Alkyl Alkanolamines

Dow's World Class Quality

Alkyl Alkanolamines

- Backed by more than 50 years of experience and innovative technical development
- Dependable supply supported by Dow's position as the leading producer of ethylene oxide (a basic raw material)
- Worldwide distribution network to assure fast, on-time delivery
- Consistent high quality, assured by the latest statistical quality control methods

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Introduction

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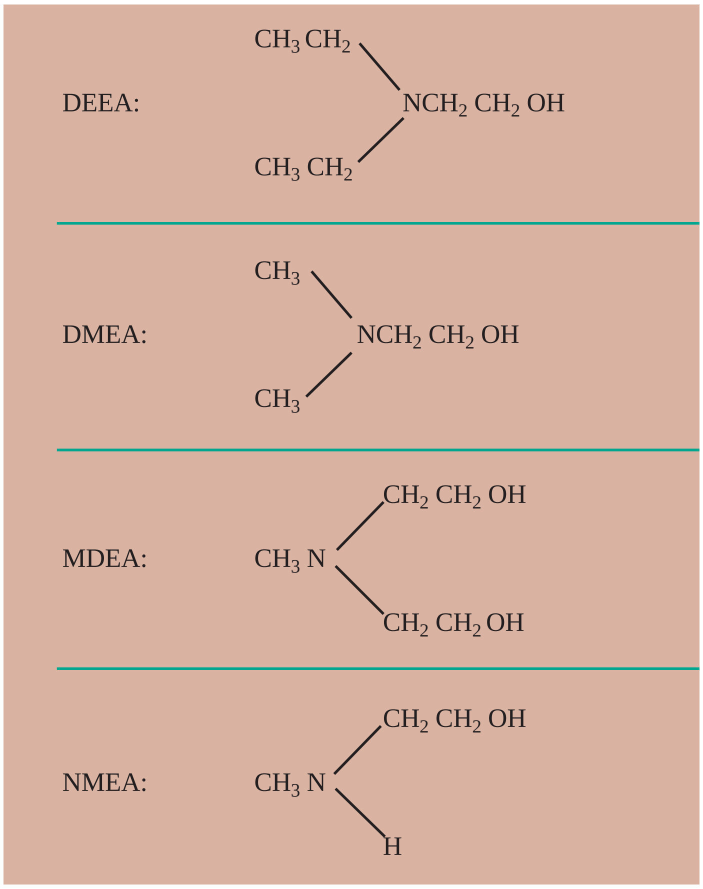
DOW alkyl alkanolamines present unique application opportunities. They are versatile, polyfunctional molecules that combine the characteristics of amines and alcohols. This makes them useful intermediates in the synthesis of numerous products, and has resulted in their use in many diverse areas. They are of major importance in the pharmaceutical, flocculant, coatings, and gas treating industries. Alkyl alkanolamines are characterized by the presence of a basic secondary or tertiary nitrogen atom and at least one hydroxyl group. They are capable of undergoing reactions typical of both alcohols and amines, but the amine group usually exhibits the greater activity.

N,N-diethylethanolamine (DEEA), N,N-dimethylethanolamine (DMEA), and N-methyldiethanolamine (MDEA) are tertiary amines. N-methylethanolamine (NMEA) is a secondary amine. MORLEX™ DEEA Corrosion Inhibitor is a proprietary version of DEEA geared to the boiler water corrosion inhibition markets. The chemical structures of these alkyl alkanolamines are:



Alkyl alkanolamines are liquids at room temperature. N-methylethanolamine has the highest freezing point of this family at -5°C, while N,N-diethylethanolamine has the lowest freezing point at -78°C. They are hygroscopic, mildly alkaline, and completely water soluble. For these reasons, they are often used for pH control in such markets as water treating and coating applications.

Alkyl alkanolamines react to form quaternary amine salts, soaps, esters, or amides. Secondary alkanolamines form salts, soaps, esters, and amides, while tertiary alkanolamines can only form esters, salts, and soaps.

The reaction of acids, such as mineral acids or strong inorganic acids, with secondary or tertiary amines results in the formation of salts.

The reaction of fatty acids with alkyl alkanolamines at room temperature results in the formation of neutral surface active soaps (e.g., N,N-diethylethanol ammonium stearate). At elevated temperatures, secondary alkyl alkanolamines (e.g., N-methylethanolamine) react with fatty acids in an equimolar ratio to give amides, along with significant quantities of amine and amide esters. Tertiary alkyl alkanolamines form only amine esters.

This booklet provides an introduction to alkyl alkanolamines. Should you need further information, please contact Dow at the numbers on the back page of this brochure.

Applications

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Coatings

Alkyl alkanolamines are used in a variety of coatings, both water- and solvent-based. Their main function is to increase the solubility of other components and enhance solution stability.

Alkyl alkanolamines such as N,N-dimethylethanolamine and, N,N-diethylethanolamine are particularly useful in waterborne coatings. They increase resin solubility or reducibility, aid pigment dispersion, and improve solution stability by reducing pH drift. This latter problem is often seen in architectural paints utilizing a volatile pH modifier such as ammonia. Studies have also shown that they provide an attractive alternative to 2-amino-2-methyl propanol (AMP). N,N-dimethylethanolamine and N,N-diethylethanolamine are both recommended for use in waterborne baking enamels and primer formulations where adhesion to a variety of topcoats is needed. N,N-dimethylethanolamine is particularly suitable for white or pastel baking enamels because of its resistance to discoloration (“yellowing”). Tests have shown that, when N,N-dimethylethanolamine is used in baked waterborne coatings formulations, it offers superior scratch- and rub-resistance, as well as allowing an energy reduction of more than 20% in the bake cycle, compared to other commonly used alkanolamines, such as AMP. An additional advantage over AMP is that, as a tertiary amine, N,N-dimethylethanolamine does not tend to form water-soluble amides that remain in the film.

Waterborne epoxy can-coating processes utilize alkyl alkanolamines, primarily N,N-dimethylethanolamine, to stabilize the final resin/solvent system and thus facilitate application by spraying, rolling, etc.

Alkyl alkanolamines are also used in a number of cathodic electrodeposition systems. N-methylethanolamine, being a secondary amine, is often used to chain-extend high MW polyepoxides with a polyol. This is made water dispersible by neutralization to provide cationic groups in the polymer. A tertiary amine, such as N,N-dimethylethanolamine, is sometimes added as a catalyst, although N-methylethanolamine can form an “in-situ” tertiary amine catalyst by reaction with the polyepoxide.

Emulsifying and Dispersing Agents

Alkyl alkanolamines react readily with long-chain fatty acids to form surface-active soaps. The products are waxy, noncrystalline materials which have widespread commercial importance as emulsifying additives in textile lubricants, polishes, detergents, pesticides and personal care products such as hand lotions, shaving creams, and shampoos.

Household Specialties and Personal Care

The most common tertiary amine-based soaps are oleates and stearates. The oleate soap is water soluble; the stearate soap is not. Solutions of the oleate soap have very good detergent properties, are widely used with organic solvents, and are, typically, utilized in dry cleaning solvents. Alkyl alkanolamine stearate soaps are frequently used in hand lotions, cosmetic creams, cleansing creams, shaving creams, and shampoos.

Fatty-acid soaps of N,N-diethylethanolamine and N,N-dimethylethanolamine are employed as emulsifying and dispersing agents for water-resistant waxes and polishes. These polishes may be used on metal, leather, glass, wood, ceramic ware, automobiles, floors, and furniture. The floor polishes are designed particularly for light-colored flooring.

Textiles

Surface-active alkyl alkanolamine soaps made primarily from oleic acid are used in cleaning and scouring textiles. When combined with chlorinated solvents, these soaps become wetting agents. Soluble in water and in most hydrocarbon solvents, they lather well in hard water. Combined with natural oils, such as linseed, olive, and castor oil, these soaps are utilized as textile lubricants, characterized by their excellent emulsifiability and ease of removal. Alkyl alkanolamine-based knitting oils prevent gum from clogging needles, and decrease the buildup of electric charge on the fiber during processing. The surface-active derivatives of alkyl alkanolamines also find use in desizing.

Esters of N,N-dimethylethanolamine are used extensively in the textile industry as emulsifying agents. N-methylethanolamine is used as a brightening agent in the dyeing of polyester/cotton blends.

Lubricants

The addition of alkyl alkanolamine soaps to mineral oils produces a soluble oil used in greases, cutting and lubricating oils, petroleum-water demulsifiers, and oil emulsifiers. N,N-dimethylethanolamine is utilized in making sulfurized oils for extreme-pressure lubricants. Alkyl alkanolamines are also used in additives that lower the pour point of lubricating oils.

Gas Treating

Elimination of undesirable hydrogen sulfide from natural gas and refinery off-gases is almost universally accomplished by a process involving contact of the gas stream with a solution, and subsequent stripping of the acid gas from the solution. The process is referred to as sweetening. N-methyldiethanolamine is used in gas treating as a scrubbing and extraction agent, and provides the capability of selectively absorbing H_2S in the presence of CO_2. Under the UCARSOL™ trademark Dow offers a line of high-performance solvents which provide additional improvements in acid gas removal from gas streams. A UCARSOL solvent is available for virtually every gas treating application. For more information concerning this product line, please contact us using the numbers on the back of this brochure.

Pharmaceuticals

Alkyl alkanolamines and their derivatives are widely used as intermediates for the production of active pharmaceutical ingredients. For example, N,N-dimethylethanolamine is an intermediate in the synthesis of procaine, a valuable local anesthetic and an intermediate in the preparation of procaine penicillin G, an important antibiotic. N,N-dimethylethanol-amine and N-methylethanolamine are used in the synthesis of antihistamines (e.g., diphenhydramine hydrochloride) for the symptomatic relief of allergies, such as hay fever as well as the common cold. N-methyldiethanolamine is an intermediate in the production of analgesics that have sedative and antispasmodic effects. N,N-dimethylethanolamine is employed in the synthesis of Tamoxifen, used in the treatment of malignant diseases.

Urethane Catalysts

DMEA is an amine catalyst, used alone or in combination with other catalysts, in the production of urethane foam. It promotes foam rise and gel strength characteristics that are particularly adaptable to intricate rigid foam molding, including refrigerator and other insulation applications. Isocyanates react with DMEA, thus limiting the amount of DMEA vapor released to the atmosphere during the foaming reaction.

Water Treatment

Alkyl alkanolamines are widely used in the water treatment industry. They are employed in the production of a number of important water treatment products, such as synthetic water-soluble polymeric flocculants and ion exchange resins. They are also used directly as corrosion inhibitors.

Flocculants

Acrylic and methacrylic acid esters of alkyl alkanolamines, particularly N,N-dimethylethanolamine, are quaternized, typically, with methyl chloride or dimethyl sulfate and then copolymerized with acrylamide to give cationic polymeric flocculants. When added in trace quantities to water, they adsorb solid and colloidal particles by electrostatic attraction to form large "flocs," which can then be readily separated.

They vastly improve solid/liquid separation processes such as sedimentation, filtration and flotation, and are thus widely used in the potable water and wastewater treatment industries to remove colloidal and suspended solids, as well as in the paper and mineral processing industries. They are also used in secondary sludge dewatering where, in conjunction with belt filter presses, high cake solid concentrations are obtained.

To avoid crosslinking in the copolymerization step, and subsequent loss in product performance, high quality raw materials are essential. DOW alkyl alkanolamines meet the tightest specifications in the industry and are uniquely suited to meeting these requirements.

Ion Exchange Resins

Strongly basic anion exchange resins are produced by reacting a tertiary amine with a chloromethylated styrene-divinyl benzene copolymer. When N,N-dimethylethanolamine is used, these resins are referred to as Type II Resins. They offer improved regeneration efficiencies and are typically used in conjunction with a strong acid cation exchange resin for water demineralization and deionization.

Corrosion Inhibitors

Alkyl alkanolamines are widely used as corrosion inhibitors in return-condensate steam and boiler systems. Two alkyl alkanolamines in particular, DMEA and MORLEX DEEA Corrosion Inhibitor meet the exacting requirements of this application. They have the correct combination of volatility and basicity to maintain a constant alkalinity in the boiling solution, vapor, and condensate. They do not form solid hydrates or react to form solid products which would impede line flow. These alkyl alkanolamines offer distinct advantages over morpholine and cyclohexylamine, the two volatile amines traditionally employed in this application. The lower molecular weight of DMEA enables a more efficient use, on a pound-for-pound basis, than cyclohexylamine, and gives significant cost benefits. Similarly, the superior ability of DMEA to neutralize CO_2 results in a lower requirement to achieve a given pH, in the range 7.0 to 8.5, than any other standard amine. MORLEX DEEA Corrosion Inhibitor and DMEA provide better protection than cyclohexylamine in high-temperature condensates, and better protection than morpholine in long runs of low-pressure steam lines.

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Typical Physical Properties†

	N,N-Diethyl-ethanolamine	N,N-Dimethyl-ethanolamine	N-Methyl-diethanolamine	N-Methyl-ethanolamine
Structural Formula	$(CH_3CH_2)_2N-CH_2CH_2OH$	$(CH_3)_2N-CH_2CH_2OH$	$CH_3N-(CH_2CH_2OH)_2$	$CH_3NH-CH_2CH_2OH$
Molecular Weight	117.19	89.14	119.16	75.11
CAS Number	100-37-8	108-01-0	105-59-9	109-83-1
Specific Gravity,				
at 20/20°C	0.884	0.888	1.041	0.940
ΔSp.Gr./Δt per °C	0.00091	0.00085	0.00076	0.00078
Boiling Point, °C				
at 760 mm Hg	162. 1	134.4	247.3	159.6
at 50 mm Hg	83.4	62.2	163.5	89.6
at 10 mm Hg	51.4	32.6	128.6	60.5
Freezing Point, °C (°F)	-78 (-108)(1)	-59 (-74)	-21 (-6)	-5 (23)
Solubility, at 20°C				
in water	complete	complete	complete	complete
water in	complete	complete	complete	complete
Vapor Pressure, mm Hg at 20°C	1.3	4.4	<0.01	0.48
Viscosity, cP				
at 20°C	5.1	3.8	101	13.0
at 40°C	2.2	2.2	33.8	6.5
Refractive Index, n_D, 20°C	1.4417	1.4296	1.4694	1.4390
Heat of Combustion, BTU/lb (cal/g) at 25°C	-15,480 (-8600)	-13,900 (-7720)	-12,200 (-6780)	-12,710 (-7060)
Flash Point, °C (°F)	49 (120)(2)	39 (103)(2)	138 (280)(3)	73 (163)(4)

(1) Pour Point.
(2) Tag Closed Cup, ASTM Method D56.
(3) Pensky-Martens Closed Cup, ASTM Method D93.
(4) Setaflash Closed Cup, ASTM Method D3278.
†The data provided for these properties are typical values and should not be construed as sales specifications.

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Figure 1 Vapor Pressure of Alkyl Alkanolamines vs. Temperature

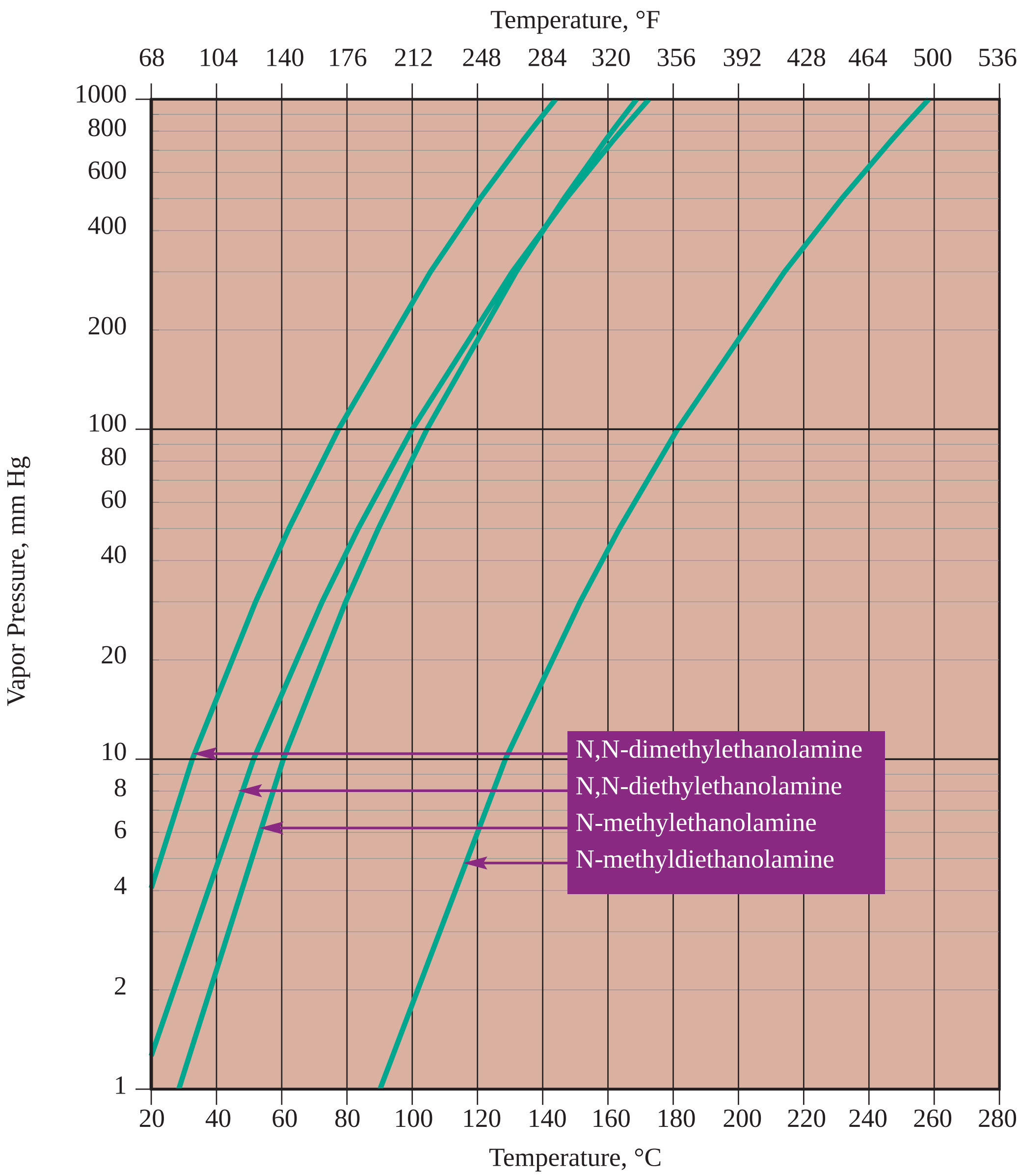

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Figure 2 Viscosity of Alkyl Alkanolamines vs. Temperature

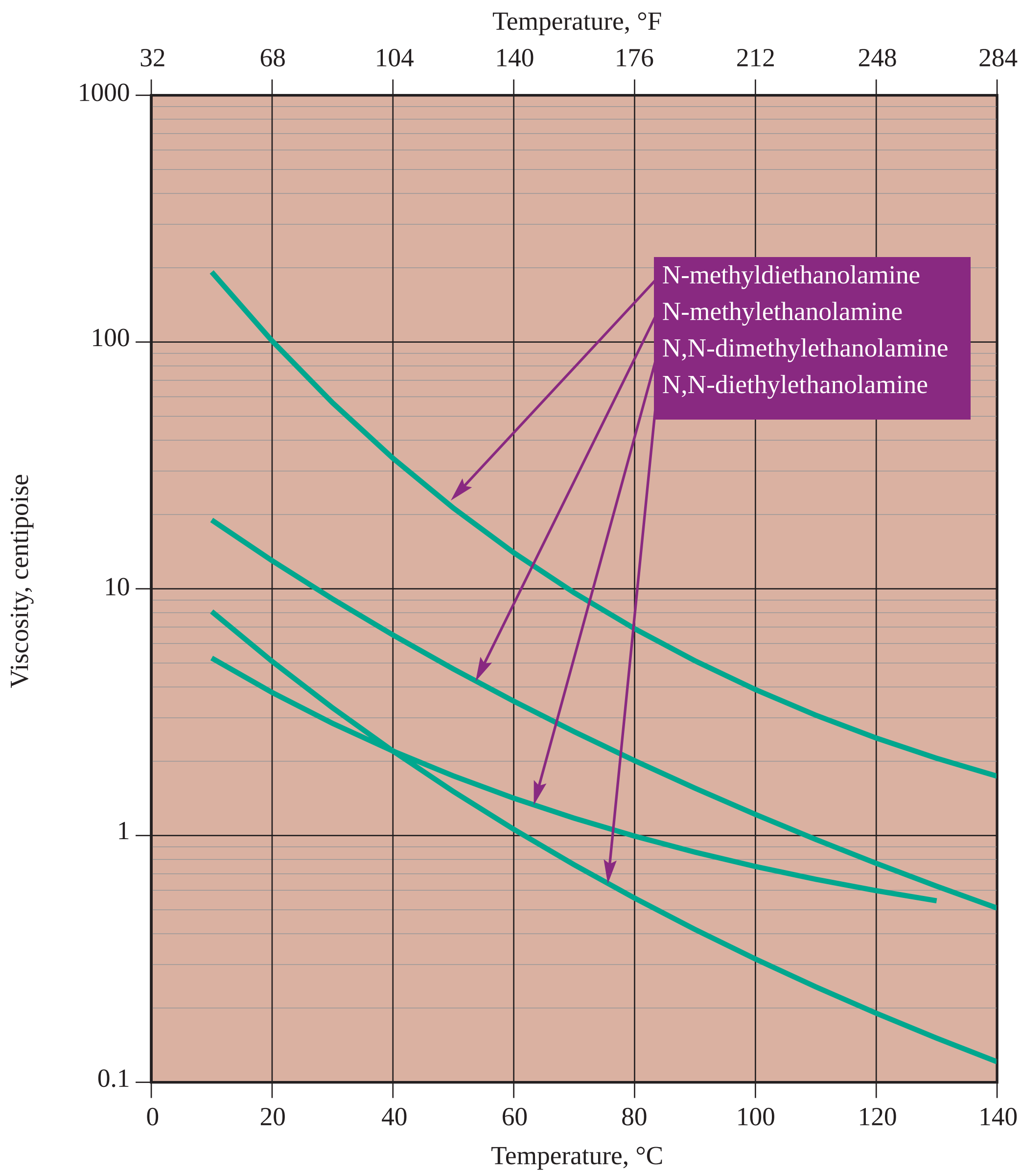

Figure 3 Density of Alkyl Alkanolamines vs. Temperature

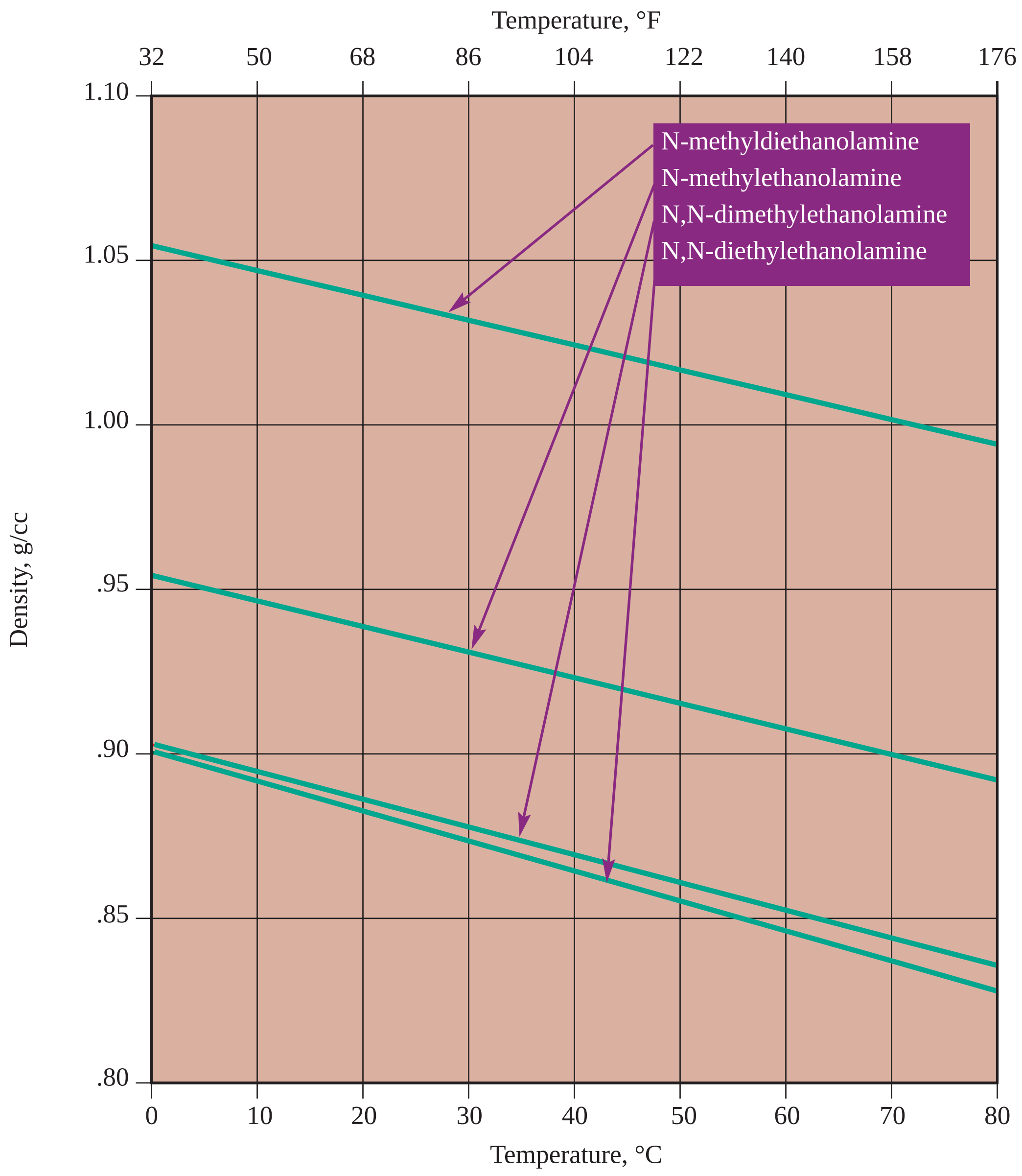

Figure 4 Vapor – Liquid Equilibria of Aqueous N,N-Dimethylethanolamine Solutions at 760 mm Hg

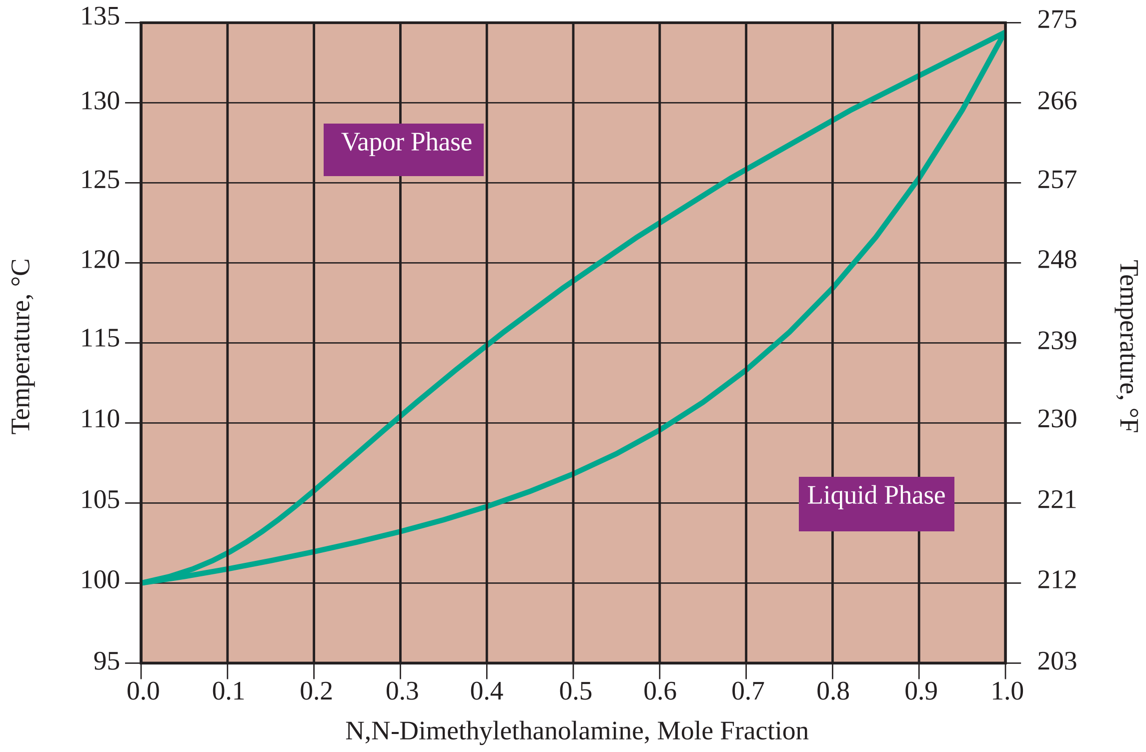

Figure 5 Vapor – Liquid Equilibria of Aqueous N-Methylethanolamine Solutions at 760 mm Hg

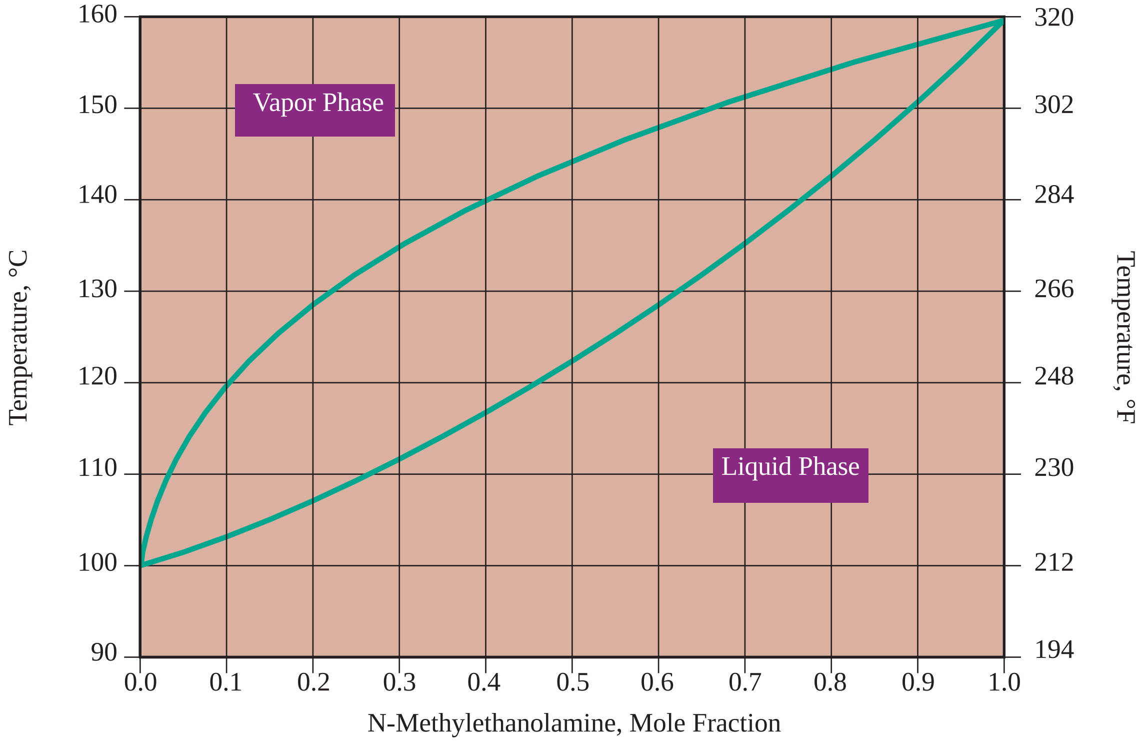

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Figure 6 Vapor – Liquid Equilibria of Aqueous N-Methyldiethanolamine Solutions at 760 mm Hg

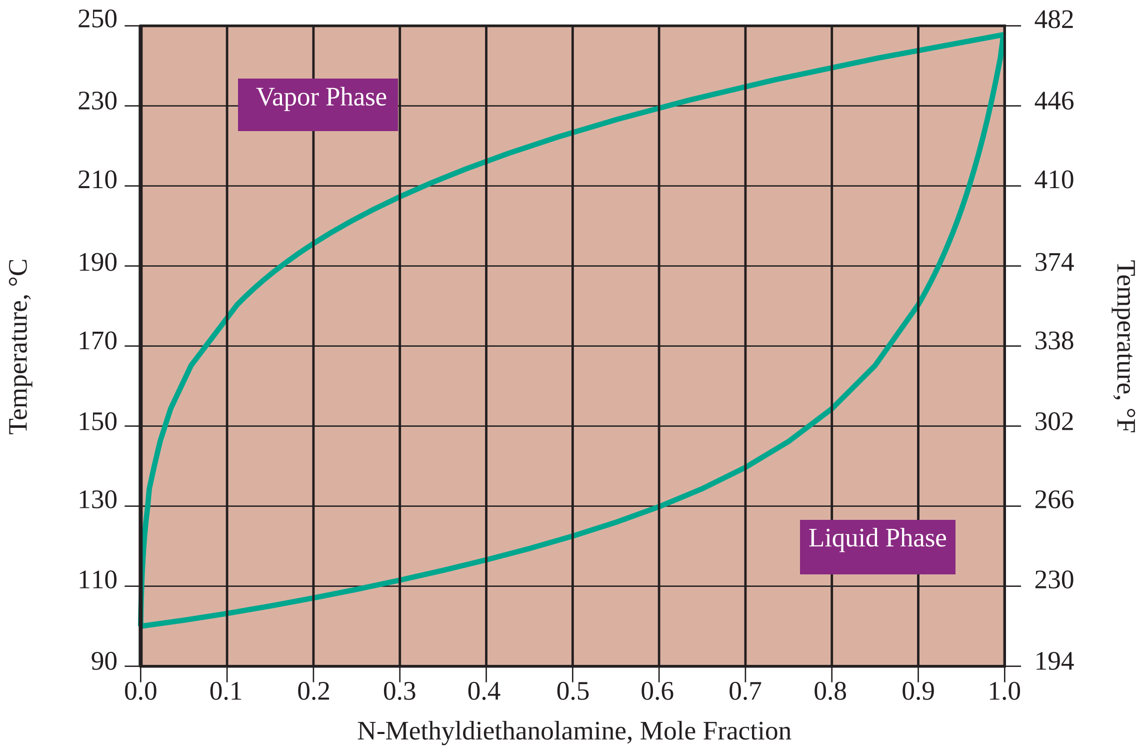
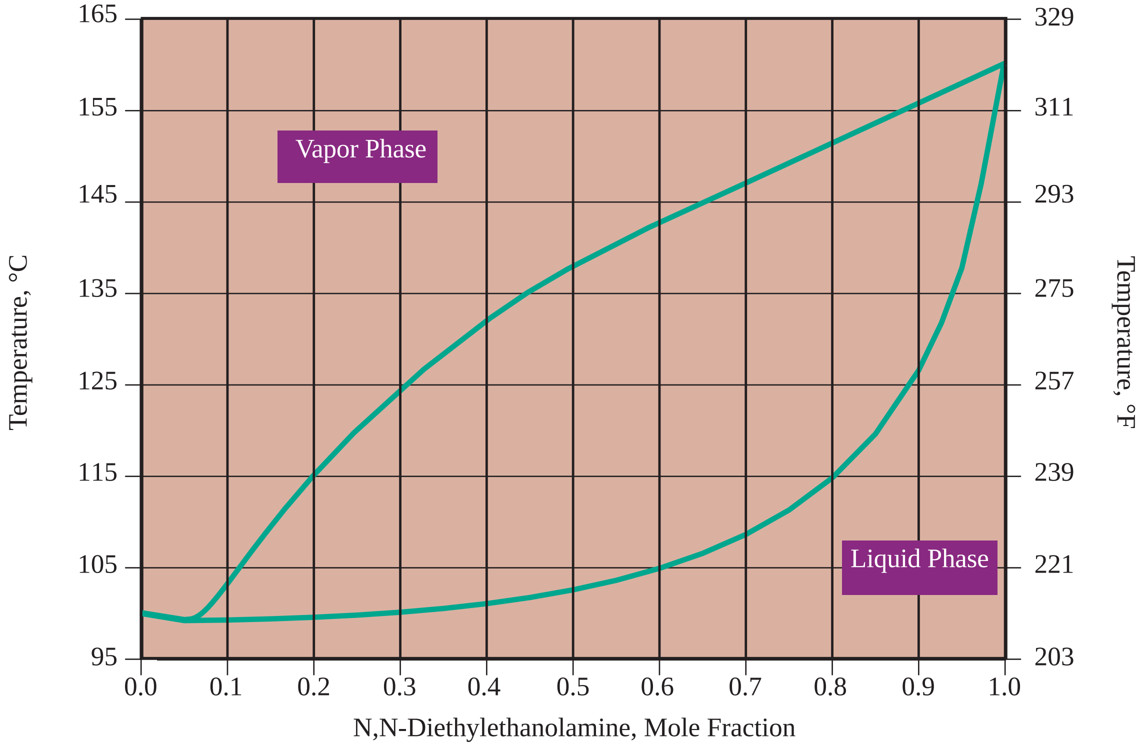


Figure 7 Vapor – Liquid Equilibria of Aqueous N,N-Diethylethanolamine Solutions at 760 mm Hg



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Shipping Data

	Average Weight, Lb/Gallon (Kg/L) at 20°C	ΔLb per Gallon/Δt, 10-30°C	Coefficient of Expansion at 55°C, per °C	Flash Point, °F (°C)
N,N-Diethylethanolamine	7.36 (0.88)	0.00760	0.00107	120 (49)[1]
N,N-Dimethylethanolamine	7.39 (0.89)	0.00704	0.00098	103 (39)[1]
N-Methyldiethanolamine	8.67 (1.04)	0.00630	0.00074	280 (138)[2]
N-Methylethanolamine	7.83 (0.94)	0.00649	0.00085	163 (73)[3]
MORLEX DEEA Corrosion Inhibitor	7.36 (0.88)	0.00760	0.00107	120 (49)[1]

(1) Tag Closed Cup, ASTM Method D56.
(2) Pensky-Martens Closed Cup, ASTM Method D93.
(3) Setaflash Closed Cup, ASTM Method D3278.

Storage and Handling

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Normal precautionary measures should be taken when using alkyl alkanolamines. Avoid contact with eyes, skin and clothing, and wash thoroughly after handling. When not in use, keep containers closed and use with adequate ventilation. Keep away from heat and open flames. Alkyl alkanolamines are **for industrial use only.**

Alkyl alkanolamines may be stored and handled in carbon steel equipment. Anhydrous alkyl alkanolamines are compatible with aluminum, but aqueous mixtures can be highly corrosive to aluminum. To maintain product quality, it is recommended that storage containers, including drums, have a nitrogen blanket.

Steel equipment that is frequently cleaned may contain small amounts of rust which will be picked up by the alkyl alkanolamine. This may cause a noticeable color increase in the product. Stainless steel equipment should be considered for multiple-use service to minimize this concern. All equipment must be clean of other chemicals or residue and must be thoroughly dried prior to placing it into alkyl alkanolamine service.

Do not use copper alloys, zinc or galvanized iron. Be especially careful that pumps, valves or other equipment do not contain brass, bronze or other copper alloy components that can come into contact with the alkyl alkanolamine.

Storage and Handling (con't)

Most products may be stored at ambient outdoor conditions. However, at temperatures below 70°F (21°C) N-methyldiethanolamine becomes quite viscous; heated lines and tanks may be necessary to ease handling. N-methylethanolamine freezes at 24°F (-5°C); if ambient temperatures are expected to be this cold, then heated tanks and lines will be required.

Steel pumps, valves and piping are most commonly used, although stainless steel is also acceptable. Centrifugal pumps or positive displacement vane or gear pumps are commonly used. Provision should be made in line sizing and pump selection if ambient temperatures may cause high viscosity as noted above. "Grafoil" Flexible Graphite and TFE gasketing and packing materials are compatible with these products. For general applications use EPR elastomer. Use Kalrez 4079 for higher temperatures.

Product Safety

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When considering the use of any Dow products in a particular application, you should review Dow's latest Material Safety Data Sheets and ensure that the use you intend can be accomplished safely. For Material Safety Data Sheets and other product safety information, contact Dow at the numbers on the back of this brochure. Before handling any other products mentioned in the text, you should obtain available product safety information and take necessary steps to ensure safety of use.

No chemical should be used as or in a food, drug, medical device, or cosmetic until the user has determined the suitability and legality of the use. Since government regulations and use conditions are subject to change, it is the user's responsibility to determine that this information is appropriate and suitable under current, applicable laws and regulations.

Dow requests that the customer read, understand, and comply with the information contained in this publication and the current Material Safety Data Sheet(s). The customer should furnish the information in this publication to its employees, contractors, and customers, or any other users of the product(s), and request that they do the same.

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