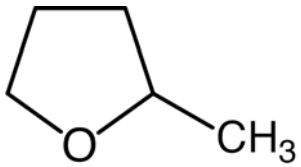
PENNAKEM
Renewable Resource Chemistry

Methyltetrahydrofuran

The Preferred Grignard Reaction Solvent



Grignard Solvent Advantages

2-Methyltetrahydrofuran (MeTHF) is produced from furfural, which is a chemical derived from renewable sources (corn cobs, sugar cane bagasse, oat hulls). MeTHF has a number of properties that make it a preferred Grignard solvent.

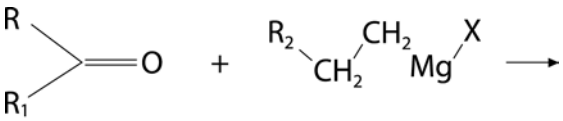
- Limited miscibility with water facilitates easy product recovery
- Can be easily dried with lower losses and lower recycle costs compared to THF
- Gives cleaner phase separations compared to processes that use solvent exchange of THF with toluene
- Especially useful for producing high concentrations of homogeneous solutions of bromo Grignard reagents
- Gives high yields of benzyl and allyl Grignard reagents
- Gives improved yields of addition product in systems where THF gives high yields of reduction product
- Permits higher reaction temperature and lower losses from reactor condensers

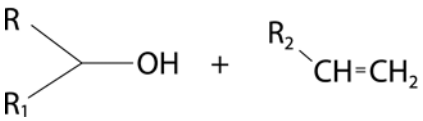
THF is the most common solvent used for commercial Grignard reactions. MeTHF has similar behavior to THF in most Grignard reactions, but its higher boiling point and limited water solubility give it several distinct advantages over THF. The 80°C boiling point of MeTHF compared to 66°C boiling point for THF means that sluggish Grignard reactants can be formed quicker. The higher boiling point of MeTHF also reduces losses of solvent from the reflux condenser. Unlike THF, MeTHF has limited solubility in water and this property makes it easier to isolate the quenched reaction product and recycle dry MeTHF. Another advantage of MeTHF is that very clean phase separations are found from the quenched Grignard reaction product. Often when THF is solvent exchanged with toluene, emulsions or rag layers are formed that prevent clean phase separations.

MeTHF has a much higher solubility for magnesium bromide and iodide than THF. For example, the solubility of magnesium bromide is more than 40g/100g at 25ºC in MeTHF, whereas the solubility is only about 5g/100g in THF. This makes MeTHF a preferred choice for preparing high concentrations of bromo Grignard reagents that do not need filtration to remove magnesium bromide. For companies that package and sell Grignard reagents, use of MeTHF insures that their aged inventory will be stable, precipitate free solutions.

MeTHF can be used to produce high yields of benzyl and allyl Grignard reagents at low magnesium ratios. THF can only be used to make benzyl and allyl Grignard reagents at reasonable yields by using high molar ratios of magnesium to benzyl or allyl halide. For instance, a yield of greater than 90% of benzylmagnesium bromide is made with MeTHF, but mostly bibenzyl is made with THF at a magnesium:benzylbromide ratio of 1.2:1.

In many systems, MeTHF behaves more like ethyl ether than like THF. A common side reaction of Grignard reagents that contain beta hydrogens is reduction of the substrate instead of addition.





This side reaction often causes reduced yields of the desired addition product when THF is the solvent. In these systems, replacement of THF with MeTHF, as with ethyl ether, will typically give improved yields of the addition product.

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Recovery of MeTHF

Recovery of dry THF from aqueous mixtures requires special equipment and high energy costs. Also, another solvent must usually be added before or after the Grignard reaction product is quenched with acid water, since THF is completely miscible in water. With MeTHF, the Grignard reaction product can be isolated in MeTHF after water quenching. MeTHF can be used to dry the reaction product in a simple batch operation by refluxing the MeTHF phase of the condensed MeTHF-water azeotrope. MeTHF can also be dried for recycle by the same simple batch azeotropic drying procedure. The energy requirements for recovering dry MeTHF are about 70% lower than for recovering dry THF by distillation. Contact Penn Specialty Chemicals for details on recycling MeTHF.

Environmental, Health and Safety

MeTHF is a flammable liquid with a mildly irritating odor. MeTHF vapors, when mixed with air, are flammable when exposed to ignition sources. It should be handled only after consulting the material safety data sheet.

If spilled, MeTHF has a CERCLA reportable quantity of 100 pounds because of its low flash point. MeTHF could carry an EPA waste code of D001 for ignitability.

Availability

MeTHF is available in bulk tank trucks, in 55-gallon steel drums (375 lbs; 170 kg) and 5-gallon steel pails (35 lbs, 16 kg).

Shipping

The DOT HM 181 shipping name for MeTHF is methyltetrahydrofuran. It is a hazard class three (3) flammable liquid, Packing Group II material that requires a red flammable liquid label. The ID Number is UN 2536. Consult the MSDS for additional shipping information.

Comparison of Properties of MeTHF and THF

Property	MeTHF	THF
Boiling Point (ºC)	80	66
Freezing Point (ºC)	-136	-108.5
Density at 20ºC	0.855	0.888
Viscosity at 25ºC (cps)	0.60	0.53
Evaporation Rate (n-butylacetate=1)	4.2	8.0
Dielectric Constant	6.3	7.6
Donicity (kcal/mol)	18	20
Solubility of MgBr2 at 25ºC	40	5
Solubility Parameter	8.52	9.15
Hansen Solubility Parameter		
Non-polar	8.3	8.6
Polar	1.9	2.4
Hydrogen Bond	3.0	2.7
Total	8.9	9.4
Solubility at 20ºC (wt %)		
In Water	14	inf
Water in Solvent	4.4	inf
Esters, Alcohols, Ketones, Hydrocarbons, Aromatics, Chlorinated Hydrocarbons	inf	inf
Flash point, TC (ºC)	-11.1	-14.5
Auto-Ignition Temperature (ºC)	270	321
Water Azeotrope		
Boiling Point (ºC)	71	63
Composition, wt % Solvent	89.4	93.3
wt % Water	10.6	6.7

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