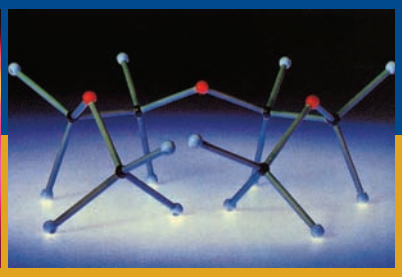
High Performance Solvents

- **Proglyme –** Dipropylene glycol dimethylether
- **Glymes –** Glycol diethers based on ethylene oxide
- **Acetals** including 1,3-Dioxolane
- **Aprotic ethers** including 1,4-Dioxane

NOVOLYTE technologies

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For contact information go to www.novolyte.com

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Novolyte High Performance Solvents

Novolyte Technolgies continues to focus on the development of high performance aprotic solvents:

- Glycol diethers (glymes) – having a wide range of solubilities and boiling points
- New Proglyme and Higlyme solvents offer formulators excellent tox profiles and high solvency
- Acetals – Including 1,3-Dioxolane – the subject of the Novolyte Acetals Brochure
- 1,4-Dioxane – for use in closed-loop applications – such as vented reactors for the manufacture of API's and fine chemicals

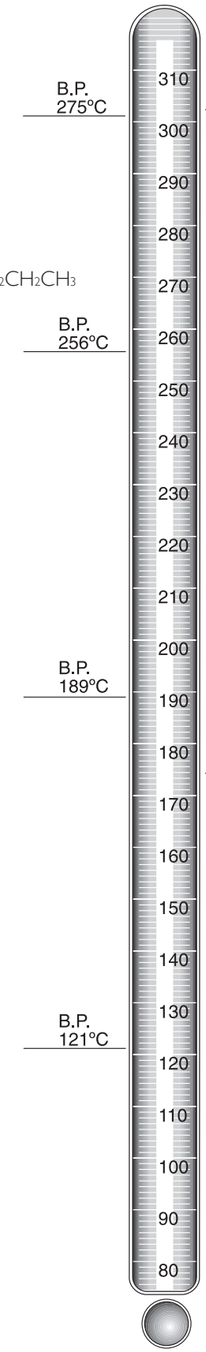
The Novolyte family of glymes continues to grow as researchers throughout the world find new commercial uses for glycol diethers. Applications embracing a very wide variety of industrial processes and products are outlined here together with a summary of the properties of these interesting and useful chemicals.

Glymes are saturated polyethers with no other functional groups; hence, they are aprotic polar compounds which are relatively inert chemically. These features account for their excellent solvent properties. For example, most glymes are completely miscible with both water and hydrocarbon solvents. Like other oxygen containing solvents, they tend to solvate cations. This leaves anions active, so that for reactions involving basic reagents, the use of glymes as solvents and reaction media can greatly enhance reaction rates.

This all-ether structure produces only weak associations between glyme molecules and is responsible for the low viscosity and excellent wetting properties of these materials, an important plus in many applications.

A further structural feature of the glymes which contributes significantly to their usefulness involves the arrangement of oxygen atoms, as ether linkages, at small and regular intervals. The model of the diglyme molecule, pictured on the cover, illustrates this periodic recurrence of oxygen atoms separated by two carbon atoms. This stearic arrangement, analogous to that of interesting but expensive crown ethers, gives glymes the ability to form complexes with many cations.

The Glymes Family



Polyglyme
CH_3-O-(CH_2CH_2-O)$_n$-CH_3
Poly(ethylene glycol) dimethyl ether
[24991-55-7]

B.P. 275°C

Butyl Diglyme
$CH_3CH_2CH_2CH_2$-O-(CH_2CH_2-O)$_2$-$CH_2CH_2CH_2CH_3$
Diethylene glycol dibutyl ether
Bis(2-butoxyethyl) ether
Dibutoxydiethylene glycol
Dibutyl Carbitol*
5,8,11-trioxapentadecane
[112-73-2]

B.P. 256°C

Ethyl Diglyme
CH_3CH_2-O-(CH_2CH_2-O)$_2$-CH_2CH_3
Diethylene glycol diethyl ether
Bis(2-ethoxyethyl) ether
Diethoxydiethylene glycol
Diethyl Carbitol*
Ethane, 1, 1'-oxybis[2-ethoxy-
3,6,9-trioxaundecane
[112-36-7]

B.P. 189°C

Ethyl Glyme
CH_3CH_2-O-CH_2CH_2-O-CH_2CH_3
Ethylene glycol diethyl ether
1,2-Diethoxyethane
Diethoxyethylene glycol
Diethyl Cellosolve*
Ethane, 1,2-diethoxy
3,6-dioxaoctane
[629-14-1]

B.P. 121°C

Common Name
Structure
Synonyms
IUPAC Name
Chemical Abstract Service Registry Number (CAS)

*Trademark of Union Carbide Chem. Co.

B.P. >300°C

New! Higlyme
Highly ethoxylated diether of a High
modecular weight alcohol

B.P. 275°C

Tetraglyme
CH_3-O-(CH_2CH_2-O)$_4$-CH_3
Tetraethylene glycol dimethyl ether
Bis[2-(2-methoxyethoxy) ethyl] ether
Dimethoxytetraethylene glycol
2,5,8,11,14-pentaoxapentadecane
[143-24-8]

B.P. 216°C

Triglyme
CH_3-O-(CH_2CH_2-O)$_3$-CH_3
Triethylene glycol dimethyl ether
1,2-Bis(2-methoxyethoxy) ethane
Dimethoxytriethylene glycol
2,5,8,11-tetraoxadodecane
[112-49-2]

B.P. 175°C

New! Proglyme
CH_3-O-(CH_2CHCH_3-O)$_2$-CH_3
Dipropylene glycol dimethyl ether
[111109-77-4]

B.P. 162°C

Diglyme
CH_3-O-(CH_2CH_2-O)$_2$-CH_3
Diethylene glycol dimethyl ether
Bis(2-methoxyethyl) ether
Dimethoxydiethylene glycol
Dimethyl Carbitol*
Ethane, 1, 1'-oxybis[2-methoxy-
2,5,8-trioxanonane
[111-96-6]

B.P. 85.2°C

Monoglyme
CH_3-O-CH_2CH_2-O-CH_3
Ethylene glycol dimethyl ether
1,2-Dimethoxyethane
Dimethoxyethylene glycol
DME
Ethane, 1,2-dimethoxy-
2,5-Dioxahexane
[110-71-4]

Applications

Widest Range of Reaction Type and Conditions of any Solvent Class:

For Pharma and Fine Synthesis

Due to high stability and solvency, glymes are widely used as reaction media for processes involving alkali metal hydroxides, sodium hydride, and alkali metals. Grignard reaction yields can be increased, and purification costs reduced by using glymes as reaction solvents. Please request of the Novolyte Glymes and Grignards brochure for details of how higher boiling points and water solubility – or insolubility – can improve yields and reduce purification costs.

Sodium borohydride at high temperature can be substituted for lithium aluminum hydride in some reductions – saving money and increasing safety. Reactions of alkali metal aluminum hydrides are likewise carried out in glymes. Sodium aluminum hydride can be prepared directly from the elements in diglyme.

Diglyme was the solvent of choice when preparing aryl sulfides via use of sodium tetrafluoroborate as a catalyst. Diglyme is also a key to the synthesis of the anti-aids drug, Nevirapine.

Preparation of urethanes, hydrogenations, condensations, oxidations, olefin insertion, oligomerization of olefins, and addition reactions can be carried out in glyme as reaction medium. Many other types of reactions can be carried out using glymes as the reaction solvent.

Glymes are also useful as solubilizing agents, extractants, and selective solvents.

Poly (ethylene glycol) dimethyl ether (polyglyme) was about 25% as active as a crown ether when serving as a solvent for a tri-n-butyl tin/sodium borohydride reduction of an alkali halide.

Methoxyacetaldehyde dimethylacetal can be prepared by electrochemical oxidation in monoglyme. Aspartame was prepared by enzymatic catalysis in triglyme-water medium.was prepared by enzymatic catalysis in triglyme-water medium.

Cleaning Applications

Glymes have applications in fabric cleaning compounds, such as a dry powder carpet cleaner, in all purpose liquid detergent compositions, in noncaustic alkaline, waterbased oven cleaners, and in bathroom mildew removers.

Glymes are useful in liquid stain removers for contact lenses, in compositions for wall paper removal, in cleaners for rubber based marking on tire sidewalls, and in cleansers for removal of biological materials from laboratory diagnostic equipment.

Semipermeable membranes used in water purification are regenerated by washing with glyme. Fouled anion exchange resins are cleaned using glymes.

Glymes are useful as priming agents for removal of surface water from parts and in compositions for removal of rust-inhibiting oil coatings. Glymes are also useful in compositions used in cleaning felts for papermaking.

Graphics Arts – Ink Solvents

Glymes are useful in a variety of ink formulations, including ink-jet inks that are stable and do not clog tiny orifices. Also, high-end writing inks with low viscosity and good stability, conductive inks and pastes, and magnetic inks.

Aqueous coating compositions useful in coating substrates immediately after printing with oil-based inks contain glymes. These coatings accelerate bonding and drying of the ink which permits faster printing. Other applications of glymes in printing include uses in formulations of deletion fluids for positive printing plates; retouching agents for lithographic printing, waterless lithographic plates, and in cleaning agents for removing inks from printing machines.

Glymes are useful in correction fluids and re-touching liquids for toner images, in photosensitive coating solutions in diazo processes, in alkaline processing solutions in diffusion transfer photography, and for desensitizing compositions for pressure sensitive copying paper. And as white-board cleaners without a harsh smell.

Applications

Absorption Refrigeration, Heat Pumps

Glymes are useful as the solvent in design of sorption heat pumps and in absorption refrigeration units. Heat pumps using R-134, methyl amine or trifluoroethanol with various glymes have been patented. For example, tetraglyme is used to both clean refrigeration systems before recharging, as well as to lubricate the compressor to extend unit life and reduce energy consumption.

Refrigeration absorption fluids using glymes as solvent in various compositions are well known. Glymes are useful in working fluids for solar absorption refrigeration units.

Gold Refining

Butyl diglyme is a selective solvent for the extraction of gold from hydrochloric acid solutions containing other metals. Treatment of the extract with hydrogen or oxalic acid reduces the trivalent gold to gold powder. One variation of the process has been demonstrated in large scale continuous operation to recover 99% of the gold at 99.99% purity.

Scrap metal containing gold is treated with aqua regia, extracted with butyl diglyme and the pure gold released from the glyme with potassium oxalate.

Adhesives And Coatings

The glymes are powerful solvents for many polymer systems and find a role in many coating applications, including one and two-part polyurethanes and epoxies. Adhesive compositions bases on alpha-cyano-acrylates show decreased setting times when glymes are incorporated into the formulation.

Diglyme is used in a formulation for improving the bonding of tire cord to rubber.

Polyamic acids, which are heated to form polyimide adhesives, are prepared with improved adhesive properties by polymerizing the monomers in diglyme solvent to yield the adhesive solution.

Glymes are useful in formulating adhesives for cigarette filter fibers and the covering tape.

Textiles

Polyester fibers with improved moisture retain are manufactured by incorporating 7-15% of a polyglyme into the poly(ethylene terephthalate), melt spinning the fibers, followed by washing to remove the polyglyme.

Synthetic fibers for sportswear having a high drying rate are made from a composition of poly (ethylene terephthalate), 10% polyglyme and ethylene glycol-polyethylene glycol -terephthalic acid copolymer which is melt spun. The polyglyme is then extracted to produce the multiporous hydroscopic fibers.

Polyglymes are incorporated into dispersions of monoazo and diazo dyes used to dye polyester-cotton textiles to give gold color strength and light fastness on both constituents of the textile blend. Polyglymes are also useful in discharge printing of these textile blends.

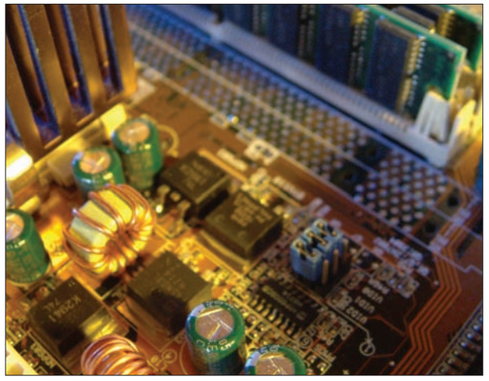
The dyeability of polyolefins with a water soluble dyestuff is improved if a glyme is added to the dyebath. The treatment of dyed fabrics, e.g. nylon, polyester, or blends of polyester with cotton, wool, and acetate, with monoglyme increases the colorfastness of the fabrics.

Tetraglyme has been used as an inert additive for the fixation of methylated methylolmelamine resins in durable-press cotton and cellulosic fabrics. The abrasion resistance, wrinkle resistance, and tear strength of the fabric were improved. In a modification to the double-cure process for durable-press cotton fabrics, tetraglyme was used as a nonreactive additive to improve process control.

Electronics

The production of uniform thin film coatings is a process repeated several times in the manufacture of even elementary semi-conductor circuits. A simple technique for accomplishing this involves deposition of viscous fluid on a rotating disk. For instance, photoresist, a photo sensitive polymer, and polyimide, a polymeric film used as an interlevel and overcoat insulator, are dispensed in solution onto a substrate wafer.

Glymes are useful as solvents for both photoresists and polyimides. In addition, glymes are useful in developers, after exposure of the photosensitive polymers.



Glymes can perform other functions in electronic component manufacture. Diglyme is used in a conducting thermoplastic paste. Glymes are used in cleaning of wafers due to their excellent ability to complex metals. Monoglyme and diglyme are only to be used in closed-loop applications with excellent engineering controls.

Glymes are used in paste-like electrolytes for mass producing conductive circuit substrates and multilayer printed-circuit boards. Butyl diglyme is used in compositions for production of printed circuits and diode fabrication. Glymes are useful in preparing electrochromic display devices, as solvents for cleaning polar and nonpolar material from screening masks used in deposition of circuit patterns, and in the preparation of various types of capacitors and sintered film resistors.

Also, glymes are used in converting fluid impermeable flexible materials to fluid permeable materials for electronic applications, by extracting lithium salts from materials made by blending these salts with polyethylene under pressure.

Environmental Applications

Tetraglyme is a useful extractant for determining volatile organic compounds in solid wastes.

A suspension of sodium and naphthalene in diglyme is useful in ambient temperature treatment of transformer oil for destruction of polychlorinated biphenyls (PCB' S). A similar system is used for detection of PCB impurities in transformer oil.

Use of the higher molecular weight glymes is well known in gas purification (see previous section). Glymes are used in the scrubbing of effluent gases such as chlorinated hydrocarbons from coating operations, waste gases from metal refining operations, tail gases from sulfuric manufacture, and flue gases.

Pharmaceutical Formulations

Glymes are useful in various pharmaceutical formulations where they can serve not only as a drug carrier but also function as a stabilizer for the drug. Considering reproductive toxicity potential of lower molecular weight glymes in rats and mice, pharmaceutical applications should be limited to the higher molecular weight glymes.

Glymes high solvency can be used to dissolve drugs prior to crystallization to control particle size for – including as a co-solvent with carbon dioxide for generation of small particles for delivery by inhalation.

Applications

Gas Purification – 235 and 275 Mol. Wt. Polyglyme

The solvating ability of glymes for the acidic gases, polar and non-polar compounds, together with their chemical stability and their availability at low cost in a wide range of boiling points permits the higher molecular weight glymes to be used in a wide variety of processes for gas purification. These systems work very simply by countercurrent flowing the gases and the glymes at ambient conditions.

The very high absorptive power of the glymes for many gases allows for long operation before the glymes have to be regenerated by heating (or applying vacuum). The glyme is heated to high temperature and the absorbed gases boiled off. Since the glymes are chemically inert, many cycles are achieved. Some examples follow.

Acidic gases, such as carbon dioxide and hydrogen sulfide, can be removed from natural gas or ammonia synthesis gas feed stocks by pressure scrubbing with a mixture of glymes and diisopropanolamine. The solvent can be recycled after evaporation of the absorbed gases.

Hydrogen sulfide can be removed from varying feed gases by absorption in a solvent containing a glyme. Reaction with sulfur dioxide then yields water and sulfur. Sulfur has a very high solubility in the glymes. By adjusting solvent composition and conditions, the process can be made applicable to natural gas, synthesis gas, or tail gas from a Claus plant.

Hydrogen can be recovered from the effluent gases of hydrogenation and hydrocracking facilities by scrubbing the gas with a mixture of glymes and isopropanolamine. Light hydrocarbons, carbon dioxide, hydrogen sulfide, mercaptan, and water are removed from the effluent gas and the purified hydrogen is recycled. The absorbed contaminants are removed from the solvent by flash evaporation and refrigeration. The organic amine salts can be decomposed to acidic gases and amine by heating the solvent after flash evaporation. The solvent can then be recycled.

Natural gas can be treated to remove ethane and heavier hydrocarbons, to remove water, or to remove the acidic gases (H_2S, CO_2, COS, RSH, CS_2). Glymes should be efficient at removing carbon dioxide, hydrogen sulfide and water from gas generated by anaerobic digestion of refuse or sewerage to yield purified methane.

Water, methanol, and formic acid can be removed from formaldehyde vapor.

Glymes for Polymerization and Polymer Modification

Catalysts of the Ziegler-Natta type for the polymerization of alpha-olefins are advantageously prepared as a slurry incorporating glymes. Glymes are additionally useful in removal of unreacted monomer in this type of polymerization. When diglyme is used to modify the Ti-Al catalyzed preparation of a block ethylene-propylene copolymer, the physical properties are greatly improved.

Conjugated dienes are converted to polymers, rubbers, copolymers, block polymers, etc., using lithium or its compounds in mixtures with glymes as catalysts.

Poly (ethylene terephthalate)and its copolymers with improved properties are produced by incorporating glymes into the finished product.

Glymes are useful in formulation of rigid polyurethane foams with improved fluidity during molding and with improved bonding strength. The viscosity of polyols useful in the manufacture of polyurethanes can be reduced with glymes without adversely affecting physical properties.

Polyurethane coatings used to form pinhole-free films with good adhesive strength, applicable to electrical and electronic parts, utilize glymes. Isocyanates are processed and formulated using glymes to yield isocyanurate and polyisocyanate prepolymers used in various polyurethane applications. Glymes are also useful in formulation of storage stable vulcanizing agents for urethane rubber.

Catalyst solutions for other types of polymerization advantageously use glymes. Monomers polymerized in the presence of glymes include cyclosiloxanes, conjugated alkadiene, lactams, dicyclopentadiene, vinyl chloride, fluorinated acrylic esters and 1-octene.

Batteries

Novolyte produces all of the major glyme, carbonate, and acetal solvents used in lithium ion batteries. Novolyte also produces the major lithium salts and finished electrolytes to battery manufacturers worldwide. Furthermore, recent improvements in cell fabrication capabilities, positive electrode technology, and organic electrolytes have made rechargeable lithium cells an integral part of our lives.

Nonaqueous batteries generally use mixed organic solvents. For example, solutions containing propylene carbonate and monoglyme have been employed to obtain good cell performance. Propylene carbonate with a high dielectric constant serves to lower the ionic dissociation energy. Monoglyme with low viscosity lowers the resistance for ion transport in the solution. In addition, monoglyme, much like a crown ether, gives improved ionic mobility to captured cations. A few of the very many recent references outline the application of these principles.

Solid poly (ethylene oxide) membrane electrolytes are poor conductors at ambient temperatures. Addition of poly (ethylene glycol) dimethyl ether plasticizes the polymer thus allowing much greater lithium ion conduction at practical temperature levels.

Miscellaneous

Glymes are useful in many other different formulations and applications. The following summarizes many of these.

- In formulations for cutting oils for machining nonferrous metals
- As lubricants for gas compressors used in extended operations involving H2O or CO2
- In lubricant formulations for cold drawing or cold rolling of metals
- In formulations for manufacture of electric insulation coatings
- In solutions for electroplating aluminum
- In brazing or soldering pastes
- As frothing agents in antimony or potassium ore flotation
- In preparation of hollow microspheres by spray drying
- As extractive distillation agents
- In low temperature heat storage systems
- In mosquito repellant compositions
- As an impregnant for activated carbon for adsorption of salt from water
- As sedimentation agents for removal of silica from water
- As agents for preventing shrinkage of cement on drying
- In an analytical reagent for determining trace organic chloride in petroleum fractions
- In preparation of powdered pigments
- As solvent in odor-attractive formulations
- As a plasticizer in a dental prostheses
- Compounded in releasing agent for molded rubber

Physical and Thermodynamic Properties

	Empirical Formula	Molecular Weight	Boiling Point °C 760mm Hg	Freezing Point °C	Specific Gravity 20°C	Weight per Gallon lb 20°C	Vapor Pressure mm Hg/20°C	Volatility n-Butylacetate =100	Viscosity cp. 20°C	Surface Tension dynes/cm. 20 °C	Specific Heat cal/gm/ °C	Auto Ignition temp °C	Heat of Vaporization K cal/mole	Heat of Combustion K cal/mole	Heat of Formation K cal/mole	Flash Point °C, closed cup	Refractive Index nD at 20°C	Appearance	Odor	Solubility at 25°C In Water	Water In	Organics
Monoglyme	$C_4H_{10}O_2$	90.12	85.2	-69.0	0.8683	7.24	54	499	1.1	22.9	0.438	184	6.7	602	118	-6	1.3792	Clear Colorless	Ethereal Non-Residual	Complete	Complete	
Ethyl glyme	$C_6H_{14}O_2$	118.18	121	-74.0	0.8417	7.00	9	105	0.7							27	1.3922	Clear Colorless	Mild Ethereal Non-Residual	20.4%	3.3%	All Glymes are Miscible in all Pro-Portions in Ethanol, Acetone, Benzene, Diethyl, Ether and Octane
Diglyme	$C_6H_{14}O_3$	134.17	162	-64.0	0.9451	7.88	2	36	2.0	27.0	0.403	182	10.0	902	143	57	1.4078	Clear Colorless	Mild Ethereal Non-Residual	Complete	Complete	
Ethyl Diglyme	$C_8H_{18}O_3$	162.23	189	-44.3	0.9082	7.56	0.5	4	1.4	27.2			10.5	1199	152	90	1.4115	Clear Colorless	Mild Non-Residual	Complete	Complete	
Triglyme	$C_8H_{18}O_4$	178.22	216	-45.0	0.9862	8.23	0.02	<0.1	3.8	29.4	0.424	195	14.3	1191	179	111	1.4224	Clear Colorless	Mild Non-Residual	Complete	Complete	
Butyl Diglyme	$C_{12}H_{26}O_3$	218.34	256	-60.2	0.8814	7.36	<0.01	<0.1	2.4	27.0	0.495	190	12.0	1823	175	118	1.4235	Clear Colorless	Very Mild Non-Residual	0.3%	1.4%	
Tetraglyme	$C_{10}H_{22}O_5$	222.28	275	-29.7	1.0132	8.45	<0.01	<0.1	4.1	33.8	0.427	215	18.7	1480	217	141	1.4330	Clear Colorless	Very Mild Non-Residual	Complete	Complete	
Polyglyme*	$C_nH_{2n+2}O_{n/2}$	275	275	-23	1.04	8.6	<0.01	<0.1	12			215				>130		Clear Slightly Yellow	Very Mild Non-Residual	Complete	Complete	
Proglyme	$C_8H_{18}O_3$	162.23	175	-71	0.900	750	0.55	13	1.1	37.0	0.42	156	257J/g	29kJ/mole		65	1.408	Clear Colorless	Very Mild Non-Residual	35	4.5	
Higlyme	$C_nH_{n+2}O_x$	>400	>300	-5–10	0.975	8.12	0.1	<0.1	34							140		Clear Slightly Yellow	Very Mild Non-Residual	Complete	Complete	

*Mixture of high molecular weight glymes. 235 MW polyglyme is also available.

General Handling

Since glymes are powerful solvents for many polymers, selecting materials which can contact glymes in a process can be difficult. Teflon is highly resistant, and substances such as butyl rubber, polyethylene and polypropylene can be used in many applications. Resistance to glymes is improved when molecular weight is high or there is a high degree of crosslinking or crystallinity. Specific applications should be tested for polymer swell, softening, degradation and permeability.

Carbon steel can be used for storing and handling pure glymes. We recommend storage in an inert atmosphere such as nitrogen to assure product purity for a prolonged period. In this way, both oxygen and atmospheric moisture can be avoided.

Glymes are biodegradable in acclimated waste biotreatment units. However, it appears that biodegradation is slow and conversion may be low in normal sewerage systems.

Further details on health, safety, personal protective equipment and general handling requirements can be found in our MSDS for the particular glyme you are using.

Recovery And Recycle

Each application of glycol diethers may produce unique problems with recovery and recycle processes. In general, the lower molecular weight glymes are recovered most efficiently by distillation. Water azeotrope, however, may complicate the process. Contact with sodium hydroxide is effective in removing gross amounts of water. Trace amounts can be effectively removed by molecular sieves to a very low level.

Novolyte can provide technical information to help customers develop a safe and cost-effective recycle program. In some cases, Novolyte can also provide final "back-to-spec" purification services at the Baton Rouge plant location if needed. Please contact a service representative if you need this type of service.

Specifications

	Purity (by G.C.), wt% Min	Purity (by G.C.), wt% Typical	Acidity (as acetic acid) ppm Max	Acidity (as acetic acid) ppm Typical	Water Content ppm Max	Water Content ppm Typical	Peroxide Content ppm Max	Peroxide Content ppm Typical
Monoglyme	99.90	99.97	150	25	350	175	15	5
Ethyl Glyme	97.0	98.5	150	25	1000	300	15	5
Diglyme	99.90	99.94	150	25	250	150	15	5
Ethyl Diglyme	98.0	99.0	150	25	2000	500	15	5
Triglyme	98.0	99.0	150	25	500	100	15	5
Butyl Diglyme	98.5	99.0	100	25	500	250	15	5
Tetraglyme	98.0	99.0	150	25	500	100	15	5
Proglyme	99.2	99.5	100	25	200	100	15	5
Higlyme	97.0	98.0	150	25	2000	600	15	15

Safety

Peroxides

High-purity standards are maintained by a number of rigid manufacturing controls. The glymes are manufactured in a dry, inert environment and are packaged under nitrogen. This assures product integrity over long periods of storage. Our studies show that the peroxide concentration remains barely detectable (in the ppm range) even after storage periods as long as a year.

Peroxides in ethers can decompose to form other impurities. However, unlike ethers such as THF and ethyl ether where peroxides accumulate rapidly, glycol diether peroxides are much more labile and tend not to build to high levels. Safe decomposition of glyme peroxides can be accelerated simply by warming the glyme under nitrogen to 90°C for a brief period.

In many instances where glymes are used, air exposure cannot be avoided. In this case, peroxide concentration should be monitored and controlled. Even though this may not represent a safety-related problem (except for a flammability hazard), the peroxides could form undesirable chemical by-products in the system.

With some chemicals there is a tendency for peroxides to become isolated by phase separation which results in the formation of a zone of high peroxide concentration. This phenomenum is unlikely in glymes because of the very high solubility of peroxides and other oxygenated organic material in glymes. Peroxide formation can be effectively stopped by using a phenolic antioxidant such as BHT. At the customer's request BHT can be added to any glyme order.

To the best of our knowledge, there has never been an incident of an explosion due to peroxide buildup in glymes. We do, however, recommend that the highest standards of safety, product stewardship and responsible care be maintained when using and recycling glymes.

Toxicity

While glymes exhibit only low to moderate acute toxicity, concern regarding chronic exposure and reproductive effects indicate that glymes be used only in industrial applications.

Acute Toxic Effects

Compound LD_{50} (mg/Kg)		Compound LD_{50} (mg/Kg)	
Monoglyme	5370	Ethyl Diglyme	5000
Ethyl Glyme	4400	Butyl Diglyme	3900
Diglyme	4670	Triglyme	5000
Tetraglyme	5100	Higlyme	>4000 est

Monoglyme and diglyme have produced teratogenic and other dose related adverse reproductive effects in laboratory animals below the level of acute toxicity. Ethyl glyme is a reproductive toxicity suspect agent. A comparison of "no effect" levels for fetal and maternal exposure, shown in the table below suggests that these effects diminish as the number of EO units in the glyme increases.

Reproductive Toxicity No Effect Levels In New Zealand White Rabbits

	DIGLYME	TRIGLYME
Maternal	25 mg/kg/day	125 mg/kg/day
Fetal	50 mg/kg/day	125 mg/kg/day

Also, one finds a decrease in reproductive toxicity as the molecular weights of the end-groups increases. Butyl diglyme, for example, had no adverse effects on female fertility or embryonic development at exposures ranging from 500 to 1100 mg/kg.

Male rats exposed to 110, 370 and 1100 ppm diglyme by nose-only inhalation exhibited spermato-genic abnormalities that appeared to be dose related. At the lower levels the abnormalities reversed within 90 days of cessation of exposure, but at the highest level a profound testicular atrophy did not reverse during the same interval.

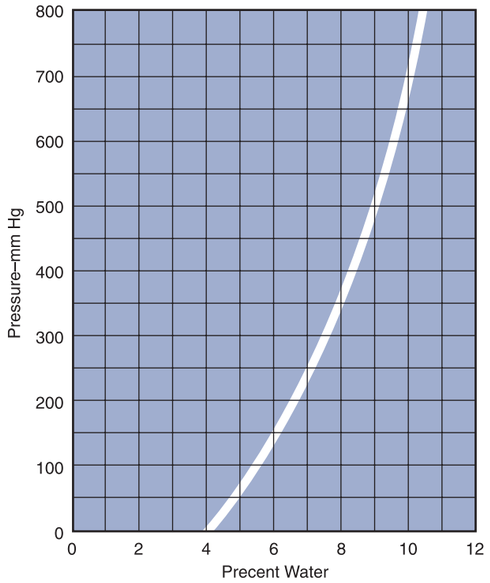
These chemicals should be used in a manner that is in keeping with good chemical hygiene practices. Adequate personal protective equipment should be employed, as well as exposure monitoring in keeping with applicable OSHA standards.

In particular, the following recommendations are made:

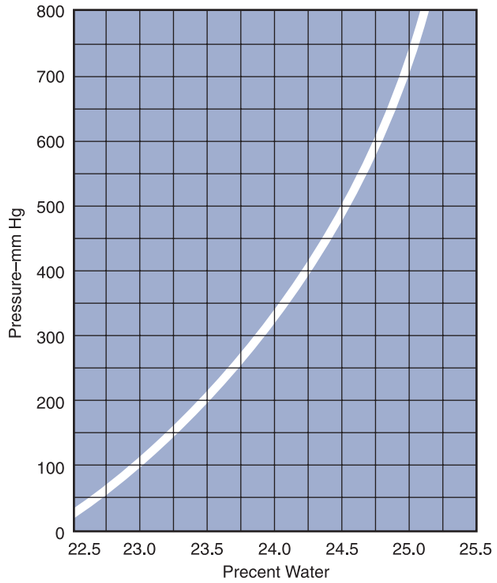
1. Avoid exposure to vapors or mists.
2. Avoid all skin contact. Contaminated clothing should be removed and skin washed immediately with soap and water.
3. For monoglyme and diglyme a TLV of 1 ppm (8 hour TWA) and an STEL of 5 ppm are recommended for women of child-bearing potential. The 15 minute STEL of 5 ppm should not be achieved more than 4 times in 8 hours. For other individuals, a 5 ppm TLV (8 hour TWA) and an STEL of 25 ppm are applicable.

Azeotropic Data

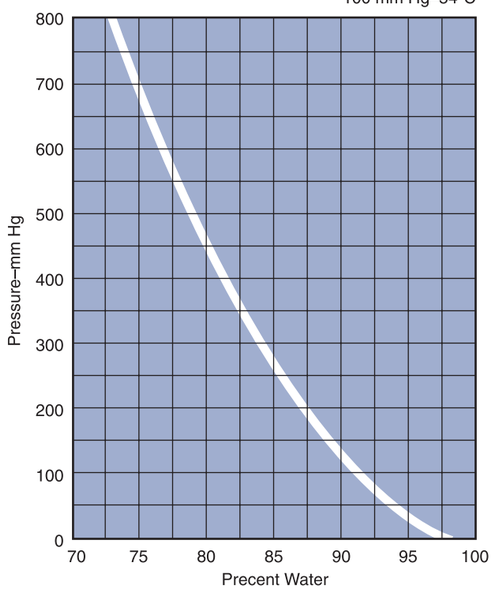
Monoglyme
Boiling point at 760 mm Hg–76°C
100 mm Hg–30°C



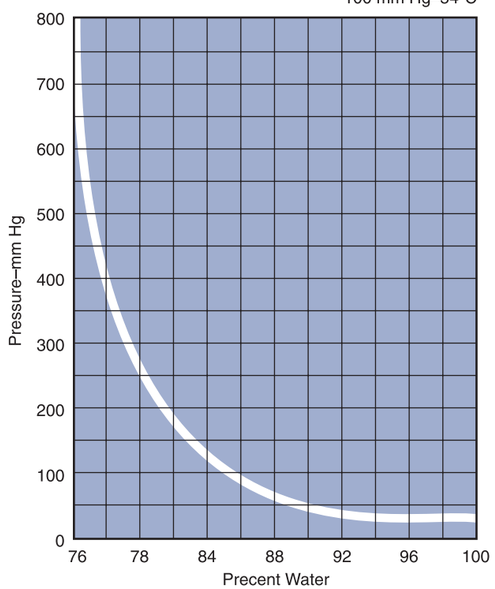
Ethyl Glyme
Boiling point at 760 mm Hg–90°C
100 mm Hg–46°C



Diglyme
Boiling point at 760 mm Hg–99.5°C
100 mm Hg–54°C

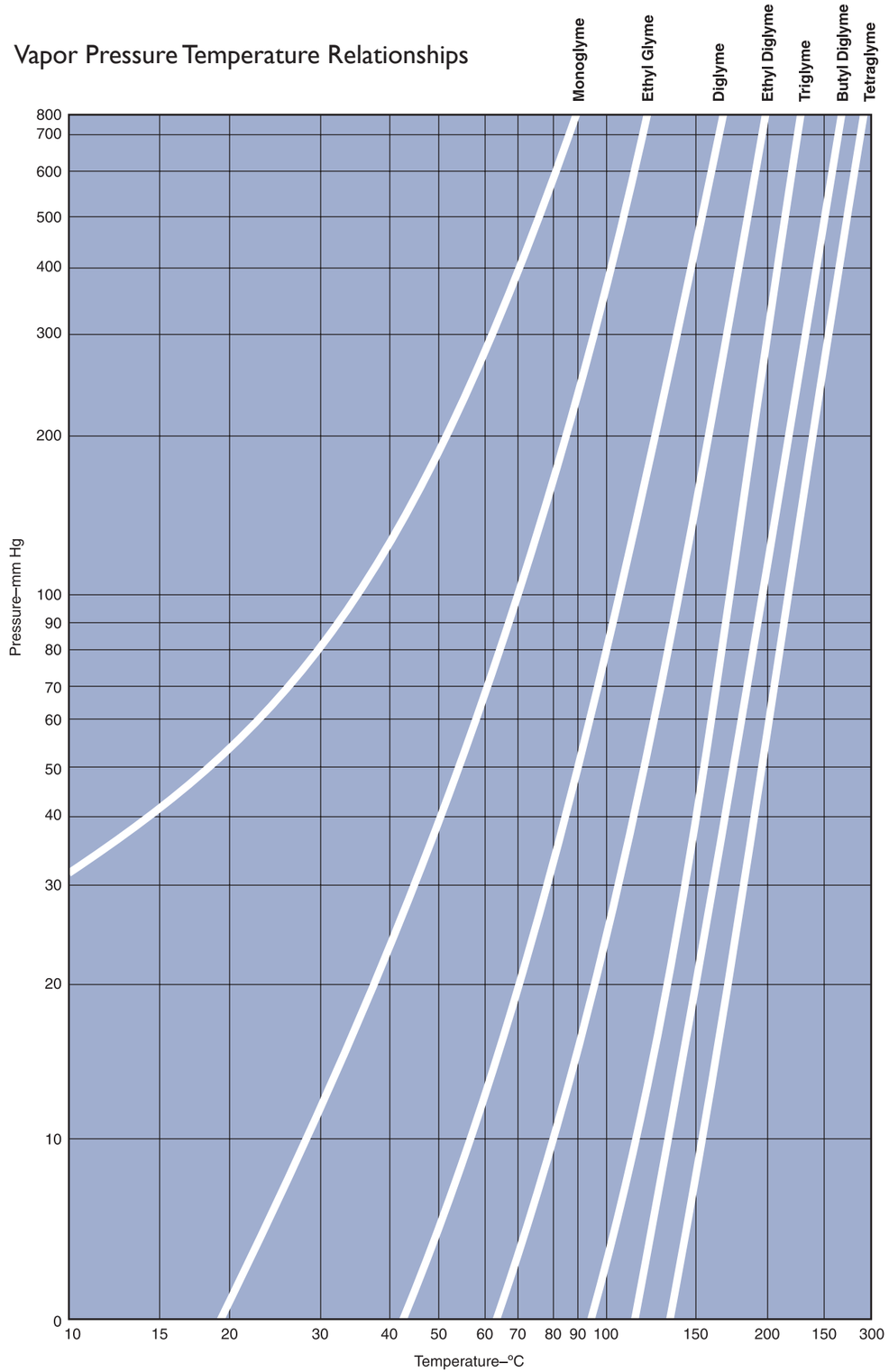


Ethyl Diglyme
Boiling point at 760 mm Hg–98°C
100 mm Hg–54°C



*Butyl Diglyme, Triglyme, and Tetralyme do not form azeotropes with water.

Vapor Pressure Temperature Relationships



Polymer Solubility*

The solubility of various plastic and elastomeric materials in glymes was determined by placing 10 grams of sample in100ml of the glyme at 21°C. The samples were examined after one week.

U–Unaffected
A–Attacked (noticeable softening; some swelling)
S–Soluble (10% or more; extreme swelling to gellation)

	Monoglyme	Ethyl Glyme	Diglyme	Ethyl Diglyme	Butyl Diglyme	Tetraglyme
Plastics						
Acrylate						
Acrylate ester	S		S			S
Polymethyl methacrylate	S		S			S
Vinyl						
Polyvinyl acetate	S		S			S
Polyvinyl chloride	A	A	A	A	U	A
Chlorinated polyvinyl chloride		A	S	A	U	
Polyvinyl chloride acetate	A	S	A	S	A	A
Polyvinyl alcohol	U	A	U	U	U	U
Polyvinylidene chloride	U	U	A	U	U	A
Cellulose						
Cellulose acetate	S		S			S
Cellulose acetate butyrate	S	A	S	A	U	S
Cellulose nitrate	S		S			S
Methyl cellulose	S	A	S	A	U	S
Condensation Polymers						
Phenol formaldehyde, cast	A		A			A
Nylon	U	U	U	U	U	U
Polyester	U	U	U	U	U	U
Polyurethane	A	A	S	A	U	S
Polycarbonate	A	U	A	A	U	A
Epoxy Resins	S	S	S	S	S	S
Polyolefins						
Polyethylene	U	U	U	U	U	U
Polystyrene	A		A			A
Polytetrafluoroethylene	U	U	U	U	U	U
Elastomers						
Neoprene	S	S	S	S	S	S
EVA	A	A	A	A	A	U
Nitrile Rubber (NBR)	S	S	S	S	A	S
Natural Rubber	S	S	A	S	S	A
EPDM	U	A	U	A	A	A
SBR	S	S	S	S	S	A

*Because of variability of polymer types and grades, user should evaluate materials for each specific application.

Novolyte Gassolve™

A One-step Acid-Gas & Moisture Removal Process for Natural Gas & Select Refinery Streams

Solubility of Gases in NOVOLYTE Polyglyme

Have high CO_2 – even >20%?

Still need to hit 4ppm max H_2S?

And keep a nice, dry 7 lb/MM scf H_2O max?

Novolyte Polyglyme is Recommended for removal of H2S… and other operating units

For removal of H_2S, CO_2, COS, and water from natural gas. For clean-up of refinery off-gas from Claus and other operating units

Operating Conditions

- Moderate to high pressure
- Ambient to 50°C
- High to low acid-gas and moisture levels
- High gas flow rates

Operating Costs

- Low energy costs relative to amine processes
- Low polyglyme cost due to chemical stability and low losses due to high boiling point
- Carbon steel for most equipment

Novolyte Polyglyme

- High Boiling
- Strong Solvency
- Excellent tox profile
- Reduce VOC's and increase safety

Physical Properties

Polyglyme Empirical Formula		$C_nH_{2n+2}O_{n/2}$
Molecular Weight		236 (275 avail)
Boiling Point	(°C 760 mm Hg)	275
Freezing Point	(°C)	-28
Specific Gravity	(20/20°C)	1.03
Vapor Pressure	(mm Hg/ 20°C)	0.01
Viscosity	(cp 20°C)	12
Auto Ignition temp	(°C)	230
Flash Point	(°C, closed cup)	135
Refractive Index	(20°C)	1.3782
Appearance	Clear, Slight yellow	
Odor	Ethereal non-residual	

Higlyme

Higlyme - New Solvent for the formulation of low-VOC performance packages!

Common Name: Methyl Ether of High Molecular Weight Highly Ethoxylated Alcohol.
A low-VOC polar aprotic diether with high solvency and low vapor pressure and low toxicity.
Allows the formulation of coatings and ag chemicals with low VOC, high solids, and high water.
Novolyte offers high activity (97.0), low peroxide (5ppm max), and low moisture (0.2% ppm max).

Physical Properties

Empirical Formula		$C_nH_{n+2}O_x$
Molecular Weight		>400
Boiling Point	(°C 760 mm Hg)	>300C
Percent Volatile Organic Compounds		6%
(0.3g in aluminum pan for 1hr at 110C in a vented oven)		
Freezing Point	(°C)	-5 to -10
Specific Gravity	(20°C)	0.975
Vapor Pressure	(mm Hg/ 25°C)	0.10
Volatility	(n-butylacetate = 100)	<0.1
Viscosity	(mPA.s 21oC)	34
Flash Point	(°C, closed cup)	140
Appearance	Clear, light yellow	
Odor		Ethereal

Solubility at 25°C

in water	Complete
water in	Complete

Low-VOC Coatings

- Urethanes and inks
- Long non-polar and long polar ends

Agro-chemical

- High-solvency
- Little vapor or odor
- Enhanced time of action of insecticides and herbicides
- Again, low-VOC

Features

- Aprotic
- High boiling, high flash
- Water soluble
- High solvency characteristics
- Powerful diluent
- Friendly tox profile
- Refer to MSDS for detailed handling and disposal information
- Use with proper PPE and engineering controls

Proglyme

Dipropylene glycol dimethyl ether (CAS: 111109-77-4)
Common Name: Proglyme, Diproglyme
A polar aprotic diether with active solvency
Proglyme is a highly polar aprotic (no hydroxyl functionality) solvent having an excellent toxicological profile. Proglyme has excellent chemical stability, and high solvency for polar coatings, organometallic reagents, agricultural formulations, and dyes.

Physical Properties

Empirical Formula		$C_8H_{18}O_3$
Molecular Weight		162.2
Boiling Point	(°C 760 mm Hg)	175
Freezing Point	(°C)	-71
Specific Gravity	(20°C)	0.90
Vapor Pressure	(mm Hg/ 20°C)	0.55
Volatility	(n-butylacetate = 100)	13
Viscosity	(cp 20°C)	1.1
Surface Tension	(dynes/cm 20°C)	27
Auto Ignition temp	(°C)	156
Heat of Vaporization	(J/gram)	257
Heat of Combustion	(kJ/g)	29
Flash Point	(°C, closed cup)	65
Refractive Index	(20°C)	1.408
Appearance	Clear, Colorless	
Odor	Mild Ethereal	

Solubility at 25°C

in water	35%
water in	4.5%

Coatings and adhesives

- Replacement for NMP
- Stabilize aqueous/organic mixtures
- Enhanced package stability

Reaction solvent

- For organomethallic reactions, including Grignard reactions
- Acting as a polycarbonate swelling agent
- Solvent vehicle for intermediate and fine chemical synthesis

Cleaner and Stripper

- For electronic cleaning
- Paint stripping – blend with 1,3-dioxolane - reformulate away from methylene chloride

Features

- Aprotic
- High boiling point
- Water soluble
- High solvency characteristics
- Stabilize agricultural formulations
- Powerful diluent
- Excellent thermal and chemical stability
- Refer to MSDS for detailed handling and disposal information
- Use with proper PPE and engineering controls

Customer Service: Customerservice@novolyte.com

NOVOLYTE technologies

What can Novolyte High Performance Aprotic Solvents Do for You?

Proglyme – A **Green** stabilizer and Coalescer for coatings.

Butyl Diglyme – Higher yields, easier start and purification of Grignards and see Novolyte US Patent 5,358,670

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