

STUDENT LABORATORY WORKSHEET EXPERIMENT B: LIQUID CRYSTALS

Student name:.....

Date:.....

- AIM:**
- Understanding of concept of self-assembly
 - Understanding that the way a material behaves at the macroscale is affected by its structure at the nanoscale
 - Learn about liquid crystals and how they work
 - Test a real thermotropic liquid crystal and see how its colour changes with temperature

BEFORE YOU FILL IN THIS WORKSHEET:

- read the STUDENT BACKGROUND sheet
- ask your teachers questions if you have any

MATERIALS:

- 4 vials of liquid crystal mixture, each containing a different one
- A water bath (hotplate, Pyrex glass water container half filled with water, thermometer)
- 1 sheet of clear contact paper
- 1 cloth peg
- 1 spatula
- 1 pair of scissors
- 1 sheet black cardboard (A4 size)
- 1 foam sheet (A4 size)
- Gloves
- Protection glasses
- Tissue paper
- A room thermometer

SAFETY NOTE: The chemicals used in this experiment need to be used according to MSDS specifications. Personal protection must be taken as indicated. As with all chemicals, use precautions. Solids should not be inhaled and contact with skin, eyes or clothing should be avoided. Wash hands thoroughly after handling. Dispose as indicated. All experiments must be conducted in the presence of an educator trained for science teaching. All experiments will be carried out at your own risk. Aarhus University (iNANO) and the entire NANOYOU consortium assume no liability for damage or consequential losses sustained as a result of the carrying out of the experiments described.

PROCEDURE

1. Prepare four different liquid crystal mixtures

Follow the synthesis procedure as described in the document **“synthesis of liquid crystal mixtures”** and prepare four different liquid crystal mixtures according to the table below. Each mixture is expected to be sensitive to different ranges of temperatures. If not doing the synthesis, get four vials containing the mixtures from instructor/teacher. **Do not inhale content of vials.**

Liquid crystal	Cholesteryl oleyl carbonate	Cholesteryl pelargonate	Cholesteryl benzoate	Temperature (°C)
Type 1	0.65	0.25	0.10	17-23
Type 2	0.45	0.45	0.10	26.5-30.5
Type 3	0.40	0.50	0.10	32-35
Type 4	0.30	0.60	0.10	37-40

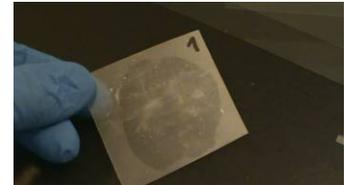
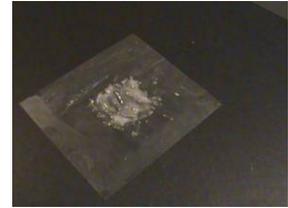
2. Prepare four different liquid crystal sheets

Cut out two pieces of transparent contact paper (about 10x10 cm), peel off the back paper and place on the laboratory bench. With a spatula place some Type 1 liquid crystal on the centre of the sheet. If the liquid crystal is very cold and has turned into a solid, heat the vial first with a hairdryer (it should be the consistency of honey). You will need 2-3 spatulas of material. Place the second piece of contact paper on top of the first one, so that the two sticky parts attach to each other. As you do so, gently press the middle area where the liquid crystal is and distribute evenly. You need to create a thin layer of liquid

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crystal about 4x4 cm. Do not press too hard, otherwise the material will come out from the edges. Cut the sheet at the end around the edges. Write with a permanent marker on the corner of the sheet a number corresponding to the type of liquid crystal (1 for "Type 1" and so on).



Repeat the same procedure for the 4 types of liquid crystals.

Q1. What is the temperature in the room you are in?.....

Q2. Can any of the four liquid crystal mixtures you have made be used for sensing the temperature of your room? If yes, which one?.....

.....

3. Now test the four different liquid crystal sheets!

Place the four liquid crystal sheets you have just made on an **A4 sheet of white paper**. Wait few seconds. What do you see? Now press with your one finger (wearing gloves) against each of the liquid crystal sheets. Repeat the experiment putting the sheets on an **A4 sheet of black cardboard**. In order to compare the different sheets you should keep the finger on each sheet for the same time. Record your observations on the table in the next page.

	White paper	Black paper
Sheet 1 (Type 1)		
Sheet 2 (Type 2)		
Sheet 3 (Type 3)		
Sheet 4 (Type 4)		

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Q3. Why do you get a different result if you test the liquid crystal sheets against white paper or black paper?

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Q4. Did all the sheets display some colour? If not, why is that? What can you do to make these sheets display colour?

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Now rub your hands and test again each of the sheets. Do you see any difference?

.....

Now turn on the water bath and set it to a water temperature of 15° C. To be able to see the colour changes, place an A4 sheet of black cardboard safely behind the water bath. **NB: paper and card should not touch the hotplate!**



Hold the first liquid crystal Sheet 1(type 1) with a clothes peg and immerse it the water bath (see figure below). Do you see any colour? Now increase the hotplate temperature so that the water reaches 23° C. Record the colours that you see as the temperature increases:

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Sheet 1 (Type 1)		
Temperature (C)	Colour	Comments
16		
17		
18		
19		
20		
21		
22		
23		

Q5. At what temperature do you start to see some colour (sheet 1)? Does this correspond to the predicted temperature (according to table 1)?

.....

Q6. Does the scale of colours that you have recorded in the table above match a wavelength scale? Why?

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Q7. When you take out the liquid crystal sheet from the water bath, does it lose its colour immediately? If not, why do you think this happens?

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Q8. Imagine putting Sheet 1 (Type 1) of liquid crystal in a water bath of which you don't know the temperature. The sheet turns orange. What temperature is the water bath?

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Continue the experiment testing the other liquid crystal sheets you have made.

- Place Sheet 2 in the water bath you have just used (now at 23° C) and increase the temperature so that the water gradually reaches 30° C. What happens? Record your observations (use the table below).

Sheet 2 (Type 2)		
Temperature (C)	Colour	Comments
22-23		
23-24		
25		
26		
27		
28		
29		
30		

- When the water temperature reaches 30° C, test Sheet 1 (Type 1) again.

Q9. Can Sheet 1 detect temperatures around 30° C? Why?.....

Continue the experiment testing the other liquid crystal sheets you have made.

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- **Test Sheet 3 (Type 3):** Place Sheet 3 in the water bath you have just used (now at 30° C), increase the temperature so that the water gradually reaches 35° C. What happens? Record your observations (use the table below).

Sheet 3 (Type 3)		
Temperature (C)	Colour	Comments
30		
31		
32		
33		
34		
35		

- **Now test Sheet 4 (Type 4):** Increase the temperature of the hotplate so that the water temperature increases from 35 to 40° C. Record your observations in the table below.

Sheet 4 (Type 4)		
Temperature (C)	Colour	Comments
35		
36		
37		
38		
39		
40		

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Q10. Was the colour sequence that you observed for Sheet 3 and Sheet 4 the same as for Sheet 1?
Why/Why not?

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Q11. When you take out the liquid crystal Sheet 3 or Sheet 4 from the water bath, does it behave like Sheet 1? What is the difference? Why?

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Q12. What type of liquid crystal among the four types that you have would you use for checking whether you have a fever? Why?

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3. Making a liquid crystal room thermometer

Now you can make a **liquid crystal room thermometer**. You can use the liquid crystal sheets made in the previous part of the experiment. You can make new ones if necessary. **Safety note:** wear gloves as you make the thermometer. Be careful not to squeeze the liquid crystal sheets so that the liquid crystal is pressed outside the sheet. If this happens, clean immediately with paper.



- Write on the white foam the word NANO. You will need to “fill” each letter with one liquid crystal sheet, so make sure the single letters are large enough (see image).

- With a paper cutter, cut the four letters from the foam board.

- Attach on the back of each letter one different liquid crystal sheet, following this order:

N – Type 1

A – Type 2

N – Type 3

O – Type 4

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- Secure each letter one at a time, using long pieces of clear contact paper. Alternatively you can use transparent tape. Make sure that the liquid crystal sheets do not overlap inside the letters. **The idea is that each letter should contain only one liquid crystal sheet.**
- Once you have attached all the liquid crystals sheets, attach the white foam to the black cardboard (placing the side where the sheets are against the black card).

- **Now you have a room thermometer!**

Q13. Does your room thermometer show any colour? If not, why not?

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If you don't get any response from the thermometer try placing it over a working laptop computer.... It will show what we all know, that they heat up!

- You can use your thermometer throughout the year. In summer take it outside under the sun, or you can place it on the class window.

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CREDIT: This experiment was adapted from the activity "Preparation of Cholesteryl Ester Liquid Crystals" available at http://mrsec.wisc.edu/Edetc/nanolab/LC_prep/index.htm and from the "Exploring materials: Crystal Liquids" activity developed by the NISE network (Creative Commons Attribution ShareAlike 3.0). The activity was developed for the NISE Network with funding from the National Science Foundation under Cooperative Agreement #ESI-0532536. Any opinions, findings, and conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the Foundation.



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