THE BASIC CHEMISTRY
OF
GLYCEROL HYDRAULIC FLUIDS

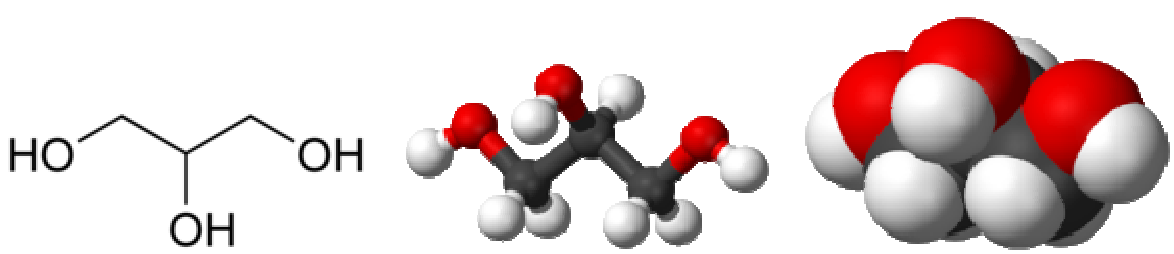
All glycerol hydraulic fluids are formulated from three basic components; glycerin glycol plus thickeners, high purity de-ionized water, and amine additives. The proportions of the basic components differ from one fluid to another and from one manufacturer to another. Each component provides separate functions, which when blended, create a fluid capable of performing as a superior hydraulic lubricant. The true difference in the fluids comes from the additive amine package. These additive packages are kept proprietary from one manufacturer to the next. This document has not been drafted to deal with the specifics of the glycerin glycol fluids that MRL Hydraulics LLC provides, but has been drafted for general information only.

Glycerin glycol hydraulic fluids are used primarily as fire-resistant fluids in general industrial applications. Glycerin glycol provides a "readily biodegradable" fluid that is considered highly eco-friendly. It has a low toxicity and is quickly degraded by micro organisms when exposed to the environment.

The following information is from Wikipedia and it is incumbent on the reader to verify the information contained herein. It is generally pertinent and correct.

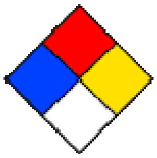
GLYCEROL

Glycerol is a chemical compound with the formula $HOCH_2CH(OH)CH_2OH$. This colorless, odorless, viscous liquid is widely used in pharmaceutical formulations. Also commonly called **glycerin** or **glycerine**, it is a sugar alcohol, and is sweet-tasting and of low toxicity. Glycerol has three hydrophilic alcoholic hydroxyl groups that are responsible for its solubility in water and its hygroscopic nature. Its surface tension is 64.00 mN/m at 20 °C, and it has a temperature coefficient of -0.0598 mN/(m K). It is a central component of lipids.



Glycerol IUPAC name Propane-1,2,3-triol Other names glycerin
glycerine
propane-1,2,3-triol
1,2,3-propanetriol
1,2,3-trihydroxypropane
glyceritol
glycyl alcohol Identifiers CAS number [56-81-5] SMILES OCC(O)CO InChl Properties
Molecular formula $C_3H_5(OH)_3$
Molar mass 92.09382 g/mol
Density 1.261 g/cm³
Melting point 18 °C (64.4°F)
Boiling point 290 °C (554°F)

Viscosity 1.5 Pa·s
Hazards MSDS External MSDS NFPA 704



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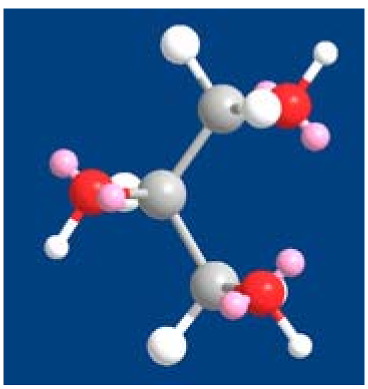
Flash point 160 °C (closed cup) Supplementary data page Structure and properties *n*, ε_r, etc. Thermodynamic data Phase behaviour Solid, liquid, gas Spectral data UV, IR, NMR, MS

Except where noted otherwise, data are given for materials in their standard state(at 25°C, 100 kPa)

Synthesis and production



Glycerol (3D model), showing the atoms and the lone electron pairs associated with the oxygen atoms (in pink)

Until recently, synthetic glycerol was mainly manufactured at an industrial scale from epichlorohydrin. Since glycerol forms the backbone of triglycerides, it is produced on saponification or transesterification. Soap-making and biodiesel production are respective examples.

Glycerol is a 10% by-product of biodiesel production (via the transesterification of vegetable oils). This has led to a glut of crude glycerol in the market, making the epichlorohydrin process no longer economical. Current levels of glycerol production are running at about 350,000 tons per annum in the USA, and 600,000 tpa in Europe. This will increase as it implements EU directive 2003/30EC which requires replacement of 5.75% of petroleum fuels with biofuel, across all Member States by 2010[1].

Applications

In foods and beverages, glycerol serves as humectant, solvent and sweetener, and may help preserve foods. It is also used as filler in commercially prepared low-fat foods (i.e., cookies), and as a thickening agent in liqueurs. Glycerol also serves as a way, along with water, to preserve certain types of leaves. Glycerol is also used as a sugar substitute. In this regard, it has approximately 27 calories per teaspoon and is 60% as sweet as sucrose. Although it has about the same food energy as table sugar, it does not raise blood sugar levels, nor does it feed the bacteria that form plaques and cause dental cavities. As a food additive, glycerol is also known as E number E422.

In organic synthesis, glycerol is used as a readily available prochiral building block.

Feedstock

It is one of the major raw materials for the manufacture of polyols for flexible foams, and to a lesser extent rigid polyurethane foams.

Glycerol is used to produce nitroglycerin, which is an essential ingredient of smokeless gunpowder and various munitions. Reliance on soap-making to supply co-product glycerine made it difficult to increase production to meet wartime demand. Hence, synthetic glycerin processes were national defense priorities in the days leading up to World War II.

Glycerol is also used to manufacture mono- and di-glycerides for use as emulsifiers, as well as polyglycerol esters going into shortenings and margarine.

Pharmaceutical and personal care applications

Glycerol is used in medical and pharmaceutical and personal care preparations, mainly as a means of improving smoothness, providing lubrication and as a humectant. It is found in cough syrups, elixirs and expectorants, toothpaste, mouthwashes, skin care products, shaving cream, hair care products, and soaps.

As a 10% solution, glycerol prevents tannins from precipitating in ethanol extracts of plants (tinctures). It is also used as a substitute for ethanol as a solvent in preparing herbal extractions. It is less extractive and is approximately 30% less able to be absorbed by the body. Fluid extract manufacturers often extract herbs in hot water before adding glycerin to make glycerites.[2][3][4]

Used as a laxative when introduced into the rectum in suppository or liquid (enema) form; irritates the bowel and induces a hyperosmotic effect.

Glycerol is a component of glycerol soap, which is made from denatured alcohol, glycerol, sodium castorate (from castor), sodium cocoate, sodium tallowate, sucrose, water, and parfum (fragrance). Sometimes one adds sodium laureth sulfate. This kind of soap is used by people with sensitive, easily-irritated skin because it prevents skin dryness with its moisturizing properties. It is possible to make glycerol soap at home.

It is also used in de-/anti-icing fluids, as in vitrification of blood cells for storage in liquid nitrogen

Potential uses

A great deal of research is being conducted to try to make value-added molecules from crude glycerol (typically containing 20 % water and residual esterification catalyst) obtained from biodiesel production, as an alternative to disposal by incineration. One such program to add value to this glut of glycerol is the UK-based initiative The Glycerol Challenge. Some potential uses for glycerol include the following:

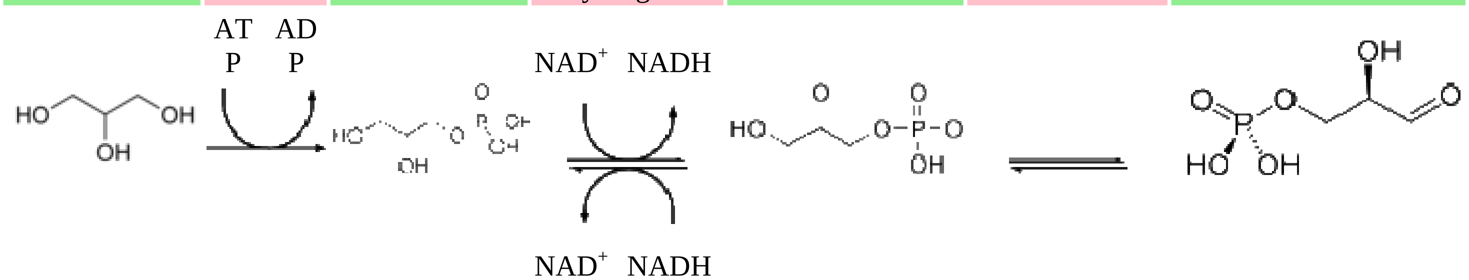
- Hydrogen gas production unit
- Glycerine acetate (as a potential fuel additive)[5]
- Compost additive
- Citric acid production
- Conversion to propylene glycol[6]
- Conversion to acrolein[7][8]
- Conversion to ethanol[9]
- Conversion to epichlorthydrin[10], a raw material for epoxy resins.

Metabolism

Glycerol is a precursor for synthesis of triacylglycerols and of phospholipids in the liver and adipose tissue. When the body uses stored fat as a source of energy, glycerol and fatty acids are released into the bloodstream. The glycerol component can be converted to glucose by the liver and provides energy for cellular metabolism.

Before glycerol can enter the pathway of glycolysis or gluconeogenesis (depending on physiological conditions), it must be converted to their intermediate glyceraldehyde 3-phosphate in the following steps:

Glycerol	Glycerol kinase	Glycerol-3-phosphate	Glyerol-3-phosphate dehydrogenase	Dihydroxyacetone phosphate	Triosephosphate isomerase	Glyceraldehyde 3-phosphate



The enzyme glycerol kinase is present only in the liver. In adipose tissue, glycerol 3-phosphate is obtained from dihydroxyacetone phosphate (DHAP) with the enzyme glycerol-3-phosphate dehydrogenase.

Danger of contamination with diethylene glycol

On May 4, 2007, the US Food and Drug Administration advised all US makers of medicines to test all batches of glycerine for the toxic diethylene glycol[11] This follows an occurrence of 100 fatal poisonings in Panama resulting from a Chinese factory deliberately falsifying records in order to export the cheaper diethylene glycol as the more expensive glycerol.[12] Glycerine and diethylene glycol are similar in appearance, smell, and taste. The US Federal Food, Drug, and Cosmetic was passed following the 1937 "Elixir Sulfanilamide " incident of poisoning caused by diethylene glycol contamination of medicine.

See also

- Oleochemicals
- Nitroglycerin

References

- U.S. Health.gov dietary guidelines

1. ^ The Glycerol Challenge
2. ^ Walter S. Long. *The Composition of Commercial Fruit Extracts* Transactions of the Kansas Academy of Science (1903-), Vol. 28, Jan. 14, 1916 - Jan. 13, 1917 (Jan. 14, 1916 - Jan. 13, 1917), pp. 157-161 doi:10.2307/3624347
3. ^ David Winston www.herbaltherapeutics.com
4. ^ http://www.newhope.com/nutritionsciencenews/NSN backs/Apr 99/backtalk.cfm
5. ^ J. A. Melero, R. vanGrieken, G. Morales and M. Paniagua (2007). "Acidic Mesoporous Silica for the Acetylation of Glycerol: Synthesis of Bioadditives to Petrol Fuel". *Energy Fuels* **21** (3): 1782-1791. doi:10.1021/ef060647q.
6. ^ Dow Chemical Company (15 Mar 2007). "Dow Achieves Another Major Milestone in its Quest for Sustainable Chemistries ". Press release.
7. ^ L. Ott, M. Bicker and H. Vogel (2006). "The catalytic dehydration of glycerol in sub- and supercritical water: a new chemical process for acrolein production" **8** (2): 214-220. doi:10.1039b506285c.
8. ^ Watanabe, M. et al (2007). "Acrolein synthesis from glycerol in hot-compressed water". Bioresource Technology **98**: 1285-1290.
9. ^ S. S. Yazdani and R. Gonzalez (2007). "Anaerobic fermentation of glycerol: a path to economic viability for the biofuels industry". *Current Opinion in Biotechnology* **18** (3): 213-219. doi:10.10116/j.copbio.2007.05.2002.Lay summary-*ScienceDaily* (27 Jun 2007).
10. ^ Dow Chemical Company (26 March 2007). "Dow Epoxy Advances Glycerine-To-Epichlorohydrin and Liquid Epoxy Resins Projects by Choosing Shanghai Site ". Press release.
11. ^ U.S. Food and Drug Administration. "FDA advises Manufacturers to Test Glycerin for Possible Contamination" Released May 4, 2007. Last retrieved May 8, 2007.
12. ^ WALT BOGDANICH and JAKE HOOKER. "From China to Panama, a Trail of Poisoned Medicine" New York Times. Published: May 6, 2007. Last retrieved May 8, 2007.

DEIONIZED/DE-IONIZED WATER

In general deionized water is water that has been stripped of all ions rendering it ultra pure for use in chemical blending. Water as it's used in water glycol hydraulic fluids is utilized as a way of controlling the viscosity of the fluid and renders the fluid fire resistant. For the fluid to burn all of the water must be boiled off before it will sustain combustion. Water constitutes from 35% to 60% of the fluid.

Deionized water (DI water or de-ionized water; also spelled deionised water, is water that lacks ions, such as cations from sodium, calcium, iron, copper and anions such as chloride and bromide. This means it has been purified from all other ions except H_3O^+ and OH^-, but it may still contain other non-ionic types of impurities such as organic compounds. This type of water is produced using an ion exchange process. Deionized water is similar to distilled water, in that it is useful for scientific experiments where the presence of impurities may be undesirable.

Properties

The lack of ions causes the water's resistivity to increase. Ultra-pure deionized water can have a theoretical maximum resistivity up to 18.31 MΩ·cm, compared to around 15 kΩ·cm for common tap water. Deionized water's high resistivity allows it, in some very highly specialized instances, to be used as a coolant in direct contact with high-voltage electrical equipment. Because of its high relative dielectic constant (~80), it is also used (for short durations) as a high voltage dielectric in many pulsed power applications, such as Sandia's Z Machine.

pH values

The pH is a logarithmic measurement of proton presence; the true pH of deionized water is 7.0, because the ionization constant of water (K_w) ~ 10^{-14}, so p[K_w] = 14, and pH + pOH = p[K_w]

In practice, the indication from chemical indicators can give a value of usually between pH 5.0 and pH 9.0 depending on the indicator used (the indication being the ions introduced by the indicator itself, its solvent and its impurities). Electronic pH meters will output an unpredictable value since the absence of ions in the liquid means that the two parts of the electrode are insulated from each other and thus would generate no EMF. In practice since absolutely pure water is an unattainable goal, the liquid will contain a very small amount of ions, but the current this would allow the probe to generate will be far smaller than that required to operate the metering circuit.

Electrodes of a pH meter should not be immersed in deionised water for prolonged periods as the lack of any ions 'sucks' them out of the electrode degrading its performance. Deionised water should be used for cleaning only rarely as the effect is cumulative. Electrodes should be cleaned using proper cleaning solution (usually very acidic), and rinsed between samples; ideally it should be rinsed using an extract from the next sample to be tested, but failing that, a pH neutral liquid such as tap water or pH 7.0 buffer solution is suitable.

Deionized water will quickly acquire a pH when exposed to air. Carbon dioxide, present in the atmosphere, will dissolve in the water, introducing ions and giving an acidic pH of around 5.0. The limited buffering capacity of DI water will not inhibit the formation of carbonic acid H_2CO_3. Boiling the water will remove the carbon dioxide to restore the pH to 7.0.

Ultrapure deionized water

The uses of ultrapure deionized water are many and varied, often having applications in scientific experimentation such as when very pure chemical reagent solutions are needed in a chemical reaction or when a biological growth medium needs to be sterile and very pure. Laboratory grade ultra pure water cannot be stored in glass or plastic containers because such materials leach contaminants at very low concentrations into the water. Storage vessels made of silica are used for less demanding applications but for highest purity uses, containers made from ultra pure Tin are used.

Deionization

Process utilizing specially-manufactured ion exchange resins which remove ionized salts from water can theoretically remove 100% of salts. Deionization typically does not remove organics, virus or bacteria, except through "accidental" trapping in the resin and specially made strong base anion resins which will remove gram-negative bacteria.

AMINE ADDITIVES

Amines are organic compounds and a type of functional group that contain nitrogen as the key atom. In structure, amines resemble ammonia, wherein one or more hydrogen atoms are replaced by organic substiuents such as alkyl and aryl groups. An important exception to this rule is that compounds of the type $RC(O)NR_2$, where the C(O) refers to a carbonyl group, are called amides rather than amines. Amides and amines have different structures and properties, so the distinction is chemically important. Somewhat confusing is the fact that amines in which an N-H group has been replaced by an N-M group (M = metal) are also called amides. Thus $(CH_3)_2NLi$ is lithium dimethylamide.

Amines are central in organic chemistry. All known life processes depend on amino acids each of which contains an amine group.

Amines in the fluid blend are used to control lubricity and are base pH from 8.0 to 10.0. The amine additives range from 5% to 10% of the fluid. The additive package provides not only lubricity, but also anti-wear agents, anti-oxidation agents, anticorrosion agents and anti-foaming agents. The package is proprietary to the manufacturer and controlling the pH of the fluid is used to control the boundary layer lubrication film between the mating surfaces.

ADDITIONAL ADDITIVES

Different dyes may be added to the fluid to colorize it. These dyes do not affect the fluid or the fluid's performance. Some companies add additional additives to assist in maintenance leak detection. Again these do not alter the fluid in any way.