KYOTO ELECTRONICS MANUFACTURING CO.,LTD.

Application Note
Temperature dependence of viscosity of liquid crystal

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

1. Scope

Liquid crystal has properties that span between both those of conventional liquid and those of crystalline solids, and it is popularly used in the display of electronic devices as its properties can be conveniently influenced by electric fields and heat for example.

In this application note, the determination of the temperature dependence of the dynamic viscosity of liquid crystal 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: 5CB(4-cyano-4’-pentylbiphenyl),
- Toluene (diluent)

6. Procedure

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

✧Temperature	:5CB (100%)	25-50°C*
	5CB (96.8%)	10-45°C*
	5CB (93.8%)	0-35°C*
✧Motor rotation speed	:1,000 rpm	
✧Meas. time	:I (1 second)	
✧Repeat times	:20 times	
✧Meas. interval	:5 seconds	
✧Hold time	:5 minutes/300 sec	

2) Transfer a 2mm diameter aluminum probe (φ2mm) and 300μL 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. (5CB (100%); see "1)" above)

3) After the measurement is complete, remove the sample tube and return it to room temperature. Once at room temperature, remove its cap, add 10μL of toluene, recap the tube and set it back into the instrument, and click the measurement button (5 CB (96.8%); see "1)" above).

4) After the measurement is complete, remove the sample tube and return it to room temperature. Once at room temperature, remove its cap, add 10μL of toluene, recap the tube and set it back into the instrument, and click the measurement button (5 CB (93.8%); see "1)" above).

* measurement conducted from coldest to warmest temperature

7. Results & Discussion

The EMS Viscometer resolved well the behavior of the viscosity of 5CB around its phase transition point for all 3 concentrations measured. Graphs for the temperature dependence of viscosity before, during, and after phase transition as well as photos showing the appearance of 5CB during the experiments are provided in Figures 1 and 2. Tables 1-3 contain the viscosity data used to generate the aforementioned graphs, inclusive of mean, standard deviation, and RSD calculated from 20 measurements for each temperature point.

It was evident that viscosity increased over the small phase transition temperature range. Making very small temperature increases around the phase transition point allowed a more detailed characterization of the viscosity of 5CB during phase transition. Figure 2 shows that the more dilute the 5CB sample was, the lower the temperature that phase transition occurred.

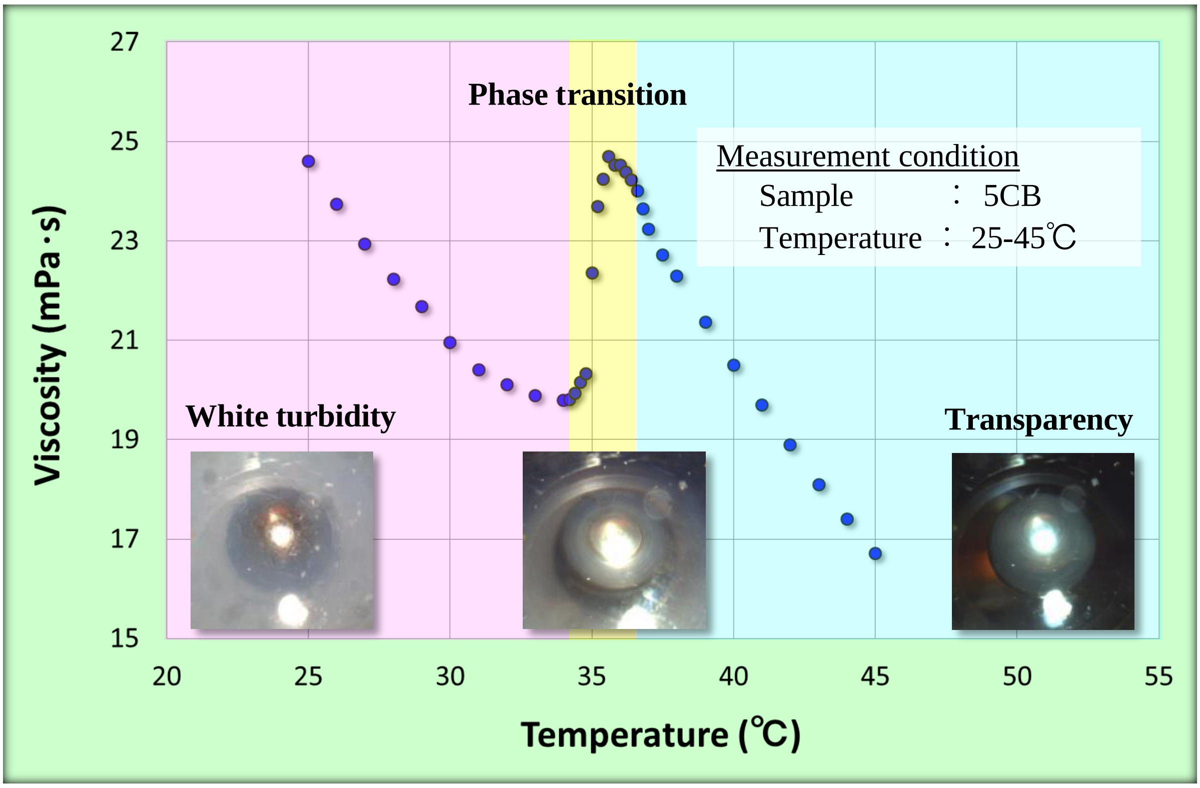

Figure 1. Temperature dependence of viscosity for 100% 5CB before, during and after phase transition.

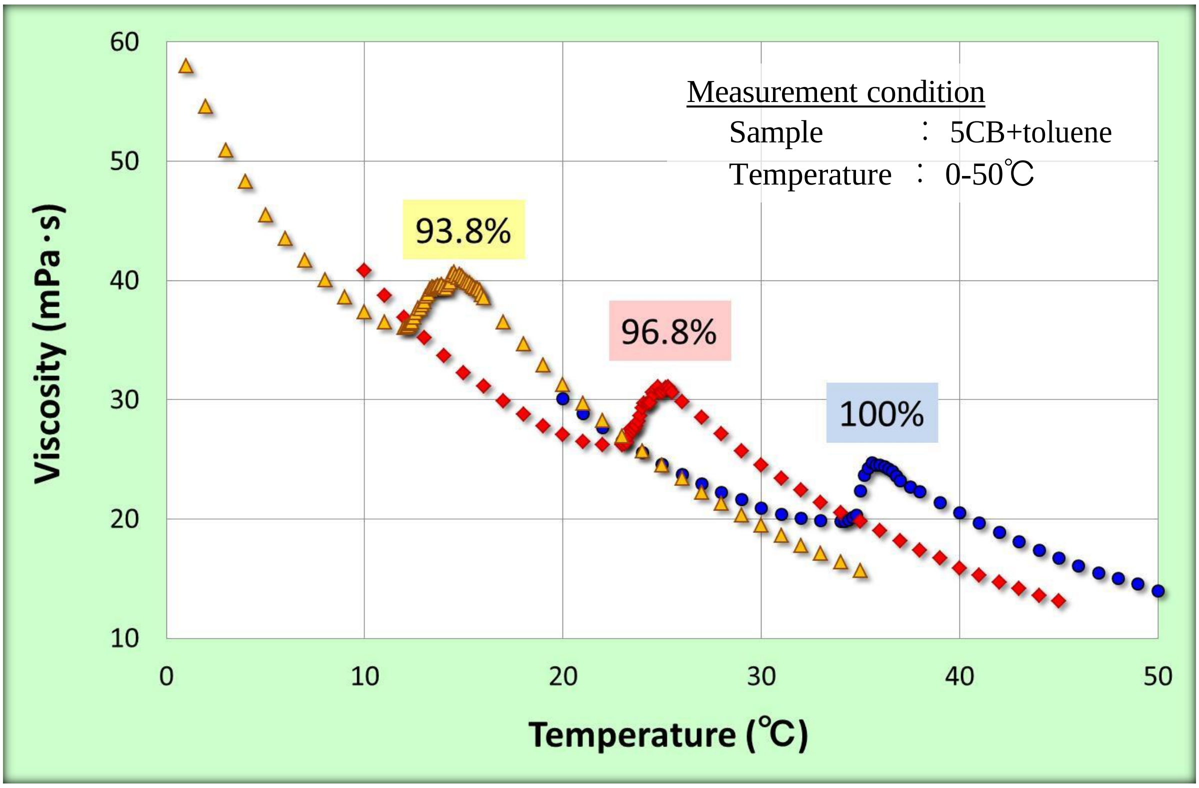

Figure 2. Temperature dependence of viscosity for 93.8%, 96.8% and 100% 5CB before, during and after phase transition.

Table 1. 5CB (100%) viscosity data over a temperature range of 25-50°C

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. 5CB (96.8%) viscosity data over a temperature range of 10-45°C

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
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. 5CB (93.8%) viscosity data over a temperature range of 0-35°C

Temperature °C	Mean mPa･s	Standard deviation mPa･s	RSD %
0	60.3	0.2	0.3
1	58.0	0.3	0.5
2	54.6	0.2	0.3
3	50.9	0.1	0.1
4	48.3	0.0	0.1
5	45.5	0.0	0.1
6	43.5	0.1	0.1
7	41.7	0.1	0.2
8	40.1	0.1	0.1
9	38.6	0.0	0.1
10	37.4	0.0	0.1
11	36.5	0.0	0.1
12	36.0	0.1	0.1
12.1	36.1	0.0	0.1
12.2	36.2	0.0	0.1
12.3	36.4	0.1	0.1
12.4	36.5	0.1	0.3
12.5	36.9	0.0	0.1
12.6	37.3	0.0	0.1
12.7	37.7	0.0	0.1
12.8	37.6	0.0	0.1
12.9	37.9	0.0	0.1
13	38.2	0.1	0.2
13.1	38.7	0.1	0.1
13.2	38.9	0.1	0.2
13.3	39.2	0.1	0.2
13.4	39.5	0.1	0.3
13.5	39.4	0.0	0.1
13.6	39.5	0.1	0.1
13.7	39.6	0.1	0.1
13.8	39.5	0.1	0.2
13.9	39.7	0.2	0.5
14	39.5	0.2	0.4
14.1	39.3	0.1	0.3
14.2	39.7	0.1	0.2
14.3	39.8	0.1	0.2

Temperature °C	Mean mPa･s	Standard deviation mPa･s	RSD %
14.4	40.5	0.0	0.1
14.5	40.7	0.2	0.6
14.6	40.4	0.1	0.1
14.7	40.2	0.1	0.2
14.8	40.5	0.2	0.5
14.9	40.4	0.2	0.4
15	40.2	0.0	0.1
15.1	40.0	0.0	0.1
15.2	39.9	0.0	0.1
15.3	39.8	0.0	0.1
15.4	39.6	0.0	0.1
15.5	39.5	0.1	0.1
15.6	39.4	0.1	0.1
15.7	39.3	0.1	0.3
15.8	39.2	0.1	0.2
15.9	38.8	0.0	0.1
16	38.6	0.1	0.2
17	36.5	0.1	0.1
18	34.7	0.1	0.1
19	32.9	0.0	0.0
20	31.3	0.1	0.2
21	29.7	0.0	0.0
22	28.3	0.0	0.2
23	27.0	0.1	0.3
24	25.7	0.0	0.1
25	24.5	0.0	0.1
26	23.4	0.0	0.2
27	22.2	0.1	0.2
28	21.3	0.0	0.0
29	20.4	0.1	0.2
30	19.5	0.0	0.2
31	18.6	0.0	0.0
32	17.8	0.0	0.0
33	17.1	0.0	0.0
34	16.4	0.0	0.3
35	15.7	0.0	0.0

8. Summary

Diluting 5CB as outlined in section “6. Procedure” above, results in no change in its viscosity, allowing for convenient temperature of dependence studies to be conducted on it at various concentrations.

The viscosity of expensive and/or scarce samples can be evaluated at little cost or loss thanks to the EMS Viscometer being able to measure small volume samples (standard system minimum sample is 300μL; customized system minimum sample is 90μL)

The built-in CMOS camera of the EMS Viscometer was useful in monitoring the color and transparency of the sample during the experiments.

9. References

None.