

## Application Note

# Temperature dependence of viscosity of ethylene glycol

Industry	:	Petroleum, Energy
Instrument	:	EMS Viscometer
Measurement method	:	Electro Magnetically Spinning Method
Standards	:	-

## 1. Overview

Ethylene glycol is a kind of dihydric alcohol that is widely used, for example, as a solvent, and an ingredient for antifreeze and synthetic materials.

When used as antifreeze and kept in the minus temperature range, its viscosity will increase the higher its concentration becomes, negatively impacting its capacity to flow and provide cooling. This is why viscosity is such an important thing to measure when analyzing the performance of antifreeze.

In this application note, the determination of the temperature dependence of the dynamic viscosity of ethylene glycol using the EMS Viscometer, a non-contact viscometer that uses autoclavable and airtight sample tubes, is shown.

## 2. Precautions

If the instrument is set to measure at temperatures lower than ambient, make sure to introduce dry air into the instrument before starting measurement to prevent condensation.

## 3. Post-measurement procedure

All sample tubes and samples are discarded according to proper waste disposal procedures.

## 4. Apparatus

- EMS Viscometer
- Control Laptop PC
- Dry Air Unit
- Compressor

## 5. Reagents

- Sample: Ethylene glycol

## 6. Procedure

1) Select sequence mode in the control software and set the following measurement parameters:

✧ Temperature	: 0-200°C (10°C intervals)
✧ Motor rotation speed	: 1,000 rpm
✧ Meas. time	: 1 (1 second)
✧ Repeat times	: 10 times
✧ Meas. interval	: 5 seconds
✧ Hold time	: 10 minutes/600 sec

2) Transfer a 2mm diameter aluminum probe ( $\phi 2\text{mm}$ ) and 300 $\mu\text{L}$  of sample into a sample tube, seal it with its tube cap and packing, set the sample tube into the EMS Viscometer, and then click the measurement button.

## 7. Results & Discussion

The viscosity data for ethylene glycol across a temperature range of 0-200°C is shown in Table 1 and Table 2, and plotted on the graph in Figure 1, illustrating its temperature dependence of viscosity. The data agree very well with those outlined in the literature referenced below in section “9. References” at the end of this application note.

Though a relative elevation in data variation was observed for measurements at the highest temperatures (~180-200°C), the R.S.D. remained under 3%, with stable measurement achievable even at and above ethylene glycol’s boiling point (197.3°C).

This temperature dependence of viscosity study required 4 and a half hours to perform all measurements.

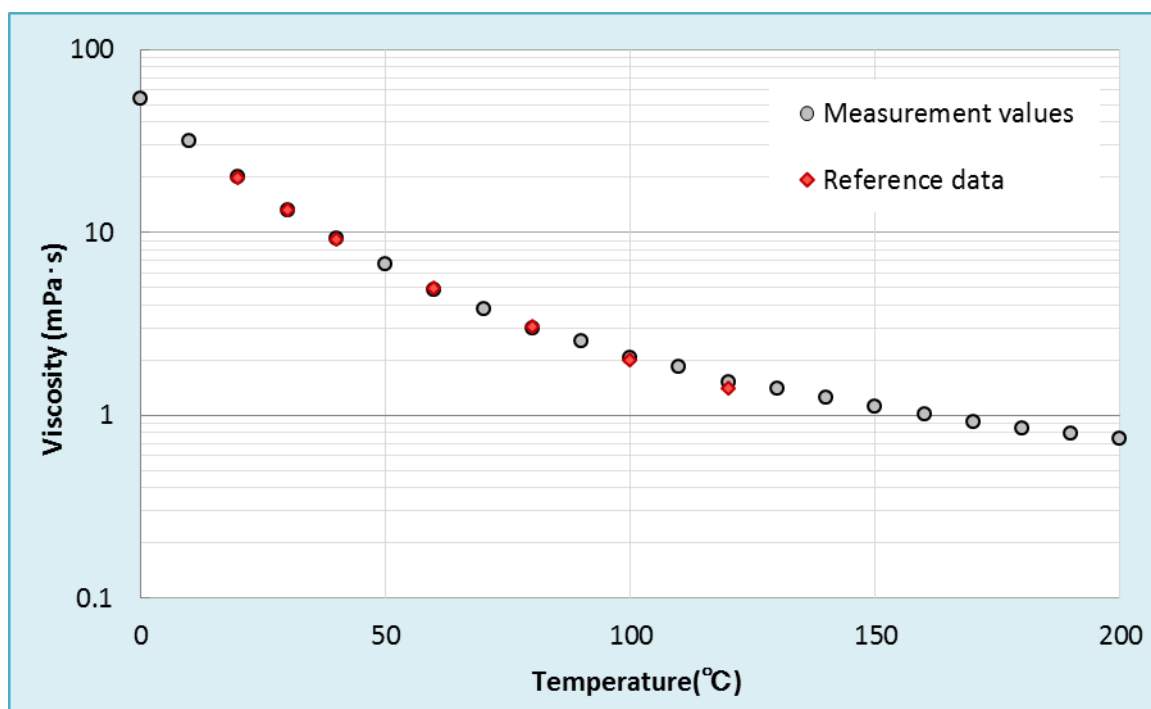


Figure 1. Data showing the temperature dependence of viscosity for ethylene glycol

**Table 1. The viscosity of ethylene glycol over a temperature range of 0 - 100°C**

(mPa·s)

Measurement Order	Temperature (°C)										
	0	10	20	30	40	50	60	70	80	90	100
1st	53.8	31.4	20.0	13.2	9.29	6.65	4.88	3.82	2.98	2.53	2.05
2nd	53.8	31.4	20.0	13.2	9.26	6.69	4.88	3.82	2.98	2.53	2.05
3rd	53.8	31.5	20.0	13.2	9.28	6.67	4.88	3.82	2.99	2.53	2.06
4th	53.8	31.4	20.0	13.2	9.29	6.68	4.89	3.83	2.99	2.53	2.05
5th	53.8	31.5	20.0	13.2	9.28	6.67	4.89	3.83	2.99	2.53	2.06
6th	53.8	31.5	20.0	13.2	9.29	6.66	4.88	3.82	2.98	2.53	2.05
7th	53.7	31.5	20.0	13.2	9.28	6.67	4.88	3.82	2.98	2.53	2.05
8th	53.7	31.5	20.0	13.2	9.28	6.67	4.89	3.83	2.98	2.53	2.05
9th	53.7	31.4	20.0	13.2	9.28	6.67	4.88	3.82	2.98	2.53	2.05
10th	53.7	31.5	20.0	13.2	9.29	6.67	4.88	3.82	2.98	2.53	2.05
Mean	53.8	31.5	20.0	13.2	9.28	6.67	4.88	3.82	2.98	2.53	2.05
Standard deviation	0.1	0.1	0.0	0.0	0.01	0.01	0.00	0.00	0.00	0.00	0.00
RSD (%)	0.1	0.2	0.0	0.0	0.1	0.2	0.1	0.1	0.2	0.0	0.2
Reference data			19.9	13.2	9.13		4.95		3.02		1.99

**Table 2. The viscosity of ethylene glycol over a temperature range of 110 - 200°C**

(mPa·s)

Measurement Order	Temperature (°C)									
	110	120	130	140	150	160	170	180	190	200
1st	1.84	1.51	1.39	1.24	1.12	1.01	0.92	0.85	0.79	0.70
2nd	1.83	1.52	1.39	1.24	1.12	1.01	0.92	0.85	0.78	0.77
3rd	1.83	1.51	1.39	1.25	1.12	1.00	0.92	0.85	0.77	0.76
4th	1.83	1.51	1.39	1.25	1.11	1.01	0.93	0.85	0.81	0.74
5th	1.82	1.51	1.40	1.24	1.12	1.01	0.92	0.85	0.81	0.74
6th	1.83	1.51	1.39	1.24	1.12	1.01	0.92	0.84	0.80	0.72
7th	1.83	1.51	1.39	1.24	1.12	1.00	0.92	0.86	0.79	0.74
8th	1.83	1.51	1.39	1.24	1.12	1.01	0.92	0.83	0.80	0.74
9th	1.83	1.51	1.39	1.26	1.13	1.01	0.92	0.85	0.80	0.74
10th	1.83	1.51	1.39	1.25	1.12	1.01	0.92	0.85	0.80	0.74
Mean	1.83	1.51	1.39	1.25	1.12	1.01	0.92	0.85	0.80	0.74
Standard deviation	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.02
RSD (%)	0.3	0.2	0.3	0.6	0.4	0.4	0.5	1.0	1.7	2.6
Reference data		1.40		1.04						

## 8. Summary

Temperature dependence of viscosity studies of ethylene glycol can be performed over a wide temperature range of 0-200°C with the EMS Viscometer. Even highly hygroscopic samples such as ethylene glycol can be measured stably thanks to the EMS Viscometer's airtight sample tubes.

## 9. References

Chemical Handbook (Revision the fifth edition) Basic course II -40

[Table 7.15 Temperature  $\theta$  dependence of viscosity coefficient  $\eta$  of organic compound]