Choosing a Constant Temperature Bath Liquid

In order to accurately measure kinematic viscosity in glass capillary viscometers, the viscometers must be suspended in a constant temperature bath. The ideal bath fluid would possess low viscosity, high heat capacity, and low vapor pressure over a wide range of temperatures. In addition, the liquid should have a very high flash point and be relatively low in cost. Because the viscometer must be viewed through the bath liquid, it is important for the liquid to clear and without color. Unfortunately, no single fluid meets all these requirements. When selecting a fluid, keep the following guidelines in mind.

Viscosity: Should be very low so that moderate stirring can effectively eliminate temperature gradients in the bath.

Heat Capacity: Temperature changes in the bath are less rapid when bath liquids with a high heat capacity (thermal conductivity) are used. With the exception of water, most choices for bath fluids will have about the same heat capacity.

Volatility: A liquid which is relatively volatile will require frequent replenishment. Furthermore, rapid evaporation at the bath surface produces a cooling effect, making control more difficult.

Because no single fluid can be used at all possible bath temperatures, the choice of a suitable fluid must begin by establishing the temperature range over which the bath will be operated. The following is a list of operating temperature ranges and some liquids suitable for use in these ranges.

Temperature Range	Recommended Bath Fluid
-100 °C to 10 °C (-148 °F to 50 °F)	Methyl Alcohol
-100 °C to 10 °C (-148 °F to 50 °F)	Ethyl Alcohol
-10 °C to 20 °C (14 °F to 68 °F)	Isopropyl Alcohol Low Viscosity Silicones
5 °C to 60 °C (41 °F to 140 °F)	Water, Low Viscosity Oils Silicones (Dow Corning® 200 fluid, 1 cSt)
60 °C to 100 °C (140 °F to 212 °F)	White Oil with oxidation inhibitor (IBF Bath Oil) Silicones (Dow Corning® 200 fluid, 10 cSt)
80 °C to 135 °C (212 °F to 275 °F)*	White Oil with oxidation inhibitor (IBF Bath Oil) Silicones (Dow Corning® 200 fluid, 20 cSt)
100 °C to 150 °C (212 °F to 275 °F)*	Silicones (Dow Corning® 200 fluid, 50 cSt)
135 °C to 200 °C (135 °F to 392 °F)*	Silicones (Dow Corning® 200 fluid, 200 cSt)
200 °C to 300 °C (392 °F to 572 °F)*	Silicones (Dow Corning® 550 fluid)

* The PMX 200 silicone oils can begin to decompose at temperatures above 150 °C. The decomposition process emits formaldehyde. These oils remain serviceable to 200 °C, but adequate ventilation infrastructure needs to be in place during use.

Methyl alcohol is quite volatile, has a low flash point, and has a degree of toxicity. Ethyl alcohol is also volatile and has a low flash point, but unless ingested is relatively non- toxic. Some halogen-based fluids are marketed as low temperature bath fluids, but these also have a high volatility, may be slightly toxic, and are quite expensive.

Isopropyl alcohol is less toxic than methyl alcohol and somewhat less volatile. However, it becomes highly viscous at low temperatures and is therefore unsuitable for use at very low temperatures.

Silicone fluids are available in a number of viscosities and can be used over a wide range of temperatures if the proper selection of viscosity is made for the temperature range of interest. A bath containing silicones requires extra care when used for capillary viscometry. If silicones enter inside a viscometer, its calibration factor may be altered by a significant amount. Silicones are also relatively expensive liquids. Likewise, degradation can occur at temperatures of 150 °C and above, so adequate ventilation must be in place if using silicone oils at high temperatures.

Water is almost the ideal fluid in the temperature range for which it is suitable. Because in some cases there is a tendency for algae formation, some degree of water treatment may be necessary. Water can be used at temperatures close to the boiling point, but water replenishment to offset evaporation becomes a nuisance and the hot vapor can make working above the bath uncomfortable. Also, it may be difficult to establish optimum control at elevated temperatures because of the rapid cooling resulting from surface evaporation.

Refined white oils (paraffin oils) of relatively low viscosity can be used at temperatures above the level at which water becomes unsatisfactory. Because these oils will turn faintly yellow and continue to darken with prolonged exposure to heat, we recommend using an oil like CANNONís IBF Bath Oil which contains an oxidation inhibitor to retard discoloration. Even with the addition of an inhibitor, after several months the oil will darken and must be replaced with new oil. Nevertheless, over the long term IBF Bath Oil will prove to be less expensive than silicones. It is also easily cleaned from viscometers without affecting the calibration factor.

The search for more suitable bath fluids is unending. Hydrogenated vegetable oils, coconut oil, synthetic oils, and certain chemical compounds have been used with some success at various temperatures. However, at CANNON, long experience has shown that the fluids listed in the above table will provide the best results.