N-METHYLMMORPHOLINE (NMM)

NMM is a clear, low-color, water miscible, liquid amine possessing a penetrating, ammoniacal odor.

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\begin{align*}
\text{H}_3\text{C} & \text{N} \\
& \text{O}
\end{align*}
\]

SALES SPECIFICATIONS

<table>
<thead>
<tr>
<th>Property</th>
<th>Specifications</th>
<th>Test Method*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Clear and substantially free of foreign matter</td>
<td>ST-30.1</td>
</tr>
<tr>
<td>Color, Pt-Co</td>
<td>50 max.</td>
<td>ST-30.12</td>
</tr>
<tr>
<td>NMM, wt%</td>
<td>99 min.</td>
<td>ST-5.5</td>
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<tr>
<td>Water, wt%</td>
<td>0.5 max.</td>
<td>ST-31.53, 6</td>
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</tbody>
</table>

*Methods of Test are available from Huntsman Corporation upon request.

ADDITIONAL INFORMATION

Typical Physical Properties

- Boiling point, °C (°F) 112 (234)
- Flash point, TCC, °C (°F) 13 (55)
- Freezing point, °C -66
- pH 10.8
- Specific gravity, 20/20°C 0.9
- Vapor pressure, mm Hg, 20°C (68°F) 18
- Viscosity, cSt, 20°C (68°F) 1
- VOC Content (%) 100
- Water solubility (%) > 10

TOXICITY AND SAFETY

Acute Toxicity

The results of acute toxicity testing using N-methylmorpholine (NMM) indicate that this product is considered to be moderately toxic by single oral exposures and practically non-toxic by single dermal exposures. The oral LD<sub>50</sub> in rats and the dermal LD<sub>50</sub> in rabbits are 1.44 g/kg and greater than 3 g/kg, respectively.

Acute irritation studies have shown this product to be extremely irritating/corrosive to the skin of rabbits, with a Draize dermal irritation score of 8.0 (maximum score 8.0). Given the results of the dermal irritation study, it is assumed that NMM will be extremely irritating and corrosive to the eyes, as well.

In dermal sensitization studies using guinea pigs (Beuhler method), NMM was not found to be a dermal sensitizer at challenge concentrations of 10% NMM in acetone.

Genetic Toxicity

A battery of genetic toxicity studies, comprised of an Ames Assay and an Unscheduled DNA Synthesis (UDS) Assay, was conducted using N-methylmorpholine. These studies were negative (non-genotoxic) in their responses to NMM.

Human Health Effects and First Aid

On the basis of the above animal toxicity studies, the principal health hazard from accidental exposures to N-methylmorpholine is a moderate to severe irritation/corrosion of the eyes, skin, and mucous membranes. Chemical-type goggles with face shield must be worn during handling or use of the undiluted product or concentrated solutions. Contact lenses should not be worn. Protective clothing, and gloves resistant to chemicals and petroleum distillates, must be worn.

Should accidental eye and skin contact occur, flush eyes with large amounts of water for at least 15 minutes, after which a physician should be consulted. During flushing of the eyes, eyelids should be held apart to permit rinsing of entire surface of eye and lids. For skin contact, immediately flush skin with large amounts of water for at least 15 minutes.
Clothing wet with the product must be removed immediately and laundered before reuse.

If NMM is accidentally ingested, and the individual is conscious and can swallow, they should be given two large glasses of water, after which a physician should be consulted. Since this product is expected to produce severe irritation/corrosion of mucous membranes, vomiting should not be induced, due to the possibility of lung damage from aspiration of the product into the lungs during vomiting.

Under usual circumstances, exposure to harmful quantities of vapor should not be a health problem, however, exposure to appreciable concentrations of N-methylmorpholine vapors has been shown to result in irritation to the eyes, nose and throat, and may produce a temporary and reversible hazy or blurred vision. These symptoms disappear when exposure to NMM is terminated. Adequate ventilation should be provided where a large quantity of product is exposed, or where mists or vapors are generated. Spills in confined areas should be cleaned up promptly, using appropriate personal protective equipment.

Although no occupational exposure limits have been established for NMM, the American Conference of Governmental Industrial Hygienists (ACGIH) has established a Threshold Limit Value (TLV) for a similar chemical, N-ethylmorpholine (NEM), at 5 ppm as an 8-hour time weighted average (TWA) and has included a "SKIN" notation. Adherence to this TLV should also be protective for NMM exposures, as well. For further information, please refer to the Material Safety Data Sheet (MSDS) for this product.

**HANDLING AND STORAGE**

In order to maintain the high degree of purity with which N-methylmorpholine (NMM) is manufactured and shipped, the following storage and handling considerations are recommended:

**Dry Inert Gas Blanket:** This product should be stored under a dry inert gas blanket, such as nitrogen, to minimize contamination resulting from contact with air and water.

**Materials of Construction:** Clean carbon steel is satisfactory as a material of construction for storage tanks and transfer systems, provided adequate precautions are observed to guard against rust contamination. In those cases where additional precautions are needed to preserve low color, stainless steel or aluminum should be used. Copper, or alloys containing copper, should be avoided.

**Storage Temperature:** NMM has an extremely low viscosity and freezing point (-73.5°F). It will not freeze or become viscous during normal handling even though subjected to very severe weather conditions.

**Spills or Leaks:** Eliminate all sources of ignition in case of spills or leaks. Spills should be removed by absorbent materials or by washing with water.

**Flammability:** Since NMM has a low flash point (55°F), adequate precautions should be observed to reduce fire hazards. It should be used only in a well-ventilated area and precautions should be taken to avoid exposure to sparks and open flames. Ground wires should be welded to the storage tank to reduce the chances of static electricity buildup. Where possible, equipment should also be electrically bonded. Either float or manometer type gauges are recommended for tank metering. Gauge glasses are not recommended for this service as they are subject to accidental breakage, resulting in a serious fire hazard. Proper fire-fighting equipment should be available wherever NMM is handled. Carbon dioxide, dry chemical, foam, and water spray are effective in controlling fires. Vapors from the burning of NMM may include carbon monoxide, carbon dioxide, and ammonia. Therefore, personnel fighting fires involving this product should be equipped with self-contained breathing apparatus and protective clothing.

**AVAILABILITY**

NMM is available for shipment in tank cars, tank wagons, and 55-gallon drums. Samples are available by contacting our sample department at 1-800-662-0924.