohol Alkoxylates Emulsifiers

Physical and Chemical Properties

TERMUL® Surfactant	Alkylphenol- Based	HLB	Specific Gravity @ 25°C	Pour Point °C	Appearance @ 25°C	Typical Application
200	Yes	16.1	1.030 ¹	30 ²	Solid	Primary nonionic emulsifier for EC
203	No	17.5	1.030 ¹	33	Solid	Primary nonionic emulsifier for EC, suited to polar solvent / high active ingredient content
5370	Yes	14.5	1.040	17 ²	Liquid	Low pour point primary nonionic emulsifier for EC
5429	No	14.5	1.020 ³	37	Solid	Primary nonionic emulsifier for EC
5459	No	16.1	1.040	45	Solid	Alternative to alkylphenol-based TERMUL® 200 for EC
5500	No	14.5	1.050 ⁴	20	Liquid	Low pour point primary nonionic emulsifier for EC

1. Measured at 50°C

2. Melting point °C

3. Measured at 65.6°C

4. Measured at 20°C

Formulated Emulsifiers

Physical and Chemical Properties

TERMUL® Surfactant	Alkylphenol- Based	Specific Gravity @ 25°C	Pour Point °C	Appearance @ 25°C	Typical Application
3640	No	0.990 ¹	< 0	Liquid	Formulated emulsifier for trifluralin 480 EC
5030	Yes	1.030	23	Paste	Formulated emulsifier for oil-in-water emulsions (EW)
7250	Yes	1.040	< 0	Liquid	Formulated emulsifier for triallate 500 EC

1. Measured at 20°C

Solvents

Physical and Chemical Properties

SURFONIC® Solvents	Type	Specific Gravity @ 25°C	Flash Point °C	Melt Point / Boiling Point °C	Solvent-into-water / Water in Solvent %	Typical Application
AG 1700	Aromatic ester	1.000	118	-34 / 141	0.37 / 0.0	Primary solvent for EC
AG 1705	Aromatic ester	1.050	90	-54 / 212	< 1.0 / < 0.5	Primary solvent for EC
AG 1710	Fatty acid diester	1.090 ¹	121	< -48 / 244	5.3 / 3.1	Co-solvent for EC
AG 1732	Fatty amide blend	0.900	> 150	-18 / n/a	22.0 / 0.1	Primary solvent for EC
AG 1740	C ₈ /C ₁₀ dimethyl amide	0.880	> 110	-9 / 285	23.0 / 0.3	Primary solvent for EC

1. Measured at 20°C

Dispersants

Physical and Chemical Properties

TERSPERSE® Dispersant	Type	Active Content % w/w	Specific Gravity @ 25°C	Pour Point °C	Appearance @ 25°C	Typical Application
2020	Alkyl-NSF Condensate, Na Salt	n/a	0.400 ¹	n/a	Tan powder	Dispersant for suspension concentrate (SC), water dispersible granule (WG) and wettable powder (WP) formulations
2202	Ethoxylated TSP Phosphate, TEA Salt	100	1.130 ²	10	Liquid ³	Ionic dispersant for SC
2218	Ethoxylated TSP Sulphate, NH ₄ Salt	100	1.170	16	Liquid	Ionic dispersant for SC, anionic emulsifier for EC
2280	Formulated surfactant	n/a	1.050 ²	< 0	Liquid	Formulated surfactant for suspoemulsions (SE)
2288	Formulated nonionic-ionic dispersant / wetter	n/a	1.070	4	Liquid	Formulated dispersant / wetter for SC
2500	Acrylic graft co-polymer	32	1.070	< 0	Liquid	Industry benchmark polymeric dispersant for high loading SC
2510	Fatty acid, PEG ester	100	0.940	45 ⁴	Solid	Dispersant for oil dispersions (OD), emulsifier for EW
2612	Styrene-maleic graft co-polymer	50	1.030	-10	Liquid	Polymeric dispersant for troublesome SC, particularly those challenged by Ostwald ripening
2700	Anionic co-polymer	n/a	0.250 ¹	n/a	White powder	Polymeric dispersant for WG, dispersant for SC
4894	Formulated nonionic dispersant / wetter	n/a	1.000 ³	7	Liquid	Formulated dispersant / wetter package for SC

1. Bulk density g/ml
2. Measured at 40°C
3. Measured at 20°C
4. Melting point °C

General Wetting Agents and Tank-Added Adjuvants

Physical and Chemical Properties

TERWET® Surfactant	Type	Specific Gravity @ 25°C	Pour Point °C	Appearance @ 25°C	Typical Application
245	Alcohol alkoxylate	1.000	< 0	liquid	High performance tank-added adjuvant
260	Alcohol alkoxylate	0.990	16	liquid	High performance tank-added adjuvant
1004	Anionic surfactant	0.400 ¹	n/a	powder	Wetting agent for WG, WP and SC
1300	Polyalkylene glycol	1.090	< 0	liquid	Soil wetting agent
3001	C ₈ /C ₁₀ alkyl polysaccharides	1.150 ²	< 0	liquid	Adjuvant

1. Bulk density g/ml

2. Measured at 25°C

Herbicide Wetting Agents and Adjuvants

Physical and Chemical Properties

TERWET® Surfactant	Type	Specific Gravity @ 20°C	Pour Point °C	Appearance @ 25°C	Typical Application
107	Anionic / nonionic blend	1.070	11	Liquid	Wetter / adjuvant for bipyridyl-based herbicide soluble liquid (SL) formulations
436	Formulated nonionic	1.140	< 0	Liquid	Low aquatic toxicity adjuvant for herbicide SL
1170	Ethylene diamine alkoxyate	1.090	< 0	Liquid	Low aquatic toxicity wetting agent for glyphosate SL
1215	Formulated nonionic surfactant blend	1.140	< 0	Liquid	Low aquatic toxicity adjuvant / wetter for glyphosate IPA 360 SL
1221	Ethylene diamine alkoxyate	1.070	50	Solid	Low aquatic toxicity adjuvant for dry glyphosate (SG) formulations
1253	Formulated ethoxylated tallow amine phosphate / APS	1.080	< -10	Liquid	Adjuvant for high-load glyphosate
1255	Ethoxylated tallow amine	0.978	1 ¹	Liquid	Adjuvant for glyphosate MEA
1256	Formulated ethoxylated alkyl amine	0.982	< 0	Liquid	Adjuvant for high-load glyphosate K SL
3777	Formulated ethoxylated tallow amine	1.000	5	Liquid	Adjuvant for high-load glyphosate K SL
3780	Formulated ethoxylated tallow amine	1.050 ²	< 0	Liquid	Industry standard adjuvant for glyphosate IPA SL
3784	Ethoxylated tallow amine	1.010 ³	0	Liquid	Herbicide adjuvant

1. Melting point °C

2. Measured at 25°C

3. Measured at 50°C

Tank-mix Additives

Physical and Chemical Properties

TERMIX® Surfactant	Type	Specific Gravity @ 20°C	Pour Point °C	Appearance @ 25°C	Typical Application
4110	Non-ammoniated water conditioner	1.260 ¹	-30	Liquid	Water conditioner
5920	Alcohol alkoxylate	0.930	-10	Liquid	Spray drift reduction agent
6010	Alkylamine alkoxylate	0.990	< -10	Liquid	Compatibility agent, adjuvant
AIS 4000	Non-ammoniated water conditioner	1.290	< -50	Liquid	Water conditioner

1. Measured at 25°C

Specialty Surfactants for Cleaning – Blended Concentrates

Physical and Chemical Properties

ALKANATE® Surfactant	Type	Concentration % w/w	Density g/cm ³ @ 25°C	Viscosity cP @ 25°C	Anionic Content % w/w	Typical Application
LDC90	An anionic / nonionic detergent concentrate	90	1.024	1300	18	Manufacture of high performance liquid laundry detergents, manual dishwashing liquids, hard surface and general purpose cleaners
CC40	An anionic / nonionic detergent concentrate	42	1.200	360	23	Multipurpose detergent concentrate with outstanding grease cutting properties
VBS-D10	Vegetable oil derived solvent and nonionic surfactant, with added anionic component	100	0.973	33	20	Powerful non-alkaline degreasing agent, stain remover and industrial strength multi-purpose cleaning

Specialty Surfactants for Paints and Coatings

Physical and Chemical Properties

Trademark	Product Code	Water % w/w	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Typical Application
ALKANATE®	PG30	77.0	-	< 0	1.040	< 1000 ¹	Emulsion polymerisation
ALKANATE®	PL50	50.0	-	< 0	1.100 ¹	1300 ¹	
ALKANATE®	WC60	22.5	-	-	-	100	
TERIC®	161	< 0.5	12.3	< 0	1.034	340	Pigment wetter, dispersant synergist
TERIC®	164	< 0.25	10.8	2	0.988	68	Low foaming wetting agents
TERIC®	168	< 0.5	11.1	< -10	0.991	70	
TERIC®	305	< 4.0	~14.0	15	1.145 ²	1800 ²	Emulsion polymerisation
TERIC®	320	20.0	14.9	20	1.021 ³	200 ¹	Rubber latex coagulant
TERIC®	324	-	-	< -5	1.028 ¹	62 ¹	Rubber latex coagulant
TERIC®	340	12.0	13.0	20	1.010 ¹	103 ¹	Dispersant and wetter for rubber latex coagulant bath
TERIC®	460	35.0	17.1	-	1.072 ²	310	Stabiliser for use in the manufacture of acrylic latex
TERIC®	461	20.0	14.9	< 5	1.050	200	Emulsion polymerisation APE alternative Wetter and dispersant for water-based paints
TERIC®	462	30.0	17.5	< 10	1.080	650	
TERIC®	463	30.0	18.1	10	1.090 ¹	590 ¹	
TERIC®	528	21.0	14.4	8	1.028	220	Wetter and stabiliser for coatings
TERIC®	BL8	< 0.5	13.7	< 0	1.003	63	Wetting agents
TERIC®	LA8N	12.5	12.6	12	1.002	100	
TERIC®	N30L	30.0	17.2	2	1.095	1750	Emulsion polymerisation
TERIC®	N40LP	30.0	18.0	5	1.099	1750	
TERIC®	X40L	30.0	17.6	5	1.097	1750	

1. Measured at 25°C

2. Measured at 50°C

3. Measured at 30°C

Specialty Products for Mining and Mineral Processing

Physical and Chemical Properties

Trademark	Product Code	Specific Gravity @ 20°C	Flash Point 20°C	Typical Application
POLYFROTH®	H15	1.194	146	POLYFROTH® 10 Series frothers are weak frothers and are used for fine particle flotation or where a high degree of selectivity is required
POLYFROTH®	H19	1.123	> 100	
POLYFROTH®	W160	0.995	70.5	
POLYFROTH®	H185	1.162	170	
POLYFROTH®	W22	0.923	79	POLYFROTH® 20 Series frothers are low-medium strength frothers with good selectivity
POLYFROTH®	W22C	0.960	79	
POLYFROTH®	W24	1.026	179	
POLYFROTH®	H27	0.960	> 112	
POLYFROTH®	H206	1.085	63	
POLYFROTH®	W290	0.992	> 100	
POLYFROTH®	H30	1.080	108	POLYFROTH® 30 Series frothers are intermediate strength frothers that produce a more stable froth that can be used for coarser particle flotation
POLYFROTH®	W31	0.980	105	
POLYFROTH®	W34	1.020	211	
POLYFROTH®	H368	1.080	> 100	
POLYFROTH®	W53	0.980	155	POLYFROTH® 50 Series frothers are the strongest in our range and can be used for coarse particle flotation
POLYFROTH®	W55	1.015	160	
POLYFROTH®	H57	0.936	101	

Specialty Products for Mining and Mineral Processing (continued)

Physical and Chemical Properties

Trademark	Product Code	Specific Gravity @ 20°C	Flash Point 20°C	Typical Application
UNIFROTH®	BPG 30	0.932	71	Glycol feedstocks typically blended with alcohol or other streams to formulate frothers
UNIFROTH®	BTG 35	1.006	> 114	
UNIMAX®	SD Series Dispersants	-	-	Iron sulphide depressants (e.g. pyrite, pyrrhotite) used in the flotation separation of base metal sulphides
POLYMAX®	T Series Dispersants	-	-	Aqueous solutions of a high molecular weight poly (oxyalkylene) glycol They are low foam dispersants, effective for fine gangue particles (dolomites, etc.) and clays They can also modify froths to reduce entrainment They are useful in improving metal recovery (and MgO rejection) in sulphide flotation
POLYMAX®	G Series Dispersants	-	-	Depressant used in gold leaching processes (CIP / CIL) to prevent “preg-robbing” by carbonaceous or graphitic gangue
POLYMAX®	K Series Dispersants	-	-	Versatile dispersants used to facilitate the rejection of clays, fibrous minerals and hydrophobic gangue typically found in sulphide ores
POLYMAX®	EW920	1.020	-	Acid mist suppressant for use in electrowinning cells
POLYSIL®	RM1250	1.090	-	Liquid polymeric coagulants for the treatment of fine particles in aqueous suspension The POLYSIL® Coagulants range is designed to be effective against colloidal silica across a broad pH range
POLYSIL®	RM2050	1.050	-	
UNIDRI®	F47	1.032	-	Dewatering aid for sulphides, iron, and coal concentrates

Specialty Surfactants for Industrial Processes

Physical and Chemical Properties

TERIC® Surfactant	Water % w/w	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Typical Application
304	< 1.5	-	< 0	1.044 ¹	400	Demulsifier, antistatic agent
305	< 4.0	14.0	15	1.145 ²	1800 ²	Emulsifier, alkali-soluble wetting agent, dispersant
306	< 1.5	n/a	10	1.400	5000	Hydrotrope, low foam wetting agent in alkaline media

1. Measured at 25°C

2. Measured at 50°C

Specialty Surfactants for Industrial & Institutional Cleaning Formulations

Physical and Chemical Properties

Trademark	Product Code	Water % w/w	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Typical Application
ALKANATE®	PK100	< 1.5	-	< 0	1.070	500	Hydrotrope and dry-cleaning detergent
TERIC®	305	< 4.0	~14.0	15	1.145 ¹	1800 ¹	Hydrotrope and detergent
TERIC®	306	< 1.5	n/a	10	1.400	5000	Hydrotrope
TERIC®	528	21.0	14.5	8	1.023	350	Solubiliser and detergent synergist
TERIC®	534	10.0	12.6	10	1.000	170	Biodegradable nonionic detergent in liquid form

1. Measured at 50°C

Specialty Surfactants for Textile and Fibre Processing

Physical and Chemical Properties

Trademark	Product Code	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Typical Application
BIONIC®	1265	5	1.003	108	For scouring all types of natural textile and raw fibres
HYDRAPOL®	ALN755	< -2	1.040	125	Carding and combing lubricant specifically designed to maximise fibre length. Suitable for worsted and woollen processes
HYDRAPOL®	BD40	2	0.970 ¹	120	Readily biodegradable detergent for high efficiency scouring of natural textiles and raw fibres
HYDRAPOL®	BD50	< -7	1.016	125	Premium performance biodegradable non-ionic wool scouring detergent
HYDRAPOL®	TN450	0	1.056	350	An alkylphenol ethoxylate detergent for neutral or alkaline scouring of raw wool and other natural textile fibres
TERIC®	168	< -10	0.991	70	High efficiency very low foam nonionic wetting agent for use in carbonising and shrink-proofing of wool
TERIC®	532N	< 5	1.005	130	A versatile high-performance biodegradable scouring detergent, compatible with soda ash and alkaline scouring conditions

1. Measured at 50°C



Alkyl Polysaccharide Surfactants

Physical and Chemical Properties

Solution Properties

Trademark	Product Code	Composition	Water %w/w	HLB	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%		Solubility of 2.5% w/w Alkyl polysaccharide						
										Initial	Final	Water	Propylene Glycol	Ethanol	Mineral Oil	Vegetable Oil	25% NaCl	40% NaOH
ALKADET®	15	C ₈ - C ₁₀ alkyl polysaccharide	28-32	15.0-20.0	< 0	1.150 ¹	2250	26.9	29.8	14.8	14.8	s	s	i	i	i	s	s
ALKADET®	20	C ₈ - C ₁₀ alkyl polysaccharide	40	~16.0	< 0 ²	1.110	375	30.3	16.0	9.0	8.5	s	s	i	i	i	s	s
ALKADET®	45	C ₈ - C ₁₀ alkyl polysaccharide	28-32	15.0-20.0	< 0	1.150 ¹	~7000	-	-	-	-	s	s	i	i	i	s	s
ECOTERIC®	7500	C ₁₀ - C ₁₂ alkyl polysaccharide	48-52	13.0	< 0	1.083	1600	-	10.0	18.2	18.0	s	s	i	i	i	s	s

1. Measured at 25°C

2. Melting point °C

Unique Solubility Characteristics of ALKADET® 15, ALKADET® 20 and ALKADET® 45 alkyl polysaccharides¹

Electrolyte Solution	Solubility	Electrolyte Solution	Solubility
Sodium hydroxide, 47%	s	Potassium pyrophosphate, 20%	s
Sodium molybdate, 30%	s	Sodium tripolyphosphate, 14%	s
Calcium nitrate, 50%	s	Sodium chloride, 25%	s
Zinc sulphate, 25%	s	Sodium silicate solution, 40%	s

1. Alkyl polysaccharide concentration used for the screening was 2.5% w/w

Anionic Surfactants

Physical and Chemical Properties

Solution Properties

Trademark	Product Code	Composition	Actives %	Pour Point °C	Specific Gravity @ 20°C	Viscosity cP @ 20°C	Surface Tension mN/m, 0.1%	Tape Wetting sec, 0.1%	Foam Height cm, 0.1%	
									Initial	Final
ALKANATE®	PA100	Phosphated alkylphenol ethoxylate	> 97	< 0	1.120	6000				
ALKANATE®	PB95	Mixture of alkyl- and alkyl-ether phosphate	> 97	< 0	1.040	570	27.8	24.0	3.6	0.1
ALKANATE®	PG30	Phosphated alkylphenol ethoxylate	23	< 0	1.040	-				
ALKANATE®	PK100	Alkyl ether phosphate	> 98	< 0	1.070	500				
ALKANATE®	PL50	Phosphated alkylphenol ethoxylate	50	< 0	1.100 ¹	1300 ¹				
ALKANATE®	WC60	Ammonium alkylphenol ether sulphate	60	< 0	-	100	27.2	9.0	16.6	16.6
TERMIX®	1190	Alkyl phosphate, high mono-ester content	100	< -15	1.130 ¹	500 ¹	34.7	219	0.3	0.0

1. Measured at 25°C

Alkyl Dimethyl Amine Oxides

Physical and Chemical Properties

OXAMIN® Surfactant	Composition	Actives %	pH	Specific Gravity @ 20°C	Viscosity cP @ 20°C
LO	Lauryl Dimethyl Amine Oxide	30	7.0-8.0	0.965	25
LO-MB	Lauryl Dimethyl Amine Oxide	30	7.0-8.0	0.965	25
MO	Myristyl Dimethyl Amine Oxide	30	6.0-8.0	0.965 ¹	3000
OB/KU	Lauryl Dimethyl Amine Oxide	30	7.0-8.0	0.965	25
OB/KU-MB	Lauryl Dimethyl Amine Oxide	30	7.0-8.0	0.965	25

1. Measured at 25°C

APPLICATIONS GUIDE

In a publication of this type it is impossible to detail all applications for each and every Indorama Ventures surfactant. Instead, in this section the more popular applications are listed together with suggestions of the common surfactant products appropriate to these applications.

Antistatic Agents

Nonionic surfactants are effective antistatic agents for use on many synthetic fibres and plastics. External antistatic agents are typically applied as a dilute aqueous solution. Alcohol ethoxylates such as TERIC® 12A9N and TERIC® LA8N surfactants are effective temporary antistats in light duty situations. Esters such as ECOTERIC® T20 surfactant provide a strong antistatic effect on both fibres and plastics. For demanding situations, TERIC® 304, TERIC® 16M15 or OXAMIN® LO surfactants are suggested. Polyethylene glycols have been used as internal antistatic agents in spun fibres.

Conditioners

OXAMIN® MO amine oxide in a slightly acidic solution is a good base for a light duty hair conditioner.

Defoamers

Non-specific defoamers for general industrial use include TERIC® PE61 and ECOTERIC® T80 surfactants. Specialty surfactants like ECOTERIC® E surfactant can be used to increase the efficacy of simple defoamer formulations which are based on hydrocarbon solvents or solutions of waxes in hydrocarbon solvents. Nonionic surfactant defoamers do not show the rapid knock-down characteristic of silicones, but they do not plate out on process vessels and auxiliaries, which can be important in some applications. UNIMAX® WL polyalkylene glycol series products, especially UNIMAX® WL-5000 functional fluid, will control foam with hydrocarbons and similar non-aqueous solutions.

Demulsification

Emulsions can be destabilised in several ways, all of which involve disruption of the orientation of the stabilising surfactant at the interface. This can commonly occur by pH changes, increased electrolyte concentrations and HLB shifts. Specific demulsifiers can be developed to destabilise defined systems, but many common surfactants will function as demulsifiers under the right conditions. For simple oil-in-water emulsions, addition of a low HLB surfactant such as TERIC® N2 or TERIC® PE61 surfactant is suggested. For water-in-oil emulsions, addition of a high HLB surfactant with a remnant affinity for the oil phase, such as TERIC® 17A10 or TERIC® 305 surfactant, is suggested. Where it is desired to remove a relatively small amount of oil from a large amount of water, TERIC® 304 surfactant is recommended.



APPLICATIONS GUIDE

Detergents

Where a single component general purpose detergent is required, TERIC® N8, TERIC® N9 or TERIC® N10 surfactants are recommended. Where ready biodegradability is required, TERIC® BL8, TERIC® LA8N, TERIC® 12A8N, TERIC® BL12 and TERIC® 552 surfactants are suggested. ECOTERIC® 7500 alkyl polysaccharide is suggested if a non-ethoxylate is required. Where low foaming and good wetting, combined with good detergency is required, then the TERIC® 160 surfactant group is recommended. TERIC® 164 low foam wetting agent also has good detergency properties.

Blends of nonionic surfactants will show improved detergency under some specific use conditions. For oily soils on synthetic fibres, TERIC® 12A3N plus TERIC® 12A6N or TERIC® 12A4N plus TERIC® 12A8N surfactants are suggested. To improve the performance of alkylbenzene sulphonate-based detergents in hard or saline waters, addition of TERIC® 12A8N or TERIC® 12A12N surfactants are suggested. If additional stability is required without the use of hydrotropes, TERIC® N15 or TERIC® 12A23N surfactants will be found to be effective.

The foaming ability of ether sulphates based detergent formulations will be enhanced by addition of OXAMIN® LO or OXAMIN® MO alkyl dimethyl amine oxides. Alkyl polysaccharides such as ECOTERIC® 7500 surfactant can improve the foaming ability of detergent formulations based on linear alkylbenzene sulphonate (LABS).

HYDRAPOL® BD40 and HYDRAPOL® TN450 detergents are specific to many aspects of textile processing, including wool scouring.

Dispersants

Nonionic surfactants have limited application as dispersants but work well in conjunction with poly-anionic dispersants. Highly ethoxylated nonionic surfactants such as TERIC® N30 and TERIC® X40L surfactant provide excellent steric stabilisation in dispersed systems. Alkyl ether phosphates, including ALKANATE® PA100 and TERIC® 305 surfactant, particularly as their amine salts, are suggested as dispersants for iron oxide pigments. Similarly, tristyrylphenol ether phosphates and sulphates including TERSPERSE® 2202 and TERSPERSE® 2218 dispersants are broad utility ionic dispersants useful for dispersion of organic pigments and stabilization of agrochemical aqueous suspension concentrates (SC).

For simplified development and ease-of use in less-demanding agrochemical SC applications, formulated dispersant / wetter offerings such as TERSPERSE® 4894 and TERSPERSE® 2288 dispersants provide reliable utility.

The TERSPERSE® polymeric dispersant range, especially TERSPERSE® 2500 and TERSPERSE® 2700 dispersants are designed for high-performance in more demanding paint, pigment and particularly agrochemical applications. For agrochemical SC, TERSPERSE® 2500 dispersant is typically recommended for use with TERSPERSE® 4894 or TERSPERSE® 2288 dispersants. For agrochemical water dispersible granules (WG), TERSPERSE® 2700 dispersant is typically used with TERWET® 1004 wetting agent, and TERSPERSE® 2020 as a co-dispersant in very demanding applications.

TERSPERSE® 2612 dispersant is a new, patented technology designed for particularly demanding agrochemical SC applications challenged by stability deficiencies associated with Ostwald ripening.

APPLICATIONS GUIDE

Emulsifiers

Emulsification is the most diverse and potentially most complex application for surfactants. In a publication of this type it is possible to cover only the general aspects of the technology. A separate publication, 'The HLB Concept and Emulsification' is recommended as a source of further information and can be requested from the listed Indorama Ventures sales offices.

For most emulsion systems a pair of surfactants is preferable to a single surfactant, and an anionic / nonionic pair is generally preferable to an all nonionic system. Appropriate anionic surfactants are the TERMUL® AIS alkylbenzene sulphonate series and the ALKANATE® P ether phosphate range.

There are several systems used to assist formulators in the selection and optimisation of emulsion systems, including Hydrophilic – Lipophilic Balance (HLB), Phase Inversion Temperature (PIT), and the Winsor R-Rule. Used intelligently, all will aid the process of selection and optimisation, but none will eliminate the need for systematic experimentation. A list of HLB values of common Indorama Ventures emulsifiers is included further on in this publication.

Foam Boosters

The OXAMIN® alkyl amine oxide range, and particularly OXAMIN® LO amine oxides are specifically recommended as foam boosters for formulations based on alkyl ether sulphates, alcohol sulphates and alpha olefin sulphonates. Alkyl polysaccharides can be used as foam boosters for formulations based on alkylbenzene sulphonates.

In detergent systems, foaming under heavy soil load will be improved by including a nonionic surfactant such as TERIC® 12A12N, TERIC® N13 or TERIC® 528 surfactant in the formulation.

Froth Flotation

The POLYFROTH® frother series products have been specifically designed for use in flotation processes. POLYFROTH® H57 frother is among the strongest, most hydrophobic in the series. POLYFROTH® W55 and POLYFROTH® W53 frothers are strong frothers, but less selective in use. POLYFROTH® W55, POLYFROTH® W34 and POLYFROTH® W31 frothers have low to moderate hydrophobicity. Intermediate froth strengths are afforded by POLYFROTH® W34 and POLYFROTH® W31 frothers. POLYFROTH® W22 and POLYFROTH® H20 frothers are lower strength, highly selective frothers and comparable to methyl isobutyl carbinol (MIBC). They have been specifically designed as high flash point alternatives to MIBC, which gives them an improved safety profile.

Hydrotropes

ALKADET® 15 and ECOTERIC® 7500 alkyl polysaccharides are excellent for coupling conventional nonionic surfactants into aggressive environments such as strongly alkaline solutions or concentrated electrolyte solutions. TERIC® 306 surfactant will hydrotrope both anionic and nonionic surfactants into solutions of relatively high ionic strength. The ALKANATE® P alkyl ether phosphates series all show the hydrotropic effect, as is characteristic of their class.

Low Foam Surfactants

The TERIC® 160 surfactant group comprises both low foam wetting agents and detergents. TERIC® 161 surfactant is an alkylphenol based, general purpose wetter and detergent. TERIC® 164 surfactant is a fatty alcohol based low foam wetter and detergent, well suited to most domestic and industrial cleaning products formulation. TERIC® 168, TERIC® 169 and TERIC® 569 nonionic surfactants provide excellent wetting and very low foam in dynamic situations, which makes them ideal for modern machine dishwasher, laundry and industrial cleaning applications. TERIC® PE62 and TERIC® PE64 surfactants are very low foam wetting agents which also facilitate rewetting.

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Lubricants and Release Agents

Aqueous solutions of fatty alcohol based nonionic surfactants such as TERIC® 12A8N or TERIC® BL8 surfactants can act as assembly lubricants for rubbers and synthetic elastomers. The UNIMAX® WL polyalkylene glycol range of lubricants are specifically recommended as water-soluble broad-spectrum lubricants and release agents. Lower molecular weight polyethylene glycols, for example PEG 200, are effective light duty lubricants alone or as aqueous solutions. If aqueous solutions of surfactants are used as lubricants in contact with ferrous metals, then inclusion of a corrosion inhibitor should be considered.

Solubilisers

ECOTERIC® T20, ECOTERIC® T80 and TERIC® ME240-60 surfactants are excellent solubilisers for most essential oils. TERIC® X10 surfactant will effectively solubilise pine oil and eucalyptus oil, whilst TERIC® 12A12N and TERIC® ME240-60 surfactants are suggested for melaleuca oil. Alkylamine ethoxylates, particularly the TERIC® 16M surfactant range, are effective at solubilising water or low molecular weight glycols in hydrocarbon fuels and solvents.

Textile Auxiliaries

Wetting agents, detergents or scouring agents, dispersants and dye levelling agents are commonly used in formulated textile auxiliaries. The TERIC® 160 surfactant group are appropriate wetting agents for inclusion in dyeing processes. Formulated spin finishes based on ECOTERIC® T80 surfactant and UNIMAX® WL polyalkylene glycol series work well on polypropylene fibres and yarns. TERIC® 161 surfactant provides very low foam wetting in jet dyeing. The alkylamine ethoxylates are suggested as the starting point for formulated levelling agents.

Wetting Agents

TERIC® X8 and TERIC® N8 wetting agents are conventional broad spectrum nonionic wetting agents with wide ranging applications potential. TERIC® 161, TERIC® 164, TERIC® 168, TERIC® 169 and TERIC® 569 wetting agents are low foam general purpose wetting agents. ALKADET® 20 alkyl polysaccharide also shows temperature-dependent low foam properties and is soluble in strongly alkaline solutions. Where a good penetrative wetting is required and low foaming properties are unimportant, TERIC® 10A6N, TERIC® BL8, or TERIC® BL12, HYDRAPOL® RP40 and HYDRAPOL® RP50 surfactants are recommended. ALKADET® 15 and ECOTERIC® 7500 alkyl polysaccharides are high foaming general purpose wetting agents which are soluble in strongly alkaline solutions and in concentrated solutions of inorganic salts.

TERIC® PE61, TERIC® PE62 and TERIC® PE64 surfactants or mixtures thereof are very low foam wetting agents with excellent rewetting ability and are suggested for use in situations where surfaces or substrates are required to be alternately dry and wet.

Wool Scouring and Finishing

Scouring of raw wool is possibly the most demanding detergency-related industrial process.

HYDRAPOL® TN450 and HYDRAPOL® BD40 surfactants are industry-proven high-performance wool scouring agents.

HYDRAPOL® ALN-755 auxiliary surfactant is non-oil-based carding and combing lubricant with outstanding antistatic performance, applicable to wool types from carpet wools to superfine apparel wools.

INCI NAMES FOR SOME INDORAMA VENTURES SURFACTANTS

The designation of an International Nomenclature of Cosmetic Ingredients (INCI) name for a cosmetic ingredient is an essential part of ingredient identification; however, it does not mean that the ingredient has been approved for use in cosmetics. The assignment of an INCI name to an ingredient does not imply that the ingredient is safe, has been certified, or that its use complies with the laws and regulations of any country or global region. The safety and appropriate use of an ingredient, along with regulatory considerations, should be carefully evaluated before use.

Product Code	INCI Name
TERIC® Sufactant	
10A5N	Deceth-5
10A6N	Deceth-6
10A8N	Deceth-8
12A2N	Laureth-2
12A3N	Laureth-3
12A4N	Laureth-4
LA4N	Laureth-4
12A6N	Laureth-6
12A7N	Laureth-7
12A8N	Laureth-8
LA8N	Laureth-8
12A9N	Laureth-9
12A12N	Laureth-12
12A23N	Laureth-23
13A7	Trideceth-7
13A9	Trideceth-9
PE61	Poloxamer 181
PE62	Poloxamer 182
PE64	Poloxamer 184
ME240-60	Methoxy PEG-10 Cocoate, PEG-20 Glyceryl Cocoate

Product Code	INCI Name
PEG Sufactant	
PEG 200	PEG-4
PEG 300	PEG-6
PEG 400	PEG-8
ECOTERIC® Sufactant	
E	PPG-15 Stearyl Ether
T20	Polysorbate 20
T80	Polysorbate 80
T85	Polysorbate 85
7500	C10-16 Alkyl Glucoside
ALKADET® 15	Caprylyl / Capryl Glucoside
OXAMINE® Sufactant	
LO	Lauramine Oxide
MO	Myristamine Oxide
OB/KU	Lauramine Oxide
ALKANATE® Sufactant	
PK100	Deceth-4 Phosphate

HLB VALUES FOR SOME INDORAMA VENTURES SURFACTANTS

Product Code	HLB
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TERIC® Sufactant

10A5N	11.6
10A6N	12.4
10A8N	13.7
12A2N	6.0
12A3N	7.1
12A4N	9.8
12A6N	11.2
12A7N	12.1
12A8N	12.6
12A9N	13.6
12A12N	14.4
12A23N	16.6
LA4N	9.8
LA8N	12.6
13A7	11.8
13A9	13.3
309	14.7
17A8	11.6
17A10	12.7
PE61	3.0
PE62	7.0

Product Code	HLB
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PE64	15.0
BL8	13.7
BL12	13.7
ME240-60	13.1
161	12.3
164	10.8
168	11.1
169	12.7
569	12.0
305	~14.0
320	14.9
340	13.0
460	17.1
461	14.9
462	17.5
463	18.1
528	14.4
534	12.6
552	12.0
16M2	9.5
16M5	10.5

Product Code	HLB
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16M15	13.8
17M5	~10.0
17M8	11.0
X5	10.4
X8	12.6
X10	13.6
X40L	17.6
N2	5.7
N5	10.5
N6	10.9
N8	12.3
N9	12.8
N10	13.3
N11	13.7
N12	13.9
N13	14.4
N15	15.0
N20	16.0
N30	17.2
N40LP	18.0

Product Code	HLB
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ECOTERIC® Sufactant

T20	16.7
T80	15.0
T85	11.0

TERMUL® Sufactant

200	16.1
203	17.5
1284	13.1
1285	14.4
3150	12.5
3512	7.3
5370	14.5
5429	15.3
5030	13.6

HYDRAPOL® Sufactant

RP40	7.8
RP50	10.2
RP80	12.0
RP90	13.0
RP120	14.7

HANDLING AND STORAGE

Most nonionic surfactants are almost anhydrous, and as such they are not corrosive to most common metals. However, aqueous solutions of virtually all nonionic surfactants will show some degree of corrosivity toward common ferrous metals such as black iron, mild steel, forged steel and cast iron. Virtually all grades of stainless steel are impervious to attack by surfactant solutions. Aluminium and its alloys are generally resistant to attack by anhydrous surfactant and to attack by aqueous solutions at ambient temperature.

Prolonged storage of diluted surfactant solutions' at elevated temperatures, in aluminium, is not recommended. Some staining may occur on copper or brass, particularly with dilute solutions, but corrosive attack is minimal. Ferrous metals may be protected against corrosive attack by use of appropriate polyester or epoxy resin linings.

Plastics

Both plasticised and unplasticised polyvinyl chloride (PVC) show good resistance to attack by both concentrated and dilute surfactant solutions, as does polypropylene, nylon 6/6 and fibre reinforced epoxy resins. Cellulose acetate butyrate, polycarbonate, high density polyethylene and methacrylate-based resins show fair resistance to attack but should be used with care. Low density polyethylene and polystyrene are not recommended for surfactant storage. Surfactants in general and alkylphenol ethoxylates in particular can induce environmental stress cracking in some grades of polyethylene and PVC. Oriented polyolefin plastics, however, are quite acceptable materials for handling and storing surfactants.

Hoses

Wire reinforced polypropylene is the preferred material for hoses. For gasketing in pipework, CAF is the preferred material and the preferred elastomers for seals are nitrile, silicone, VITON™ elastomer. TEFLON™ fluoropolymer is quite impervious to surfactant solutions and is recommended for seats and seals in valves.

Pumps

Centrifugal pumps are widely used throughout the chemical industry and are quite suitable for handling low viscosity liquids. If a centrifugal pump is selected, Indorama Ventures recommends the following general requirements:

- Pump to be single stage, back pull-out, of cast iron construction.
- Impeller preferably to be of the closed type.
- Provided with a single mechanical seal fitted with silicon carbide/carbon faces and TEFLON™ fluoropolymer O-rings.
- Fitted with a direct coupled electric motor of a suitable hazard rating for the area, via a flexible coupling.
- Pump and motor to be mounted on a rigid baseplate.

Positive displacement pumps are preferred for higher viscosity products. Tri-lobe pumps and gear pumps are suitable. An air operated double diaphragm pump is recommended as the preferred positive displacement pump. These pumps offer the following benefits:

- | | |
|------------------------------------|----------------------------------|
| ■ Ease and simplicity of operation | ■ Can self-prime if necessary |
| ■ Can be run dry | ■ No mechanical seals |
| ■ Can be "dead headed" | ■ Low cost and easy installation |

Surfactants

Alkanolamines

Oxygenated Solvents

Polyglycols and Alkoxy-Polyethers

Alkanolamines

Monoethanolamine, diethanolamine, and triethanolamine are alkanolamines or amino alcohols and have been prepared industrially since the early 1930's and on a significant scale after 1945. They find diverse industrial application where world alkanolamines capacity was roughly 1.09×10^6 tonnes per annum by 1999.



CHEMISTRY OF ALKANOLAMINES

Alkanolamines are commercially produced by reacting ethylene oxide with ammonia yielding a mixture. Monoethanolamine, diethanolamine and triethanolamine are obtained through fractionation.

Alkanolamines are characterised by the presence of a basic nitrogen atom and at least one hydroxyl group and therefore capable of undergoing reactions typical of both amines and alcohols.

Monoethanolamine and diethanolamine can undergo reactions leading to the formation of various nitrogen heterocycles, for example diethanolamine can be dehydrated to yield morpholine. Alkanolamines readily form salts with inorganic and organic acids.

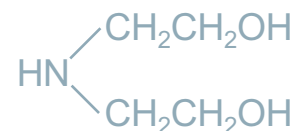
PRODUCT NOMENCLATURE AND RANGE

Monoethanolamine, diethanolamine and triethanolamine are available as 99% minimum concentration products. Triethanolamine 85 contains a minimum of 85% w/w triethanolamine with the balance being predominately diethanolamine.

Monoethanolamine (MEA)



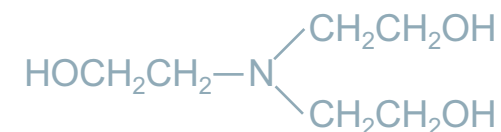
Diethanolamine (DEA)



Triethanolamine 85

Mixture of triethanolamine and diethanolamine

Triethanolamine-99% (TEA)



Triethanolamine LFG-85% Grade

This is an aqueous solution which typically contains 15% water and exhibits a lower freezing point in comparison to the 99% concentration product.

ALKANOLAMINE TYPICAL PROPERTIES

Typical Properties

Physically, these compounds are clear, viscous liquids at room temperature and white crystalline solids when frozen. Diethanolamine has the highest freezing point of the group, 28°C, and monoethanolamine the lowest, 10.5°C.

Alkanolamines have comparatively high boiling points, although subject to decomposition at elevated temperatures, particularly diethanolamine.

Alkanolamines are ammoniacal in odour, hygroscopic and miscible with water, most alcohols, and polyols.

Alkanolamines and their aqueous solutions are alkaline in pH.

Physical and Chemical Properties

Product	Appearance @ 30°C	Boiling Point °C	Melting Point °C	Flash Point PMCC °C	Specific Gravity 20/20 °C	Vapour Pressure kPa @ 20°C	Viscosity cS @ 30°C	pH	Molecular Weight g/mol
Monoethanolamine	Clear liquid	171	11	96	1.0179	-	-	11.8	61
Diethanolamine	Clear liquid	269 ¹	28	154	1.0919 ²	< 0.0013	321	11.5	105
Triethanolamine-85%	Clear liquid	355	12	190	1.1230	-	-	10.5	149
Triethanolamine-99%	Clear liquid	360	21	202	1.1255	< 0.0013	527 ³	11.0	149
Triethanolamine LFG-85% Grade	Clear liquid	100	-5	-	1.1230	-	75 ⁴	10.8	149

1. Decomposes

2. Specific gravity 30°C / 20°C

3. Measured at 25°C

4. Measured at 40°C

APPLICATIONS GUIDE

Monoethanolamine

A chemical intermediate in the manufacture of cosmetics, surface active agents, emulsifiers and plasticising agents. A gas-scrubbing agent for removal of hydrogen sulphide (H_2S) and carbon dioxide (CO_2) from refinery and natural gas streams and CO_2 from ammonia manufacturing. Also finds application as a corrosion inhibitor in metal working fluids.

Diethanolamine

An intermediate in the manufacture of cosmetics, surface-active agents used in household detergents and textiles specialties, insecticides, herbicides and petroleum demulsifiers. A gas scrubber in refinery and natural gas operations. Other applications include waxes, polishes, coatings emulsifiers, soluble oils, metal working fluids applications.

Triethanolamine

An intermediate in the manufacture of surface-active agents used in textile demulsifiers, toiletry formulations, cement additives, cutting oils and photographic-film developers. Dispersant for dyes, casein, shellac and rubber latex. Also has applications as a corrosion inhibitor, sequestering agent and as a rubber chemical intermediate.

SAFETY IN USE

As most alkanolamines exhibit corrosive properties, precautions need to be taken to prevent contact with the skin and eyes. **Persons handling concentrated solutions of these materials should be provided with:**

- Rubber gloves
- Appropriate safety footwear
- Chemical goggles
- Protective coveralls

If the water content of the ethanolamine is to be minimised, a dry inert gas pad, such as nitrogen should be used on storage tanks. Similarly, a gas pad should be used if low color is important since absorbed atmospheric oxygen will cause all ethanolamines to develop color.

Ethanolamines should not be used in tanks made from zinc, galvanized steel or copper and its alloys since ethanolamines react with copper to form complex salts. Carbon steel storage tanks constructed according to a recognized code are generally satisfactory. In cases where low color or low iron content is important, aluminum or stainless steel is preferred. Aluminum will react with the ethanolamines at elevated temperatures or in the presence of water. Therefore, it should not be used to store aqueous blends or in the construction of steam coils.

Comprehensive SDS are available upon request from Indorama Ventures Customer Service Centres. These provide further guidance on the toxicity and safe handling of these products. It is essential that the SDS is reviewed prior to the use of any Indorama Ventures alkanolamine products.



Surfactants

Alkanolamines

Oxygenated Solvents

Polyglycols and Alkoxy-Polyethers

Oxygenated Solvents

The oxygenated solvents produced by Indorama Ventures include glycols and glycol ethers. They are used in a diverse range of industries and applications.



CHEMISTRY OF GLYCOLS

Ethylene glycols are straight chain aliphatic compounds terminated on both ends with a hydroxyl group. Monoethylene glycol, diethylene glycol and triethylene glycol have the following structures:

Monoethylene Glycol



Diethylene Glycol



Triethylene Glycol



Monoethylene glycol is manufactured by the hydration of ethylene oxide. Diethylene glycol and triethylene glycol are prepared by the reaction of monoethylene glycol with ethylene oxide. A statistical distribution of ethylene glycols is formed which are easily separated into the various components through distillation.

The ethylene glycols are characterised by their water solubility, hygroscopicity, freezing point depression of water and low corrosiveness. They are used as plasticisers and in a wide number of applications such as coolants / antifreeze, polyesters and solvent extraction.

PRODUCT RANGE AND NOMENCLATURE

Product Name	Alternative Name(s)	CAS Number
Monoethylene glycol	Ethylene glycol; MEG	107-21-1
Diethylene glycol	DEG	111-46-6
Triethylene glycol	TEG	112-27-6

PRODUCT RANGE AND NOMENCLATURE

Physical and Chemical Properties

Parameter	Ethylene Glycol	Diethylene Glycol	Triethylene Glycol
Acidity (as acetic acid) %w/w	0.002 max	0.005 max	0.01 max
Colour, Pt-Co	10 max	10 max	25 max
Water, %w/w	0.2 max	0.2 max	0.25 max
Diethylene glycol, %w/w	0.2 max	99.0 min	2 max
Chloride, (as NaCl) %	< 0.200	0.005	0.009
Sulphate	Not detectable	Not detectable	Not detectable
Flash point, closed cup, °C	110	143	172
Molecular weight, g/mol	62	106	150
Refractive index @ 20°C	1.4316	1.4475	1.4559
Specific gravity @ 20/20°C	1.114 – 1.116	1.117 – 1.120	1.123 – 1.128
Specific heat, J/g/°C @ 20°C,	2.35	2.31	2.20
Surface tension, mN/m @ 20°C	48	48	45
Viscosity, cP @ 20°C	21	38	49
Vapour pressure, kPa @ 20°C	0.008	0.001	0.001
Distillation range, 5 - 95%, °C	196 – 198.5	-	-
Melting point, °C	-13	-6	-5
Boiling point, °C	197	245	285
Relative vapour density	2.2	3.7	5.17
Flammability limit, lower, %	3.2	1.7	0.9
Flammability limit, upper %	12.8	10.5	9.2
Ignition temperature, °C	412	229	360
Coefficient of expansion @ 20°C	0.00062	0.00064	-
Electrical conductivity, S @ 25°C	1.07 x 10 ⁻⁶	-	-
Heat of vaporisation, J/g	800	628	749

Solubility

Monoethylene glycol, diethylene glycol and triethylene glycol are all completely miscible with water. They are also soluble in lower aliphatic acids, alcohols, aldehydes, amines and ketones. Aromatic compounds in general have appreciable solubility in monoethylene glycol, diethylene glycol and triethylene glycol. Moving up the series from monoethylene glycol to triethylene glycol the solubility of hydrocarbons in the glycols increases. Vegetable oils are only very slightly soluble in monoethylene glycol, diethylene glycol and triethylene glycol.

APPLICATIONS GUIDE

Coolants / Antifreeze

Monoethylene glycol has low volatility and in aqueous solutions depresses the freezing point and elevates the boiling point of water. These properties have resulted in its widespread use as an automotive engine coolant. When coupled with corrosion inhibition systems it forms the basis of most commercial automotive engine coolants. Corrosion inhibited monoethylene glycol based automotive engine coolants do not affect automobile finishes, rubber hoses, gaskets or other engine components.

Monoethylene glycol is also used as a basis for heat transfer fluids in other industries, where use temperatures are unlikely to exceed 150°C. The freezing point depression of inhibited aqueous glycol solutions enables it to be used as an alternative for the more corrosive salt brines. The higher flash point of monoethylene glycol allows it to be a replacement for ethanol based solutions in appropriate applications. However, it is not recommended for use in systems where incidental contact with food could occur. Uninhibited aqueous glycol solutions are corrosive towards ferrous metals, aluminium, magnesium, solders and to a lesser extent brass. Heat transfer fluids based on monoethylene glycol must contain a formulated corrosion inhibitor pack.

The following table shows the freezing point depression as a function of concentration of monoethylene glycol over the practical concentration range.

Monoethylene Glycol

Concentration, % by Volume	10	15	20	25	30	35	40	50
Freezing Point, °C	-4	-7	-9	-13	-17	-21	-26	-49

Polyesters

Monoethylene glycol, diethylene glycol and triethylene glycol are all used in the manufacture of polyester resins. Polyester resins are the product of reaction between dibasic acids and diols, usually glycols. The choice of the glycol portion of the polyester resin is dictated by the required properties of the final product, such as the flexibility, water sensitivity and crystallinity.

Plasticisers

Diethylene glycol and triethylene glycol may be used as plasticisers for laminated safety glass, vinyls and nitrocellulose. They can also be used as plasticisers for cellulose sponges, cork, synthetic rubber, vinyl floor tiles, and paper.

Solvent Extraction

Glycols can be used as processing aids to separate aromatic hydrocarbons from aliphatic hydrocarbons in mixtures that are not easily separated via distillation. The solvent may be a single glycol, such as diethylene glycol, or a mixture of glycols.

Humectants and Dehydrating Agents

Monoethylene glycol, diethylene glycol and triethylene glycol are efficient hygroscopic agents. These humectant properties are of value in their application as dehydrating agents for natural gas and in air conditioning systems where they are used to remove water from the air without cooling. Gas dehydration involves the use of a liquid desiccant to remove water vapour from the gas.

APPLICATIONS GUIDE

Although many liquids possess the ability to absorb water from gas, the liquid that is most desirable to use for commercial dehydration purposes should possess the following properties:

1. High absorption efficiency
2. Easy and economic regeneration
3. Non-corrosive and non-toxic
4. No operational problems when used in high concentrations
5. No interaction with the hydrocarbon portion of the gas, and no contamination by acid gases

The glycols, particularly monoethylene glycol (MEG), diethylene glycol (DEG), triethylene glycol (TEG), come closest to satisfying these criteria to varying degrees. Water and the glycols show complete mutual solubility in the liquid phase due to hydrogen-oxygen bonds, and their water vapor pressures are very low.

Indorama Ventures has the capability to blend specialised MEG, DEG and TEG mixtures with specific water content, pH, alkalinity and other properties as required by our customers for use in gas dehydration applications.

Chemical Intermediates

Esterification of ethylene glycols with fatty acids produces a mixture of mono and diesters. These very hydrophobic surfactants find application as defoamers, lubricants and emulsifiers.

SAFETY IN USE

Exposure from either ingestion or inhalation of vapours of monoethylene glycol can lead to adverse reactions, and in some cases death. Therefore, the use of monoethylene glycol in smoke machines and similar public entertainment devices is not recommended. Triethylene glycol or polyethylene glycols are recommended for these applications.

Monoethylene, diethylene and triethylene glycols are not classified as dangerous goods by either road, rail, sea or air transport.

Comprehensive SDS are available for all Indorama Ventures glycol products. They can be requested from the Indorama Ventures sales offices

CHEMISTRY OF GLYCOL ETHERS

Glycol ethers are a range of solvents that find application in a wide range of industries. Their solvency, coupling ability and evaporation control are some of the features that have led to the use of these materials in industries such as surface coatings, inks, industrial cleaning and as intermediates in the production of other materials.

The Indorama Ventures range of GLYSOLV® glycol ether solvents contain both ethylene glycol ethers and propylene glycol ethers. These products are manufactured by alkoxylation of the parent alcohols in high pressure tubular reactors. The reaction products are separated and purified by distillation. The degree of polymerisation of the alkylene oxide and the structure of the parent alcohol determines the properties of these solvents.

The structure of an ethylene glycol ether is shown below.

Ethylene Glycol Ether



Where n = 1, 2 or 3 and R = Alkyl

PRODUCT RANGE AND NOMENCLATURE

The Indorama Ventures range of GLYSOLV® glycol ethers are named to clearly indicate their composition. With the core products the parent alcohol is identified by its common name. The GLYSOLV® trademark indicates that the product is the mono-ether of the parent alcohol, whilst the DI-GLYSOLV® trademark indicates the diether and the TRI-GLYSOLV® trademark indicates a tri-ether. Indorama Ventures sells propylene and ethoxyphenol based glycol ethers which also use the GLYSOLV® tradename together with an acronym to indicate structure.

GLYSOLV® EPH is an aromatic ether that is phenol substituted on oxygen by a 2-hydroxyethyl group, that is 2-phenoxyethanol. It is a germicidal and germistatic glycol ether and has a role as an anti-infective agent.

Glycol Ether

Trademark Name	Composition	Acronym	CAS Number
Methyl DI-GLYSOLV®	Diethylene glycol monomethyl ether	DEGME	111-77-3
Methyl TRI-GLYSOLV®	Mixture of triethylene and tetraethylene glycol monomethyl ethers	TEGME	112-35-6 and 23783-42-8
Butyl GLYSOLV®	Monoethylene glycol monobutyl ether	MEGBE	111-76-2
Butyl DI-GLYSOLV®	Diethylene glycol monobutyl ether	DEGBE	112-34-5
GLYSOLV® EPH	2-Phenoxyethanol	EPH	122-99-6

PRODUCT RANGE AND NOMENCLATURE

Physical and Chemical Properties

Solvent Properties

Trademark	Acidity Acetic Acid %w/w, max	Colour Pt-Co max	Water % w/w	Specific Gravity 20/20 °C	Flash Point °C	Viscosity cP @ 20°C	Vapour Pressure kPa @ 20°C	Refractive Index	Specific Heat J/g°C	Boiling Point °C	Evaporation Rate Butyl acetate =1	Surface Tension mN/m @ 25°C	Conductivity S	Solubility Parameter	Hydrogen Bonding Parameter	Dipole Moment Debye
Methyl DI-GLYSOLV®	0.01	15	0.2	1.022	93 (cc)	3.9	0.010	1.426	2.15	190	0.02	34.8	0.78	10.7	13.4	1.91
Methyl TRI-GLYSOLV®	n.a	n.a	0.3	1.058	> 118	7.5	< 0.010	n/a	n/a	265	<< 0.01	39.1	0.60	10.5	11.0	-
Butyl GLYSOLV®	0.01	10	0.1	0.902	68 (cc)	6.4	0.080	1.419	2.44	166	0.06	27.4	0.17	9.8	15.5	1.80
Butyl DI-GLYSOLV®	0.01	20	0.1	0.955	114 (cc)	6.5	0.003	1.431	2.29	224	< 0.01	30.0	0.19	9.5	13.5	2.05
GLYSOLV® EPH	0.20	20	0.3	1.110	121 (cc)	20.0	0.004	n/a	n/a	245	n/a	n/a	n/a	n/a	n/a	n/a

(cc) - Pensky-Martens closed cup (oc) - Cleveland open cup

Methyl DI-GLYSOLV® glycol ether can be supplied in conformance with DEF (UK) 68-252/Issue 3 (issued September 2005) and MIL-DTL-85470B (issued June 1999) for use in fuels supplied to Australian and foreign defense authorities. In these cases, the product is designated as Methyl DI-GLYSOLV®FSII glycol ether. Laboratory standards for measuring compliance with this specification are audited by Lloyds Register.

The solubilities of some common industrial solvents in GLYSOLV® glycol ethers are tabulated below:

Solubility

	Methyl DI-GLYSOLV® glycol ether	Butyl GLYSOLV® glycol ether	Butyl DI-GLYSOLV® glycol ether
Acetone	s	s	s
Cyclohexane	64	s	s
Dibutyl Phthalate	s	s	s
Ethyl Lactate	s	s	s
Ethylene Glycol	s	s	s
Hexane	21	s	s
Hydrochloric Acid	s	s	s

	Methyl DI-GLYSOLV® glycol ether	Butyl GLYSOLV® glycol ether	Butyl DI-GLYSOLV® glycol ether
Kerosene	3	s	s
Methyl Ethyl Ketone	s	s	s
Olive Oil	i	s	s
Phosphoric Acid	s	s	s
Polyethylene Glycol	s	s	s
Propylene Glycol	s	s	s
Safflower Oil	i	s	s

	Methyl DI-GLYSOLV® glycol ether	Butyl GLYSOLV® glycol ether	Butyl DI-GLYSOLV® glycol ether
Tall Oil	s	s	s
Triethanolamine	s	s	s
Tung Oil	i	s	s
Turpentine	55	s	s
Water	s	s	s

Numeric values indicate approximate order of solubility in millilitres per 100 millilitres

APPLICATIONS GUIDE

Glycol ethers are primarily solvents, and as such their possible applications are almost infinite. Major uses are in surface coatings, printing inks, textile auxiliaries, domestic and industrial cleaning products and agricultural chemicals. Glycol ethers are also used as chemical intermediates, fuel additives and as components of some grades of automotive hydraulic brake fluids.

Surface Coatings

Lacquers

The GLYSOLV® glycol ethers are surface active solvents characterised by high dilution ratios, low evaporation rates and wide solubility ranges. They are used to eliminate resin blush, reduce moisture blush, eliminate orange peel and promote the release of latent solvents. The high solvency of the GLYSOLV® glycol ethers helps eliminate resin blush by ensuring that formulation components remain in solution. The surface tension reduction effects of the glycol ethers help eliminate orange peel effects, and the slow evaporation rates help prevent surface evaporative cooling which is one of the prime causes of moisture blush.

Enamels

GLYSOLV® glycol ethers cause dramatic viscosity reduction allowing higher pigment loading and higher resin solids in premium quality enamel coatings. Flow-out, levelling and wet edge control are also improved due to the surface-active nature of glycol ether solvents.

Inks

Glycol ethers are widely used in flexography, screen printing and gravure printing, with minor uses in other printing processes such as lithography. Glycol ethers are active solvents which promote resin solubility and compatibility, control viscosity and surface tension, increase penetration and promote adhesion.

Water-Based Coatings

In most water-based coating systems, water is not an active solvent but rather a latent solvent usually used in conjunction with small amounts of organic active solvents. Glycol ethers are cost effective active solvents in these formulations because of their high dilution ratios in water. They also control evaporation rates, aid coalescence and increase adhesion to the substrate.

Textile Printing and Dyeing

Glycol ethers aid in the solubilisation of dyes, as well as the penetration and wetting of fabric and leather, resulting in more effective and efficient colouring. In textile printing, glycol ethers facilitate evaporation control, promote more even distribution of colour and help prevent printing pastes from drying out on plates and cylinders. Glycol ethers can be added to the solvents used to clean printing machinery after a run. Addition of the glycol ether enhances ink removal and inhibits the evaporation of more volatile solvents.

Cleaning Products

Domestic Detergents and Cleaners

The physical properties and solubility characteristics of glycol ethers make them an obvious choice when formulating cleaning products. They contribute to penetrative and spreading wetting due to their surface active properties; they can act as coupling solvents to increase the stability of more concentrated high quality formulations; they can act as hydrotropes to stabilise organic components in the presence of inorganic builders; and they can enhance greasy soil removal in both pre-spotting agents and hard surface cleaners. Glycol ethers enhance greasy soil removal by their ability to penetrate and soften facilitating roll up of the greasy soils.

Butyl DI-GLYSOLV® glycol ether is typically recommended for cleaning formulations. Due to toxicity concerns, Butyl GLYSOLV® glycol ether is rarely used in cleaning products while monoethylene glycol ethers and any methyl-based glycol ethers are not recommended for use in domestic cleaning applications.

Industrial and Janitorial Cleaning Products

Janitorial products are generally similar in formulation style to domestic cleaning products, and accordingly, the benefits of the glycol ethers are similar. The key product areas are hard surface cleaners such as floor wax strippers, glass cleaners, oven cleaners, bathroom and toilet cleaners and ceramic cleaners. Butyl DI-GLYSOLV® glycol ether is recommended for use in these applications.

In highly built alkaline cleaners, glycol ethers can provide solvency to improve grease cutting ability and a measure of hydrotropic effect to stabilise non-ionic and anionic surfactants in the formulation.

Sophisticated formulations of this type will use ALKADET® 15 or ECOTERIC® 7500 alkyl polysaccharide surfactants as a combined detergent / hydrotrope, thereby allowing high levels of glycol ethers to be used to maximum effect.

Acidic cleaners can also be formulated with glycol ethers. Solvent-based acidic cleaners using a hydrocarbon solvent such as kerosene along with phosphoric acid, a glycol ether such as butyl DI-GLYSOLV® glycol ether and a specialty surfactant such as TERIC® 305 phosphate ester are but one example of this style. Glycol ethers should not be used with strong oxidising agents, including nitric acid, because of the risk of chemical reaction. The possibility of reaction also exists with sulphuric acid and phosphoric acid, but the reaction products are both stable and functional, therefore minimising risks.

APPLICATIONS GUIDE

Cleaning products where maximum solvent effect is required can also benefit from the use of glycol ethers. Aside from being excellent solvents, they can also be used as coupling agents to stabilise two otherwise immiscible solvents, each of which is required in the formulation. Examples are paint strippers, graffiti removers, solvent-based degreasers and decarbonisers.

To summarise, typical applications for glycol ether-based formulations in the industrial and janitorial cleaning products market are:

- | | | |
|-------------------------|----------------------------|-------------------|
| ■ Aluminium cleaners | ■ Laundry pre-spotters | ■ Rug cleaners |
| ■ Aluminium brighteners | ■ Liquid soaps | ■ Steam cleaners |
| ■ Automotive cleaners | ■ Magnesium wheel cleaners | ■ Floor strippers |
| ■ Carbon removers | ■ Oven cleaners | ■ Glass cleaners |
| ■ Chrome plate cleaners | ■ Paint strippers | ■ Hand cleaners |
| ■ Degreasers | ■ Graffiti removers | ■ Window cleaners |
| ■ Rust removers | ■ Engine degreasers | |
| ■ Hard surface cleaners | | |

Glycol Ethers as Chemical Intermediates

Glycol ethers behave as low molecular weight alcohols in chemical reactions. They are easily esterified and they can be further alkoxylated. The acetate esters of ethyl and butyl ethers as well as of the propylene glycol ethers are very common components of lacquer thinners and of solvent based adhesives. The reaction products with phthalic anhydride are common specialty plasticisers, and the higher fatty acid esters are used as specialty defoamers.

Glycol Ethers as Fuel Additives

Methyl DI-GLYSOLV® FSII glycol ether is specifically used as an anti-icing and antimicrobial / fungicide additive in aviation turbine fuels. This application is largely confined to military aircraft and some specialist private aircraft.

The antimicrobial / fungal property of glycol ethers is particularly applicable to diesel fuels which are stored under adverse conditions, especially marine and farm use. Fungal / microbial growth occurs at the fuel-water interface in fuel tanks and storage tanks, causing line blockages and filter plugging, which in turn reduces the reliability and introduces safety hazards. Glycol ethers can solubilise small amounts of water into diesel fuels, thereby removing the interface at which the microbes/fungi grow.

More significantly, glycol ethers strongly inhibit the growth of the bacteria and fungi, thereby removing the problem at its source. Although Methyl DI-GLYSOLV® glycol ether is likely the most effective, its mammalian toxicity restricts its use. Butyl GLYSOLV® glycol ether can be freely used in this application, either alone, diluted with distillate, or combined with other approved fuel additives. Approximately 0.15% by volume of the fuel is the suggested concentration for this application.

SAFETY IN USE

Handling and Storage

GLYSOLV® glycol ethers can be satisfactorily stored and handled in stainless steel or mild steel containers. Aluminium or alloys containing aluminium must not be used for the storage of glycol ethers, due to the possibility of alcoholate formation with the consequent formation of hydrogen. Copper and some copper rich alloys will react with glycol ethers to form strongly coloured complexes.

If maximum product quality is to be maintained in bulk storage, glycol ethers should be stored under dry nitrogen. Over time, the reaction with atmospheric oxygen will generate peroxides which in turn will lead to the formation of aldehydic and acidic contaminants. The net result of this process is a decrease in pH and an increase in acid value and the development of a yellow-brown discolouration.

Polypropylene is satisfactory for hoses and flexible couplings. Butyl elastomers are satisfactory for gaskets and seals. Natural rubbers can be used with the methyl and ethyl ethers, but not the butyl ethers. Neoprene™ elastomer can be used only with the methyl ethers. PTFE is recommended for valve seats.

Pumps are a matter of choice. Cast iron centrifugal pumps with simple slip-ring seals are satisfactory. The nature of the casting will be governed by the pressure rating of the system.

Wherever possible the glycol ether itself should be used as the lubricant. Mineral oils and greases will be dissolved by the glycol ether, with resultant contamination. Graphite and molybdenum disulphide are recommended for use in situations where a greater degree of lubricity is required.

Transfer and handling equipment should be electrically bonded to one another and all components of the system should be taken to a common ground. This is necessary to prevent the accumulation of static electricity charges.

All glycol ethers on the Indorama Ventures range classified as non-dangerous goods for storage and transport.

Toxicity of Glycol Ethers

Toxicity is the response of biological tissue after exposure to a chemical or physical agent. Any agent may give rise to a number of responses depending on which tissue is affected and the duration of the exposure. However, all toxic responses obey two fundamental laws:

The No Observed Effect Dose (NOED) or the No Observed Effect Level (NOEL) which states that if a toxic agent is sufficiently diluted it will reach a dose at which the toxic effect does not occur.

The dose-response relationship, which states that above the no effect dose, the toxic response increases in proportion to the dose.

The dose-response rule gives rise to the conclusion that all chemicals will exert a toxic effect if the dose is high enough. Toxic effects are generally divided between short term single exposure effects and long term or chronic exposure effects.

A study of the toxicity of glycol ethers has shown that there are great differences between the individual glycol ethers. It must be recognised that the lethality of their mode of toxicity varies from one species of animal to another and could well be different in humans. These considerations are particularly relevant to the butyl ethers. Monoethylene glycol butyl ether (MEGBE or 2-butoxy ethanol) has long been known to cause haemolysis, or rupture of the red blood cells, in rats and rabbits following exposure to the chemical. However, there is clear evidence that humans are far less sensitive to these harmful toxic effects after exposure to MEGBE either by oral routes, inhalation or skin adsorption. Also, there is no evidence of the reprotoxic effects shown by the lower alkyl ethers.

Butyl GLYSOLV® glycol ether, or 2-butoxy ethanol, has been exhaustively reviewed by the Australian regulator, the Australian Industrial Chemicals Introduction Scheme (AICIS) and found to represent minimal risk to public health.

Exposure Standards

The exposure standards for various glycol ethers, published by national regulatory authorities, are shown in Indorama Ventures material safety data sheets. TWA is the time weighted average airborne concentration over an eight-hour working day, for a five-day working week over an entire working life. Because glycol ethers can be absorbed by the skin, most TWA values have a “skin” annotation that means that skin exposure invalidates the inhalation exposure for that day. Also shown is the Short-Term Exposure Limit (STEL) value. STEL is the average airborne concentration over a 15-minute period which should not be exceeded at any time over a normal eight-hour working day.

The exposure standards are a guide to be used in the control of occupational health hazards. All atmospheric contamination should be kept to as low a level as is workable. Exposure standards should not be used as fine dividing lines between safe and dangerous concentrations of chemicals. They are not a measure of relative toxicity.

Indorama Ventures recommends that all users consult the SDS for the individual glycol ether products for further safety information. These are readily available through the Indorama Ventures sales offices.

CHEMISTRY OF FORMULATED GLYCOL COOLANTS

The technology behind automotive engine coolants (antifreezes) has evolved considerably over recent decades as engines have advanced to become smaller and more powerful. Indorama Ventures manufactures a range of quality glycol engine coolants under the GLYCOOL® and COOL-RAD® brands to suit specific OEMs as well as general purpose requirements. These products are manufactured to the highest Australian and International Standards and maintain a proven track record over many decades in the Australian and export markets.

Products from Indorama Ventures GLYCOOL® and COOL-RAD® coolant range conform to the following national and international standards:

- AS2108-2004 Australian Standard for Engine Coolants (Type A, Type B).
- ASTM D 3306 (American Standard Specification for Ethylene Glycol Base Engine Coolants for Automotive and Light Duty Service).
- BS 6580 (British Standard Specification for Corrosion Inhibiting, Engine Coolant Concentrate (Antifreeze).
- JIS K 2234 Japanese Industrial Standard – Engine Antifreeze Coolants.

Why use an Ethylene Glycol Based Coolant?

New vehicles are factory filled with ethylene glycol engine coolant for several reasons:

- Anti-boil protection. Ethylene glycol-based engine coolant solutions have a higher boiling point than water alone. Many new vehicles are designed to have a normal coolant operating temperature above 100°C to improve engine efficiency.
- Anti-freeze protection. Ethylene glycol-based engine coolant solutions have a much lower freezing point than water alone. If the coolant in the vehicle freezes in cold weather, serious engine damage can occur when the car is started due to poor heat transfer from the engine.
- Corrosion protection. Engine coolant contains corrosion inhibitors to protect the metal components of the cooling system from corroding. Using water alone in the cooling system will quickly corrode the alloys of a modern engine.
- Promotion of nucleate boiling. The lower surface tension of ethylene glycol-based engine coolant solutions aids nucleate boiling by reducing the tendency for bubbles to coalesce before leaving the metal surface.

Water on the other hand boils at a lower temperature and owing to its higher surface tension, is likely to undergo uncontrolled boiling above its boiling point. This can lead to bubbles coalescing on the surface of the metal, creating large areas of hot metal and vapour where corrosion can occur.

CHEMISTRY OF FORMULATED GLYCOL COOLANTS

Why use an Ethylene Glycol Based Coolant?

Currently there are 3 types of engine coolant products available in the Australian automotive market:

- Conventional Additive Technology (CAT) based on inorganic additives such as nitrates, phosphates, amines, silicates etc CAT based coolants are also known as IAT (Inorganic Additive Technology)
- Organic Additive Technology (OAT) based on mixed systems of salts of various organic acids such as benzoic acid, sebacic acid etc
- Hybrid Additive Technology (HAT) based on a mixed system of organic and Inorganic Additives HAT based coolants are also known as HOAT (Hybrid / Organic Additive Technology)

Recent formulations have trended toward the OAT and HAT style for the following reasons:

CAT Formulations contain inorganics which are:

- Generally non-biodegradable and some (but not all) are harmful to the environment or potentially toxic to people and animals
- Generally quick to deplete resulting in shorter life products - typically 1 to 2 years
- Often reactive with hard water to form deposits and scales which can cause blockages and reduce the effectiveness of heat transfer in cooling systems

OAT Formulations contain organics which are:

- Generally biodegradable and less harmful to the environment
- Very slow to deplete resulting in longer service life products - up to 5 years
- Less impact on engine componentry (and less reactive with hard water) resulting in fewer deposits and scales and improved heat transfer

Indorama Ventures manufactures two OAT style products, GLYCOOL® 660 and COOL-RAD® 680 for in warranty servicing of vehicles which were initially filled with OAT and where the vehicle service handbook requires the use of this style of product.

HAT Formulations contain inhibitor systems which combine the best characteristics of OATs and CATs resulting in:

- More robust application in a wide range of cooling systems
- Longer life products with superior general corrosion protection
- Products without the environmental / toxicological issues associated with CATs
- Products without the issues of cooling circuit design associated with OATs

The HAT type products manufactured by Indorama Ventures are compatible with both CATs and OATs and can be retrofitted with a simple water flush to either system.

PRODUCT RANGE AND NOMENCLATURE

Indorama Ventures manufactures CAT, OAT and HAT based coolant at our manufacturing plant in Botany, NSW. Listed below are all the engine coolants available, and the additive technology employed.

Physical and Application Properties

Product	Colour	Technology	Application	Specifications
RADIHIB® SC coolant	Green	OAT 2 yrs/40,000 km	General purpose, water based super concentrate	AS2108.1 Type B
GLYCOOL® 350 coolant	Green	CAT 2 yrs/40,000 km	General purpose, conventional coolant	AS 2108.1 Type A, ASTM D 3306, ASTM D 4656, BS 6580, JIS K 2234, SAE J 1034
GLYCOOL® 583 coolant	Green	HAT 4 yrs/120,000 km	General purpose, hybrid technology	Automotive: AS 2108-2004 Type A, ASTM D 3306, BS 6580, JIS K 2234, SAE J 1034, General Motors GM 1825M, GM 1899M, GME L1301, Holden HN 2217, HN2043, Ford WSS-M97B51-A1, Ford ESE-M97B44-A, Mazda MES MN 1210, Volvo (UK), BMW (UK), Saab FSD 8704, Heavy Duty: ASTM D 4985 (heavy duty engines), Ford ESE-FM97B18-C, Caterpillar 1 EO 535 (performance), Nissan NES 5059 LLC, Detroit Diesel Allison 7SE298, MWN Diesel D234 2/15
COOL-RAD® 600 coolant	Green	HAT 5 yrs/250,000 km	General purpose, old and new vehicles	AS 2108.1 Type A, ASTM D 3306, General Motors GM 1825M, ASTM D 3306, General Motors GM 1899M, SAE J20, HN2043/GM6043M (performance), SAE J1941, Ford WSS-M97B51-A1 (passenger car), Ford ESE-M97B44-A
GLYCOOL® 690 coolant	Green	HAT 2 yrs/240,000 km	Heavy Duty Trucks, Mining, Off-road, etc.	ASTM D 6210, GM1899M, GM1825, Ford ESE-M97B44-A (automotive), Ford ESE-M97B18-C, Detroit Diesel Allison 75E298, Type P (Renault), Saab FCD 8704, Cummins 92T8-9, MWN Diesel 234 2/15, Nissan NES 5059 LLC, Mazda MES MN 121D, Caterpillar 1EO 535 (performance standards only), TMC RP329 "Type A"
GLYCOOL® 660 coolant	Orange	OAT 5 yrs/250,000 km	General purpose, orange OAT	ASTM D3306 (automotive), ASTM D6210, ASTM D4945 (heavy duty), SAE J1304, AS 2108 Type A (Australia), JIS K2234, JASO M325 (Japan), KSM 2142 (Korea), BS 6580 (British), NFR 15-601 (French)
GLYCOOL® 663 coolant	Green	OAT 5 yrs/250,000 km	General purpose, green OAT	GM 6277M (GMW 3420), TSK 2601G, AS 2108: Type A or ASTM D3306
COOL-RAD® 680 coolant	Red	OAT 5 yrs/250,000 km	General purpose, red OAT	AS 2108 Type A (Glycol) GMW 3420, ASTM D 3306, Ford WSS-M97B44-D, ASTM D6210
GLYCOOL® 415 coolant	Red	OAT 500,000 km on-road 3 yrs/6,000 hrs off-road	Heavy Duty Trucks, Mining, Off-road, etc.	ASTM D3306, ASTM D6210, ASTM D7583, SAE J1034, SAE J1941, ASTM D4985, Chrysler MS9769, Cummins 90T8-4, Detroit Diesel 7SE298, Navistar SEMS B1, Ford WSS-M97B44-D, GMW 3420/GM 6277M, GSAA-A-52624A, Mack Truck, TMC RP329, Volvo VCS

SAFETY IN USE

What Coolant Concentration Should Be Used?

The optimum concentration for ethylene glycol-based engine coolants is between 33-50%, however manufacturer recommendations should always take precedence. A concentration between 33-50% gives the optimum balance of anti-boil, anti-freeze, and corrosion protection. Concentrations under 33% will significantly reduce anti-boil, anti-freeze and corrosion protection. Coolant concentrations above 60% should never be used as the ability of ethylene glycol to remove heat from the engine is reduced at high glycol concentrations.

Mixing Coolants

Different coolant products should never be mixed in a cooling system, even if the products are made by the same manufacturer. Corrosion inhibitor chemistries are sometimes physically incompatible between two different coolants resulting in corrosion inhibitors precipitating from solution. This precipitation in a cooling system can cause corrosion problems due to the created imbalance of corrosion inhibitors, as well as plugging or erosion of cooling system components.

Coolant Toxicity

Ethylene glycol is recognised as “Harmful if Swallowed” in Australia. An average lethal dose is approximately 1.6 grams per kilogram of bodyweight, and for this reason, Indorama Ventures adds bittering agents to all coolants to protect against accidental ingestion.

AUTOMOTIVE BRAKE FLUIDS

The main function of a brake fluid is to transmit the pressure applied to the foot pedal via the piston in the master cylinder to the drum or disc brakes.

In order to do this the brake fluid must:

1. Be incompressible
2. Be compatible with the braking system hardware (metals, rubber, plastic)
3. Be resistant to short term deterioration caused by ingress of contaminants (eg. water)
4. Possess the correct fluid characteristics (viscosity, lubricity)
5. Have a high enough boiling point to resist vapour lock under severe braking conditions

Indorama Ventures brake fluid technology has consistently evolved in accordance with changing braking system hardware design. Brake fluids of today must be able to exhibit the required performance characteristics in a variety of systems which include drum, disc and ABS systems.

The performance and other quality related properties are measured and controlled by standards that have evolved and have become more stringent as demands on the fluids have increased. Our brake fluids were developed with an aim to widely exceed the Australian Standard, AS/NZS 1960.1, the basis of which are the international standards FMVSS 116, SAE J1703, SAE1704 and ISO 4925.

Indorama Ventures range of brake fluids are based on glycols, glycol ethers and borate esters covering three main FMVSS 116 categories: DOT 3, DOT 4 and DOT 5.1

PRODUCT RANGE AND NOMENCLATURE

Indorama Ventures Automotive brake fluids meet all major brake fluid specifications and are quality certified.

Product	Application	Boiling Point (ERBP) ¹ °C	Wet Boiling Point (WERBP) ² °C	Low Temperature Viscosity mm ² /s	Specifications
HBF 1/260	DOT 3	268	149	1165	FMVSS116 DOT 3, SAE J1703, AS1960.1 Grade 1, ISO 4925
HBF 2/260	DOT 4, low viscosity	269	162	663	FMVSS116 DOT 4, SAE J1703, SAE 1704, AS1960.1 Grade 2, ISO 4925
HBF 3/280	Super DOT 4	285	183	1261	FMVSS116 DOT 4, SAE J1703, SAE 1704, AS1960.1 Grade 3, ISO 4925
RBF® 600 fluid	Racing brake fluid	317	218	2550	FMVSS116 DOT 4, SAE 1704
ETHOXINOL® D3 fluid	DOT 3	269	150	1238	FMVSS116 DOT 3, SAE J1703, AS1960.1 Grade 1, ISO 4925
ETHOXINOL® D4 fluid	DOT 4	277	166	1280	FMVSS116 DOT 4, SAE J1703, SAE 1704, AS1960.1 Grade 2, ISO 4925
ETHOXINOL® SD4 fluid	Super DOT 4	282	180	1294	FMVSS116 DOT 4, SAE J1703, SAE 1704, AS1960.1 Grade 3, ISO 4925
ETHOXINOL® DOT 5.1 fluid	DOT 5.1	271	184	840	FMVSS116 DOT 5.1, SAE J1703, SAE 1704, AS1960.1 Grade 3, ISO 4925

1. ERBP is Equilibrium Reflux Boiling Point

2. WERBP is Wet Equilibrium Reflux Boiling Point

Brake Fluid Requirements

Brake fluid, which generally can be described as a balanced blend of stable organic components is required to exhibit the following main properties.

Boiling Point

Fluid must have a high enough boiling point to resist vapour lock under severe braking conditions. Grades of brake fluids with boiling points exceeding 260°C, 270°C and 280°C are available from Indorama Ventures.

Viscosity

Brake fluid must possess the required viscosity over a wide temperature range. It must be sufficiently mobile at low temperature to respond rapidly to pedal pressure and be viscous enough at high temperatures to maintain good lubricating properties.

Corrosion and Oxidation

Inhibitors are added to the brake fluid formulation to reduce corrosion of the many alloys and metals that may be used in a braking system. Oxidation inhibitors are also used to prevent oxidation of the fluid itself, which may otherwise occur because of heat, and the catalytic effects of metals in the system.

Compatibility with Elastomers and Lubricity

The brake fluid should not have an adverse effect on the physical properties of the rubber cups used in the master and wheel cylinders, i.e. excessive swelling, shrinkage or softening. Indorama Ventures brake fluids consist of appropriate components in order to obtain a good seal and provide required lubricity.

PACKAGING AND HANDLING

Packaging

Indorama Ventures Automotive brake fluids are supplied in 20 metric tonne ISO tanks or in smaller packs from our local distributors.

Containers should remain closed since water absorbed from the atmosphere will lower the boiling point (ERBP) of the fluid.

Safety Aspects

Contact with most Indorama Ventures automotive brake fluids is practically non-harmful. Each brake fluid is supplied with an Australian SDS.

Contamination

Avoid any contamination with mineral oil as small amounts can cause accelerated swelling of seals within the master cylinder.

Equipment such as air operated dispensing equipment is a potential source of contamination due to the risk of carryover of mineral compressor oil.

Ideally, filling operations should be designed to minimise contamination and contact of the fluid with the atmosphere.

Spillage

Brake fluids can damage automotive paints. It is best removed by thoroughly washing with water.

Transport / Storage

Indorama Ventures Brake Fluids should have open cup flash points varying from about 140°C to about 160°C. For the purposes of transport and storage, all are considered non-flammable.

For Further Information

Contact your nearest Indorama Ventures Sales Office or agent for further information about Indorama Ventures automotive brake fluids.

Surfactants

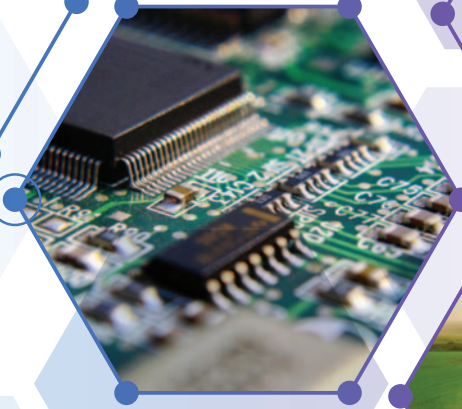
Alkanolamines

Oxygenated Solvents

Polyglycols and Alkoxy-Polyethers

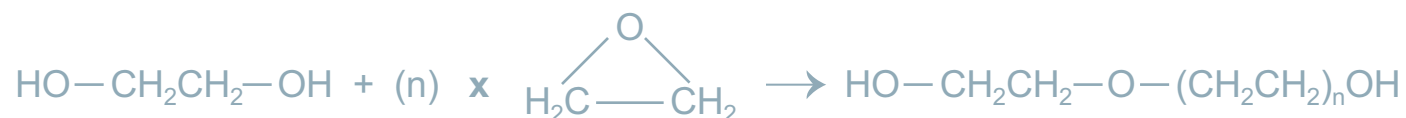
Polyglycols and Alkoxy-Polyethers

The polyglycols highlighted in this brochure comprise the polyethylene glycols and polypropylene glycols made by Indorama Ventures. Polyethylene glycols are composed of a number of linked oxyethylene groups terminated by hydroxyl groups. The polypropylene glycols consist of polyoxypropylene groups, similarly terminated, although the hydroxyl functionality in this case may be primary or secondary. Polyalkylene glycols or PAGs and methoxy polyethylene glycols are special sub-groups of polyglycols and chemically they are alkoxy-polyethers.



CHEMISTRY OF POLYGLYCOLS

There are two possible routes to manufacture polyglycols. One route would be to react the appropriate alkylene oxide with water in the presence of a suitable catalyst. However, they are more commonly manufactured from the corresponding mono glycols or di-glycols as this route affords greater control of the reaction environment, and accordingly a superior quality product. The following equation shows the reaction of mono ethylene glycol (MEG) with ethylene oxide to produce a polyethylene glycol (PEG).



Polycondensation products such as polyethylene glycols and polypropylene glycols are polydispersed, i.e. they are consistent mixtures of homologues rather than specific chemical molecules. The distribution of these homologues is a function of the reaction kinetics. For commercial polyethylene glycols derived from processes in which sodium, potassium or lithium salts are used as the catalyst, the distribution is essentially Poisson.

Homologue distribution in polypropylene glycols is somewhat broader and more variable due to the marked difference in the reactivity between primary and secondary hydroxyl groups.

The various polyethylene glycols are not pure chemical compounds with a precisely defined molecular weight, they are polymers with a molecular weight distribution. Their mean molecular weights (Mw) can be calculated from the analytical measurement of their hydroxyl values (expressed in the units mg KOH/g). This measurement is particularly useful when the polyglycols are used for chemical synthesis.

$$\text{Mw} = 56,100 \times 2 \text{ (number of hydroxyl groups per molecule) / measured hydroxyl value}$$

The terminal primary hydroxyl groups allow polyethylene glycols to undergo most conventional reactions such as esterification. Additionally, polyethylene glycols may form complexes or addition compounds due to the high electron density at the ether oxygen atoms. Their ability to act as electron donors or proton acceptors explains their tendency to form addition compounds with acids, salts, phenols and heteropoly acids. The electron pairs on the ether oxygen atoms are also directly responsible for the fact that polyethylene glycols in solution usually act as cationic flocculants and give rise to some aspects of their behaviour as lubricants and antistatic agents.

Polypropylene glycols physical and chemical properties arise due to the co-occurrence of both primary and secondary hydroxyl groups during the polymerisation, and the multiplicity of methyl side chains on the polymer. Polypropylene glycols of all molecular weights are viscous liquids which show an inverse temperature-solubility relationship, along with a rapid decrease in water solubility as the molecular weight increases. The terminal hydroxyl groups undergo reactions typical of a secondary alcohol, including esterification or etherification by way of an alkyl halide.

PRODUCT RANGE AND NOMENCLATURE

Polyglycols are named by reference to their average molecular weight. Polyethylene glycols are prefixed by PEG and polypropylene glycols by PPG. Thus, PEG 200 is a polyethylene glycol with an average molecular weight of 200. Alternatively, within the personal care industry PEGs are named according to the International Nomenclature of Cosmetic Ingredients (INCI) system. In this system PEG 200 is called PEG-4, referring to an average of 4 ethylene oxide units in the molecule.

Polyethylene Glycols



CAS Registry No. 25322-68-3

- PEG 200
- PEG 300
- PEG 400
- PEG 400 USP
- PEG 600
- PEG 600 USP

Polypropylene Glycols



CAS Registry No. 25322-69-4

- PPG 500

Indorama Ventures has the capability to manufacture higher molecular weight (up to 10,000 Mw) PEGs.

Pharmaceutical Grades

PEGs are non-toxic. They are versatile solvents, diluents and excipients, and accordingly find application throughout the pharmaceuticals industry. Although the basic chemical is unchanged the United States Pharmacopeia (USP) grades are subject to additional detailed analysis. These grades have the PEG descriptor followed by a suffix USP.

Requirements for USP compliance are provided on the certificate of analysis:

- Appearance at 25°C
- Average molecular weight
- Heavy metals content
- Completeness and colour of solution
- pH of a 5% aqueous solution
- Mono- and di-ethylene glycol content
- Residue on ignition
- Residual ethylene oxide content
- Viscosity @ 98.9°C
- 1, 4 dioxane content

SOLUBILITY AND SOLVENT CHARACTERISTICS OF PEGS

All PEGs are readily soluble in water. PEGs from molecular weight 200 to molecular weight 600 are miscible in all proportions with water. The water solubility of the PEG's decreases as the molecular weight increases towards 6000. However, the water solubility of the PEGs never falls below 50%. Addition of water to solid PEGs will reduce the pour point, making it possible to prepare concentrated liquids from the higher molecular weight solids.

PEGs are soluble in most polar solvents but solubility decreases markedly as PEG molecular weight increases. They are insoluble in non-polar solvents such as aliphatic hydrocarbons. Common organic liquids which are miscible / soluble or insoluble in all proportions with the lower molecular weight PEGs are tabulated below.

Solubility

Solvent	Solubility	Solvent	Solubility	Solvent	Solubility	Solvent	Solubility	Solvent	Solubility
Acetaldehyde	s	Castor oil	i	Diethyl phthalate	i	Lactic acid	s	Phosphoric acid 85%	s
Acetic acid	s	Chlorobenzene	s	Ethanol	s	Lemon oil	i	Polypropylene glycol	s
Acetic anhydride	s	Chloroform	s	Ethyl acetate	s	Methanol	s	Propan-1-ol	s
Acetone	s	Cottonseed oil	i	Ethylene diglycol	s	Methoxybutyl acetate	s	1,2-Propylene glycol	s
Acrylic acid	s	Cyclohexane	i	Ethylene glycol	s	Methylene chloride	s	Ricinoleic acid	i
Acrylonitrile	s	Cyclohexanol	s	2-Ethyl hexanol	s	Methyl diglycol	s	Safflower oil	i
Alkanolamines	s	Cyclohexanone	s	Formamide	s	Methyl ethyl ketone	s	Soya oil	i
Allyl alcohol	s	Diacetone alcohol	s	Furfural	s	Methyl glycol	s	Styrene	s
Amyl alcohol	s	Dibutyl sebacate	i	Gasoline	i	Methyl isobutyl carbinol	i	Styrene oxide	s
Benzaldehyde	s	Dichloroacetic acid	s	Glycerol	s	Methyl laurate	i	Tetrahydrofuran	s
Benzene	s	Diethanolamine	s	Glycerol triacetate	s	Methyl methacrylate	s	Triacetin	s
Benzyl alcohol	s	Diethylene glycol	s	Gum Arabic	i	Methyl salicylate	s	Triethanolamine	s
Butanol	s	Diethylene glycol	s	Isobutyl alcohol	s	Mineral oil	i	Triethylene glycol	s
Butyl acetate	s	dimethyl ether		Isodecyl alcohol	s	Morpholine	s	Tripropylene glycol	s
Butyl diglycol	s	Dimethyl formamide	s	Isophorane	s	Octanol	s	Vegetable oils	i
Butyl glycol	s	Dimethyl phthalate	s	Isopropyl alcohol	s	Oleic acid	s	Xylenol	s
Butyraldehyde	i	Dipropylene glycol	s	Isotridecyl alcohol	s	Orange oil	i	Xylenes	s
Canauba wax	i	Dodecan-1-ol	s	Kerosene	i	Paraffin oil	i		

SOLUBILITY AND SOLVENT CHARACTERISTICS OF PEGS

Lower molecular weight PEGs are also solvents for quite a range of organic solids and even some inorganic salts. For example, the following solids are soluble to at least 10%w/w in PEG 400 at 20°C and form stable solutions. In many cases molten higher molecular weight PEGs will show similar solvent characteristics.

Some organic solids that are soluble to at least 10%w/w in PEG 400:

- | | | |
|----------------|---------------------|------------------|
| ■ Benzoic acid | ■ Phenol | ■ Salicylic acid |
| ■ Camphor | ■ Phenothiazine | ■ Thiourea |
| ■ Citric acid | ■ Phenyl salicylate | ■ Thymol |
| ■ Paraldehyde | ■ Resorcinol | ■ Vanillin |

Hydrates of calcium chloride, cobalt chloride, ferric chloride, magnesium chloride and zinc chloride form solutions in low molecular weight PEGs at about 100°C, and these solutions remain stable at ambient temperatures.

Hygroscopicity of PEGs

PEGs are distinctly hygroscopic, where hygroscopicity decreases in a non-linear fashion as the molecular weight increases. When exposed to air, all PEGs will take up water until an equilibrium point is reached. This property is useful for creating environments of reasonably standard humidity, for retaining a certain level of moisture in an environment, or for removing moisture from an environment.

At 20°C and 65% relative humidity, PEG 200 will absorb approximately 25% of its weight as water, PEG 400 approximately 16% and PEG 600 approximately 10%.

APPLICATIONS GUIDE

Applications

PEGs are used in a wide range of applications which are summarised in the following tables:

Industry and Application	PEG 200	PEG 300	PEG 400	PEG 600
Agriculture				
Anti-dusting agents	X			
Pesticide vehicle	X	X	X	X
Ceramics & Glass				
Binders for glazes	X			X
Colour stabilisers for ceramics manufacture	X			
Lubricant / coating in glass cleaners		X	X	
Chemicals Manufacture				
PEG ester surfactants	X	X	X	X
Complexing agents			X	X
Methacrylate resin component	X			
Cork & Wood				
Plasticiser	X	X	X	
Dimensional stabiliser		X	X	X
End check control			X	
Cosmetics & Personal Care				
Antiseptic dental creams		X		
Base for skin creams		X		
Deodorant sticks and roll-ons		X	X	
Hairdressing preparations				X
High stain lipsticks			X	

Industry and Application	PEG 200	PEG 300	PEG 400	PEG 600
Moisturisers			X	
Shaving creams				X
Skin lotions		X	X	X
Soaps		X	X	X
Tooth pastes, mouthwashes			X	X
Metals Working				
Electro polishing			X	X
Brazing and soldering fluxes			X	X
Brightener in electroplating	X			
Lubricants	X	X	X	X
Paper & Film				
Adhesive plasticisers	X	X	X	X
Antistatic agent	X			
Cellophane plasticisers		X	X	
Coating of box board				X
Lubricants				X
Softeners	X	X	X	
Paints & Latex				
Dispersant in water based coatings	X			X
Humectant, dye carrier		X		
Pharmaceuticals				
Capsule and pill binders		X	X	X
Emulsion stabilizer in lubricants and veterinary products			X	
Liquid preparations		X	X	
Pathology specimens preservation			X	

CHEMISTRY OF PPG

Industry and Application	PEG 200	PEG 300	PEG 400	PEG 600
Suppository bases			X	X
Viscosity modifier in preparations and ointments		X		
Plastics				
Mould release agents	X			
Plasticisers				
Screen print viscosity control	X	X	X	
Printing & Inks				
Ball point pen inks			X	
Base for stamp pad inks	X	X		
Fluidised-bed dyeing of fabrics				X
Humectant for steam-set inks	X	X		
Softener in fibre-dye formulations				X
Rubber Processing Aids				
Heat transfer agents – latex		X	X	
Mould release agents		X	X	
Textiles Treatment				
Antistatic agents			X	
Emulsifiers			X	X
Finishing aids		X	X	X
Latex coatings				X
Spinning lubricant component		X		X

Physical and Chemical Properties

Product Name	Colour Pt-Co max	Acidity Acetic Acid %w/w, max	pH ¹	Molecular Weight	Pour Point °C	Viscosity cP @ 25°C	Flash Point PMCC, °C	Specific Gravity @ 25°C
PPG 500	100	0.05	4.5-8.0	480-510	-30	102	> 166	1.01

1. (10g in 60ml of 10:1 MeOH:H₂O)

PPG 500 is readily soluble in water, glycol ethers, simple esters, alcohols and most aromatics. It has limited solubility in mineral oils and is partially soluble in kerosene and white spirit.

SAFETY IN USE

Handling and Storage

Polyglycols are anhydrous and as such they are not corrosive to most common metals. In the case of copper and copper alloys some slight discolouration may occur if PEGs are stored in contact for prolonged periods.

Aqueous solutions of polyglycols are mildly corrosive towards ferrous metals and should be stored and handled in aluminium, stainless steel, plastic or resin lined equipment. Resin linings must be absolutely free of pinholes and other defects. Most synthetic elastomers, including nitrile, silicone, Viton™ brand elastomer, butyl and Neoprene™ elastomer are suitable for gaskets and seals.

Removal of solid or paste-like PEGs from drums will require the use of heat. Note that high skin temperatures will cause deterioration of the product. It is strongly recommended that skin temperatures in excess of 80°C be avoided. The use of warm water or controlled electrical heating is to be preferred.

Note also that repeated re-melting of high molecular weight PEGs can result in some stratification; therefore, the melt should be well mixed before use.

Polyethylene, polypropylene, polystyrene, PTFE and melamine are resistant to PEGs even at elevated temperatures. Polyamide and phenol-formaldehyde resins are marginally resistant to PEGs and their use at elevated temperatures is not recommended. Polyvinyl chloride (PVC) is not recommended due to rapid plasticiser leaching.

PEGs and PPGs are susceptible to oxidative degradation. Storage at high temperatures in the presence of air should be avoided. If products must be stored as a melt, then nitrogen padding is strongly recommended. Contact with iron oxides will catalyse oxidative degradation, particularly at elevated temperatures, hence stainless steel is the preferred material of construction for bulk storage tanks used to hold PEGs at higher temperatures.

Safety Data Sheets

Comprehensive (SDS) are available on request from the Indorama Ventures sales offices and provide further health and safety information on the individual polyglycol products.

CHEMISTRY AND RANGE OF ALKOXY-POLYETHERS

Alkoxy-polyethers are produced by reacting either propylene oxide, ethylene oxide or a mixture of ethylene oxide and propylene oxide with a low molecular weight alcohol. Indorama Ventures Oxides Australia uses the UNIMAX® functional fluid brand name for its range of polyalkylene glycols.

UNIMAX® Functional Fluid Range

The WL-660, WL-2100 and WL-5000 products are random ethylene oxide / propylene oxide copolymers based on butanol. The UNIMAX® functional fluids are distinguished by a number which relates to the Saybolt viscosity of the product.

Physical and Chemical Properties

UNIMAX® Surfactant	Functional Fluid Composition	Water % w/w	Colour Pt-Co max	pH 10% Solution	Viscosity cS @ 38°C	Viscosity Index	Pour Point °C	Specific Gravity @ 20°C	Flash Point °C	Fire Point °C
WL-660	Butanol EO:PO copolymer to MW approximately 2200	< 0.3	100	5.0-8.0	135-175	230	-34	1.051	246 (cc)	285 (oc)
WL-2100	Butanol EO:PO copolymer to MW approximately 4100	< 0.3	50	5.0-8.0	420-500 ¹	-	< -42	1.060	257 (oc)	-
WL-5000	Butanol EO:PO copolymer to MW approximately 8500	< 0.3	100	4.5-7.5	1000-1300	280	-28	1.063	180 (cc)	282 (oc)

1. Measured at 40°C

(cc) - Pensky-Martens closed cup (oc) - Cleveland open cup

Solubility Characteristics of some UNIMAX® Functional Fluids

Solvent	Solubility	Solvent	Solubility	Solvent	Solubility	Solvent	Solubility	Solvent	Solubility
Alcohols	s	Diethylene glycol	s	Glycol ethers	s	Palm oil	s	Propylene glycol	s
Benzene	s	Esters	s	Kerosene	i	Peanut oil	i	Rapeseed oil	i
Butyl methacrylate polymer	ps	Ethylene glycol	i	Ketones	s	Pine oil	s	Tall oil	s
Castor oil	s	Gasoline	ps	Lanolin	i	PEG 400	s	Toluene	s
Chlorinated solvents	s	Gum rosin	s	Mineral oil	i	PEG 4000	i	Triethanolamine	i
Coconut oil	s	Glycerol	i	Morpholine	s	Polystyrene	ps	Water	s

The compatibility of UNIMAX® WL-660 and UNIMAX® WL-5000 fluids with various common solvents is shown in the above table. Aqueous solutions of these products can show an inverse temperature-solubility relationship like that shown by most nonionic surfactants.

APPLICATIONS GUIDE

SAFETY IN USE

Industry and Application	UNIMAX® WL-660 Fluid	UNIMAX® WL-2100 Fluid	UNIMAX® WL-5000 Fluid
Ceramics			
Lubricant		X	X
Electronics			
Solder reflow baths - printed circuit board manufacture	X	X	X
Gas Production			
Defoamer			X
General Industrial			
Power transfer fluids	X	X	X
Metal Working			
Coolant	X	X	X
Lubricant	X	X	X
Plastics			
Mill and calender lubricant	X	X	
Extruder heating fluid	X	X	X
Vacuum forming processes	X	X	X
Paper			
Lubricant	X		
Rubber / Elastomers			
Assembly lubricant	X	X	X
Textile Processing			
Spin finishes	X	X	X
Lubricant / Antistatic	X	X	X
Wire Drawing			
Lubricant	X	X	

Handling, Storage and Safety in Use

The UNIMAX® functional fluids are not classified as dangerous goods for storage and transport. It is recommended that they are stored away from strong oxidising agents.

Comprehensive health, handling and safety information is provided in Indorama safety data sheets, available from the Indorama sales offices.



About Indorama

Indorama Ventures is a world-class chemical company and a global integrated leader in PET and fibers serving major customers in diversified end-use markets. Following our core strategies, we develop innovative products for customer needs and to make great products for society. Headquartered in Bangkok, Thailand, Indorama Ventures has operating sites in 31 countries on five continents – in Africa, Americas, Asia, Europe & Eurasia.

Integrated Oxides & Derivatives

Indorama Ventures Oxides & Derivatives is a leading chemical intermediates and surfactants producer with a diverse range of products in growth markets such as home & personal care, agrochemicals, oilfield technologies, fuel & lube additives and more. In January 2020, Indorama Ventures Public Company Limited completed its acquisition of Huntsman's world-class integrated oxides and derivatives business, including:

- **Surfactants:** Integrated producer of a wide range of products for home and personal care, oilfield technologies, agriculture and process industries.
- **Ethylene and Derivatives:** Highly integrated manufacturer of ethylene, ethylene oxide, ethylene glycol, ethanolamines and other derivatives.
- **Propylene Oxide & Derivatives:** Highly competitive technology offerings in propylene glycol, methyl tertiary butyl ether (MTBE) and other derivatives.

Our operating sites include a large flagship site on the US Gulf Coast (USGC) at Port Neches, as well as Chocolate Bayou, Dayton and Clear Lake in Texas, Lake Charles, Louisiana, Ankleshwar, India and Botany, Australia.

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