Application Note

Temperature dependence of viscosity of liquid crystal

Industry	:	Electricity & electronics
Instrument	:	Viscometer
Measurement method	:	Electro Magnetically Spinning Method
Standards	:	

1. Scope

Liquid crystal is a substance has a property as a solid as well as a liquid. Also, because it changes properties by heat and electric field, it is widely used as a liquid crystal display as applied equipment.
An example of measuring the temperature dependence of the dynamic viscosity of liquid crystal using an EMS viscometer that can be measured by sealing, sterilization and non-contact was shown below.

2. Precautions

When performing measurement below the ambient temperature, make sure to introduce dry air to the instrument before starting measurement in order to prevent dew condensation.

3. Post-measurement procedure

The sample container and the sample are discarded appropriately.

4. Apparatus

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

5. Reagents

- Sample ：5CB(4-cyano-4’-pentylbiphenyl),
- Toluene (dilution solvent)

6. Procedure

1) Enter the following conditions in measurement condition of the sequence mode of control software.

✧Measurement mode	:Sequence mode	
Measurement temperature	:5CB(100%)	25-50℃ ※
	5CB(96.8%)	10-45℃ ※
	5CB(93.8%)	0-35℃※
✧Motor rotation speed	:1,000 rpm	
✧Measurement time	:I (1 second)	
✧Repeat count	:20 times	
✧Measurement interval	:5 seconds	
✧Waiting time for temperature stability	:5 minutes	

2) Place an aluminum spherical probe of φ 2 mm and a sample of 300 µL in a container, cover with a cap and packing, set the sample container in the EMS Viscometer, and click the measurement button.
3) After the measurement is completed, return the temperature of the sample to room temperature, remove the cap, add 10 µL of toluene to the sample, lip and set the sample container into the EMS Viscometer again, and click the measurement button (5 CB (96.8%).
4) After the measurement is completed, return the temperature of the sample to room temperature, remove the cap, add 10 µL of toluene to the sample, lip and set the sample container into the EMS Viscometer again, and click the measurement button (5 CB (93.8%).

※measurement during raising the temperature

7. Example

The viscous behavior near the phase transition temperature of the sample at each concentration can be obtained. The measurement results are shown in Figure 1 and 2. And mean, standard deviation, and RSD of 20 times measurement results at each temperature are shown in Table 1-3.
The viscosity rises gradually along with a rise of the temperature at the phase transition. The momentary temperature of the phase transition can be confirmed by changing the temperature in detail. Figure 2 shows that the sample of the lower 5CB concentration has the low temperature of phase transition.

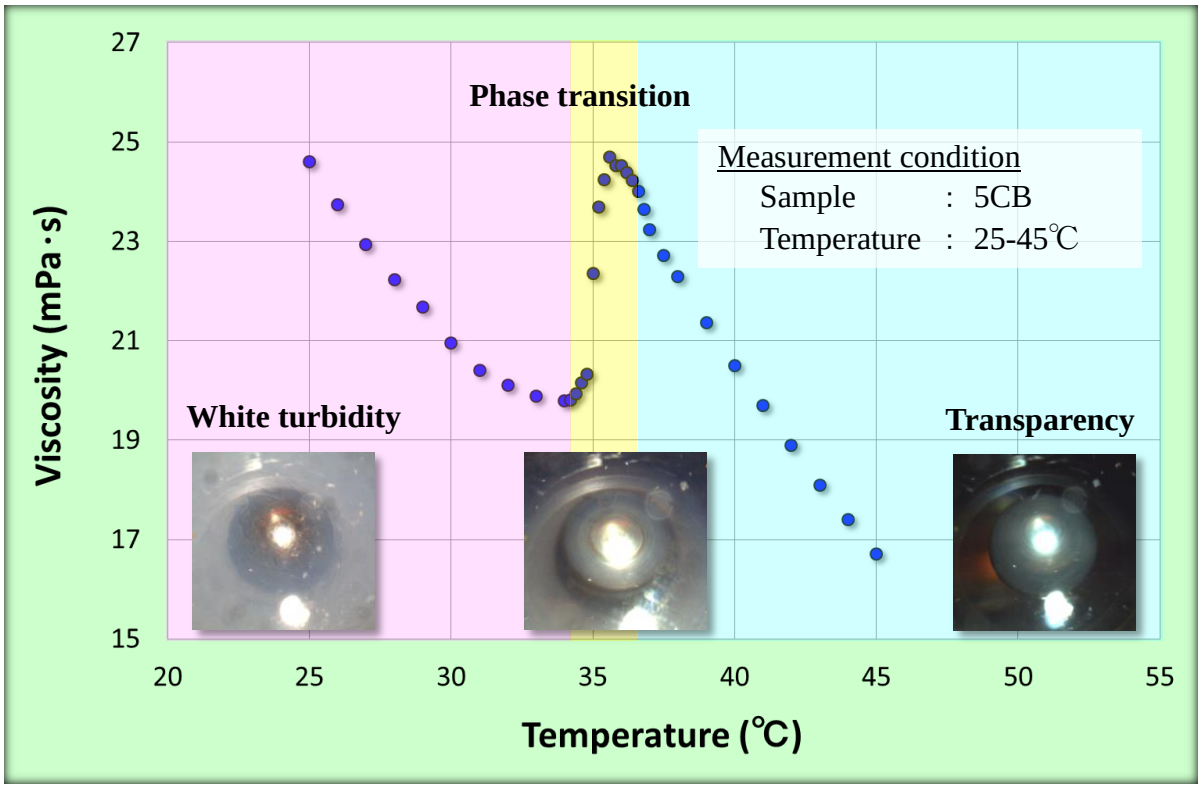

Figure 1. Measurement result about the temperature dependence of 5CB

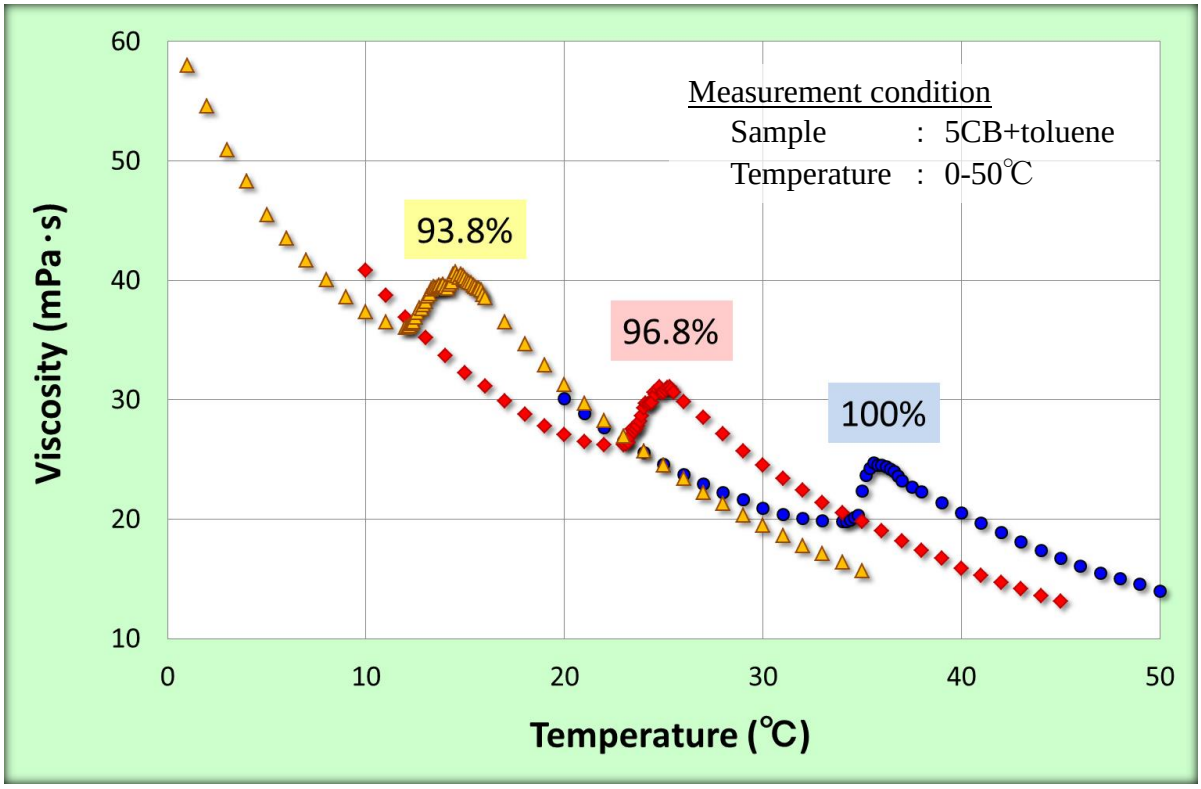

Figure 2. Measurement result about the temperature dependence of viscosity of 5CB diluted with toluene at each concentration

Table 1. Result of temperature dependence of 5CB

Temperature ℃	Mean mPa･s	Standard deviation mPa･s	RSD %
25	24.6	0.0	0.2
26	23.7	0.0	0.2
27	22.9	0.0	0.1
28	22.2	0.0	0.2
29	21.7	0.0	0.0
30	20.9	0.0	0.2
31	20.4	0.0	0.1
32	20.1	0.0	0.0
33	19.9	0.0	0.2
34	19.7	0.0	0.2
34.2	19.8	0.0	0.0
34.4	19.9	0.1	0.3
34.6	20.2	0.1	0.5
34.8	20.3	0.1	0.3
35	22.4	0.0	0.2
35.2	23.7	0.0	0.0
35.4	24.2	0.0	0.2
35.6	24.7	0.0	0.1
35.8	24.5	0.0	0.0
36	24.5	0.0	0.1
36.2	24.4	0.0	0.2
36.4	24.3	0.1	0.2
36.6	24.0	0.0	0.1
36.8	23.6	0.0	0.0
37	23.2	0.0	0.0
37.5	22.7	0.0	0.2
38	22.3	0.0	0.1
39	21.4	0.1	0.2
40	20.5	0.0	0.0
41	19.7	0.0	0.2
42	18.9	0.0	0.2
43	18.1	0.0	0.0
44	17.4	0.0	0.0
45	16.7	0.0	0.1
46	16.1	0.0	0.1
47	15.5	0.0	0.1
48	15.1	0.0	0.3
49	14.6	0.0	0.3
50	14.0	0.0	0.0

Table 2. Result of temperature dependence of 5CB diluted with toluene (concentration 96.8%)

Temperature ℃	Mean mPa･s	Standard deviation mPa･s	RSD %
10	40.8	0.1	0.2
11	38.8	0.0	0.1
12	36.9	0.1	0.1
13	35.2	0.0	0.1
14	33.7	0.1	0.2
15	32.2	0.1	0.2
16	31.1	0.2	0.7
17	29.9	0.1	0.3
18	28.8	0.1	0.2
19	27.8	0.0	0.1
20	27.1	0.1	0.2
21	26.5	0.1	0.3
22	26.2	0.1	0.3
23	26.2	0.0	0.1
23.1	26.3	0.0	0.1
23.2	26.4	0.1	0.2
23.3	26.9	0.1	0.2
23.4	27.5	0.1	0.2
23.5	27.3	0.1	0.3
23.6	27.5	0.1	0.2
23.7	27.8	0.0	0.2
23.8	28.2	0.0	0.1
23.9	28.6	0.0	0.2
24.0	29.3	0.0	0.1
24.1	29.7	0.0	0.1
24.2	29.6	0.1	0.3
24.3	29.7	0.1	0.2
24.4	29.8	0.1	0.3
24.5	30.6	0.1	0.3
24.6	30.4	0.1	0.2

Temperature ℃	Mean mPa･s	Standard deviation mPa･s	RSD %
24.7	30.8	0.1	0.3
24.8	31.0	0.1	0.2
24.9	30.6	0.0	0.1
25	30.6	0.0	0.1
25.1	30.8	0.1	0.2
25.2	31.0	0.0	0.2
25.3	31.1	0.0	0.0
25.4	30.9	0.1	0.2
25.5	30.6	0.0	0.0
26	29.8	0.0	0.0
27	28.5	0.0	0.1
28	27.1	0.1	0.2
29	25.7	0.2	0.7
30	24.5	0.0	0.0
31	23.4	0.0	0.2
32	22.4	0.0	0.0
33	21.4	0.0	0.0
34	20.5	0.0	0.0
35	19.8	0.0	0.0
36	19.0	0.0	0.0
37	18.1	0.1	0.3
38	17.4	0.0	0.0
39	16.7	0.0	0.0
40	15.9	0.0	0.0
41	15.3	0.0	0.0
42	14.7	0.0	0.0
43	14.2	0.0	0.3
44	13.6	0.0	0.0
45	13.1	0.0	0.0

Table 3. Result of temperature dependence of 5CB diluted with toluene (concentration 93.8%)

Temperature ℃	Mean mPa･s	Standard deviation mPa･s	RSD %	Temperature ℃	Mean mPa･s	Standard deviation mPa･s	RSD %
0	60.3	0.2	0.3	14.4	40.5	0.0	0.1
1	58.0	0.3	0.5	14.5	40.7	0.2	0.6
2	54.6	0.2	0.3	14.6	40.4	0.1	0.1
3	50.9	0.1	0.1	14.7	40.2	0.1	0.2
4	48.3	0.0	0.1	14.8	40.5	0.2	0.5
5	45.5	0.0	0.1	14.9	40.4	0.2	0.4
6	43.5	0.1	0.1	15	40.2	0.0	0.1
7	41.7	0.1	0.2	15.1	40.0	0.0	0.1
8	40.1	0.1	0.1	15.2	39.9	0.0	0.1
9	38.6	0.0	0.1	15.3	39.8	0.0	0.1
10	37.4	0.0	0.1	15.4	39.6	0.0	0.1
11	36.5	0.0	0.1	15.5	39.5	0.1	0.1
12	36.0	0.1	0.1	15.6	39.4	0.1	0.1
12.1	36.1	0.0	0.1	15.7	39.3	0.1	0.3
12.2	36.2	0.0	0.1	15.8	39.2	0.1	0.2
12.3	36.4	0.1	0.1	15.9	38.8	0.0	0.1
12.4	36.5	0.1	0.3	16	38.6	0.1	0.2
12.5	36.9	0.0	0.1	17	36.5	0.1	0.1
12.6	37.3	0.0	0.1	18	34.7	0.1	0.1
12.7	37.7	0.0	0.1	19	32.9	0.0	0.0
12.8	37.6	0.0	0.1	20	31.3	0.1	0.2
12.9	37.9	0.0	0.1	21	29.7	0.0	0.0
13	38.2	0.1	0.2	22	28.3	0.0	0.2
13.1	38.7	0.1	0.1	23	27.0	0.1	0.3
13.2	38.9	0.1	0.2	24	25.7	0.0	0.1
13.3	39.2	0.1	0.2	25	24.5	0.0	0.1
13.4	39.5	0.1	0.3	26	23.4	0.0	0.2
13.5	39.4	0.0	0.1	27	22.2	0.1	0.2
13.6	39.5	0.1	0.1	28	21.3	0.0	0.0
13.7	39.6	0.1	0.1	29	20.4	0.1	0.2
13.8	39.5	0.1	0.2	30	19.5	0.0	0.2
13.9	39.7	0.2	0.5	31	18.6	0.0	0.0
14	39.5	0.2	0.4	32	17.8	0.0	0.0
14.1	39.3	0.1	0.3	33	17.1	0.0	0.0
14.2	39.7	0.1	0.2	34	16.4	0.0	0.3
14.3	39.8	0.1	0.2	35	15.7	0.0	0.0

8. Summary

It is possible to add dilution solvent to an undiluted solution and measure the viscosity of the sample, because the sample volume does not affect the viscosity value even if is more than minimum required amount 300μL. A rare sample (expensive sample) can be evaluated by small amount of sample.
Moreover, as shown in Figure 1, it is possible to be observed the color change in the solution with built-in CMOS camera.

9. References

None.