Application Note
Concentration dependence of viscosity of aqueous alcohol solutions

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

1. Overview

Alcohols are utilized extensively across many industries, serving as an ingredient in products ranging from solvents, fuels, and disinfectants to foods, drinks, and cosmetics.
In this application note, the determination of the concentration dependence of the dynamic viscosity of aqueous alcohol solutions using the EMS Viscometer, a non-contact viscometer that uses autoclavable and airtight sample tubes, is shown.

2. Precautions

None.

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: Methanol, ethanol, 2-propanol, deionized water (diluent)

6. Procedure

1) Set the following measurement parameters in the EMSVisco software:

- Temperature : 20℃
- Motor rotation speed : 1,000 rpm
- Meas. time : I (1 second)
- Repeat times : 10 times
- Meas. interval : 30 seconds

Notes:
Each alcohol type is measured in order from a concentration of 100% to 10%.
A 0% (deionized water diluent) sample is also measured.
Each concentration is measured 10 times.

2) Transfer a 2mm diameter aluminum probe (φ2mm) and 300μL of sample into a sample tube, seal it with its tube cap and packing, and set the sample tube into the EMS Viscometer. Use the temperature control function to stabilize the temperature at 20℃ for 5 mins, and then commence measurement by clicking the start measurement button in the software.

3) After each measurement “time”, remove the sample tube and mix the sample by lightly shaking it. As each sample is measured 10 times, 9 shaking events are required per “measurement run”.

4) After the measurement run is complete, dilute the sample to the next concentration point and conduct a measurement run for it. Note that you simply add the desired deionized water to the same tube, no need to change the tube or probe.

7. Results & Discussion

Curves representing the concentration dependence of viscosity for all alcohol types are presented graphically in Figure 1, and the raw data used to generate them is tabulated in Tables 1-3.
Concentration dependence of viscosity plots generated from data for methanol and ethanol measured by the EMS viscometer is shown alongside that from chemical handbook literature (see Reference list) in Figures 2 and 3 respectively.
The results gained by the EMS Viscometer for all three samples show their expected characteristic concentration dependence with their viscosities peaking at about the 40% concentration mark. Results for methanol and ethanol were especially similar to reference data.

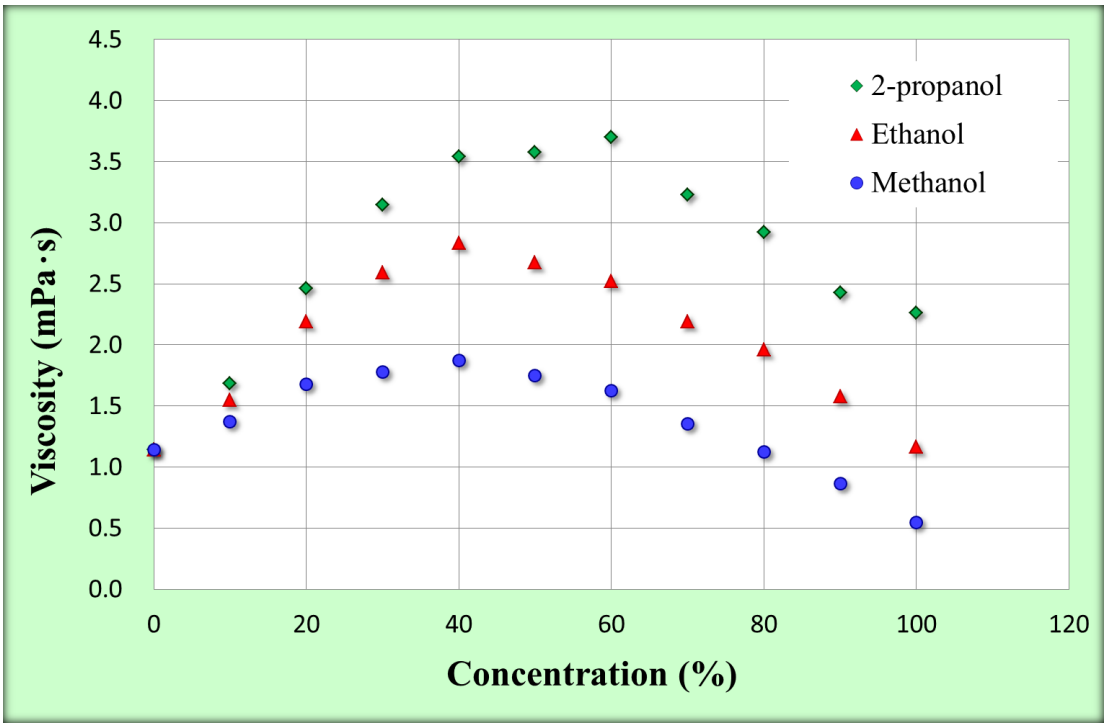

Figure 1. Concentration dependence of viscosity of 3 aqueous alcohol solutions

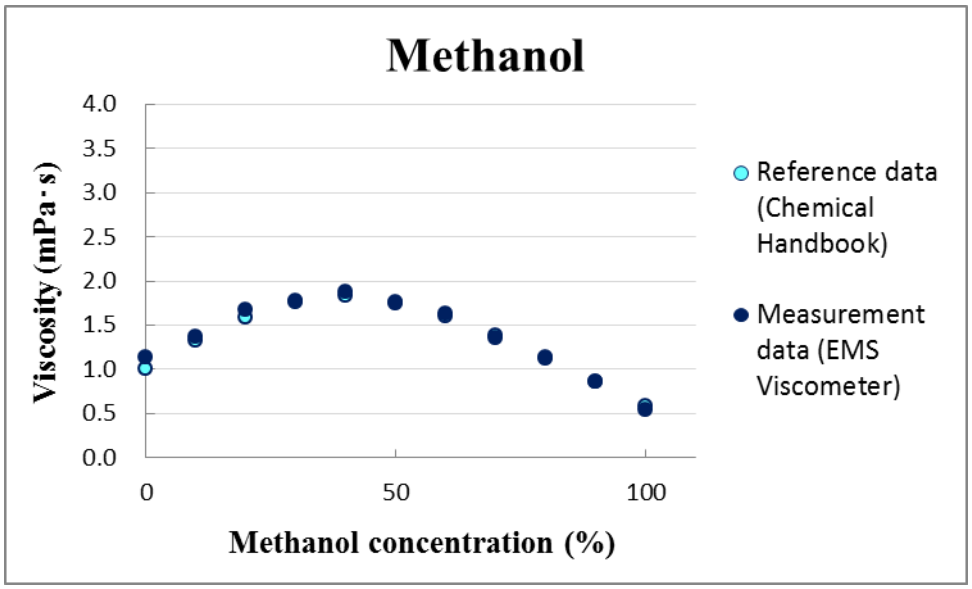

Figure 2. Concentration dependence of viscosity of aqueous methanol solution (EMS data alongside reference data)

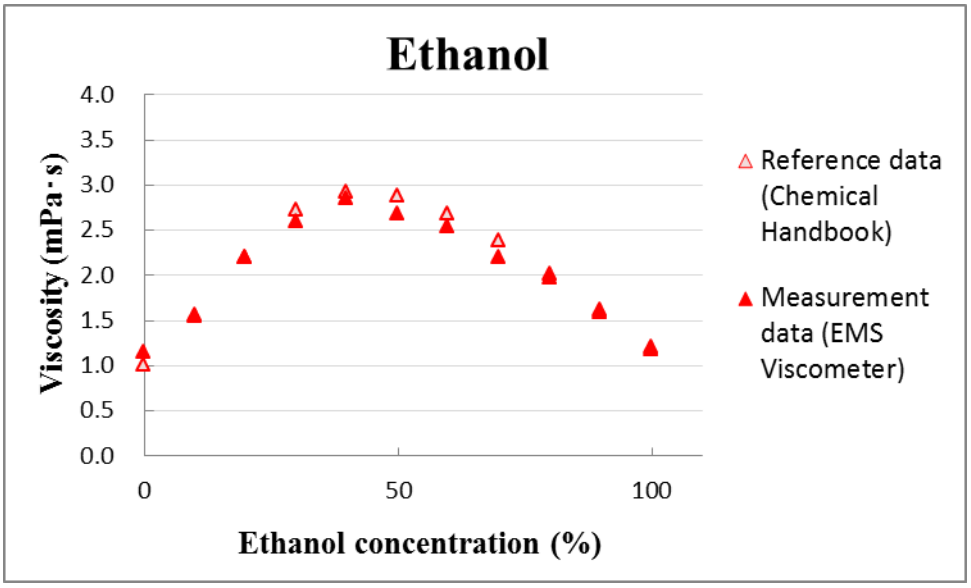

Figure 3. Concentration dependence of viscosity of aqueous ethanol solution (EMS data alongside reference data)

Table 1. Viscosity data for various concentrations of aqueous methanol solution

(mPa·s)

Methanol	Concentration (%)										
	0	10	20	30	40	50	60	70	80	90	100
1	1.10	1.32	1.63	1.74	1.83	1.80	1.58	1.32	1.07	0.82	0.51
2	1.03	1.31	1.75	1.75	1.84	1.71	1.65	1.34	1.09	0.91	0.52
3	1.20	1.42	1.79	1.76	1.82	1.85	1.56	1.36	1.13	0.88	0.52
4	1.07	1.39	1.64	1.82	1.86	1.80	1.70	1.38	1.18	0.87	0.52
5	1.10	1.42	1.66	1.79	1.88	1.73	1.58	1.36	1.12	0.82	0.56
6	1.21	1.33	1.66	1.78	1.94	1.66	1.57	1.37	1.09	0.91	0.57
7	1.14	1.37	1.64	1.76	1.88	1.80	1.58	1.35	1.11	0.88	0.55
8	1.20	1.33	1.66	1.81	1.85	1.70	1.70	1.35	1.13	0.85	0.54
9	1.21	1.33	1.66	1.81	1.87	1.73	1.69	1.37	1.15	0.84	0.58
10	1.15	1.50	1.68	1.74	1.94	1.74	1.63	1.34	1.15	0.87	0.57
Mean	1.14	1.37	1.68	1.78	1.87	1.75	1.62	1.35	1.12	0.87	0.54
Standard deviation	0.06	0.06	0.05	0.03	0.04	0.06	0.06	0.02	0.03	0.03	0.03
RSD (%)	5.64	4.42	3.09	1.70	2.22	3.33	3.52	1.31	2.96	3.75	4.68

Table 2. Viscosity data for various concentrations of aqueous ethanol solution

(mPa·s)

Ethanol	Concentration (%)										
	0	10	20	30	40	50	60	70	80	90	100
1	1.10	1.57	2.18	2.56	2.90	2.69	2.54	2.18	2.03	1.59	1.18
2	1.03	1.55	2.11	2.53	2.81	2.75	2.49	2.23	1.97	1.56	1.16
3	1.20	1.58	2.15	2.67	2.74	2.63	2.54	2.21	2.01	1.54	1.22
4	1.07	1.48	2.06	2.58	2.70	2.71	2.64	2.16	2.09	1.54	1.21
5	1.10	1.54	2.12	2.60	2.96	2.61	2.48	2.24	1.90	1.58	1.13
6	1.21	1.61	2.22	2.58	2.87	2.63	2.49	2.16	1.96	1.57	1.13
7	1.14	1.53	2.26	2.63	2.91	2.60	2.53	2.17	1.89	1.66	1.14
8	1.20	1.50	2.30	2.67	2.79	2.65	2.57	2.18	1.89	1.53	1.17
9	1.21	1.55	2.30	2.49	2.79	2.79	2.48	2.18	1.95	1.55	1.15
10	1.15	1.57	2.20	2.59	2.88	2.71	2.47	2.21	1.95	1.65	1.13
Mean	1.14	1.55	2.19	2.59	2.84	2.68	2.52	2.19	1.96	1.58	1.17
Standard deviation	0.06	0.04	0.08	0.06	0.08	0.06	0.05	0.03	0.03	0.05	0.03
RSD (%)	5.64	2.47	3.73	2.20	2.90	2.36	2.10	1.30	3.30	2.87	2.92

Table 3. Viscosity data for various concentrations of aqueous 2-propanol solution

(mPa·s)

2- propanol	Concentration (%)										
	0	10	20	30	40	50	60	70	80	90	100
1	1.10	1.63	2.43	3.22	3.44	3.55	3.84	3.18	2.98	2.45	2.25
2	1.03	1.75	2.47	3.03	3.68	3.51	3.78	3.24	2.97	2.53	2.24
3	1.20	1.66	2.43	3.21	3.65	3.53	3.69	3.19	2.92	2.46	2.23
4	1.07	1.68	2.45	3.21	3.59	3.58	3.56	3.22	3.04	2.42	2.29
5	1.10	1.74	2.44	3.21	3.64	3.57	3.89	3.24	2.93	2.39	2.29
6	1.21	1.71	2.48	3.11	3.47	3.57	3.62	3.20	2.82	2.43	2.29
7	1.14	1.74	2.43	3.16	3.53	3.73	3.62	3.27	2.82	2.38	2.29
8	1.20	1.63	2.48	3.04	3.53	3.65	3.52	3.19	2.97	2.45	2.25
9	1.21	1.62	2.49	3.02	3.42	3.51	3.84	3.23	2.86	2.38	2.24
10	1.15	1.68	2.50	3.24	3.47	3.57	3.63	3.33	2.92	2.37	2.23
Mean	1.14	1.68	2.46	3.15	3.54	3.58	3.70	3.23	2.92	2.43	2.26
Standard deviation	0.06	0.05	0.03	0.09	0.09	0.07	0.13	0.05	0.07	0.05	0.03
RSD (%)	5.64	2.93	1.10	2.45	2.64	1.88	3.51	1.40	2.46	2.03	1.18

8. Summary

Concentration dependence of viscosity studies requiring the measurement of volatile samples such as aqueous alcohol solutions can be performed with confidence by using the EMS Viscometer because it employs sealable sample tubes that prevent concentration changes caused by volatilization.

9. References

Chemical Handbook (Revision the fifth edition) Basic course II-49
[Table 7.22 Temperature θ dependence of viscosity coefficient η of ethanol aqueous solution]
[Table 7.23 Temperature θ dependence of viscosity coefficient η of methanol aqueous solution]