Sunset Yellow Phase Diagram

V. R. Horowitz

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Abstract

The procedure for mapping the phase transitions was as follows: I first mixed the solution of dye, then sealed it in a glass cell. Sealing the cell was necessary to prevent evaporation that would alter the concentration of the solution. The cell was then placed on a heating stage on a microscope, between crossed polarizers, and slowly heated. As the dye heated, more and more of it changed from nematic to isotropic, and I recorded these temperatures. I then cooled the sample and recorded the temperatures as the sample changed from isotropic to nematic.

Solid Sunset Yellow FCF absorbs moisture. In order to prevent this extra water from affecting the concentration of the solutions, I ground the solid Sunset Yellow with a mortar and pestle and put it under a vacuum overnight to dry. Afterwards, it was stored in the vacuum chamber. I mixed each concentration of Sunset Yellow on the same day I used it for measurements, so that the solution would not have much time to evaporate. Solutions were stored in sealed vials.

I used glass microscope slides, Devcon high strength two-part, two-ton all purpose epoxy adhesive, and 10-μm diameter glass fibers to make homemade glass cells, shown in Fig. 1. I mixed the epoxy with a small amount of glass fibers. I put a tiny drop of the mixture of epoxy and glass fibers on each of the four corners of a small rectangle of glass, then stuck this rectangle onto a larger

rectangle of glass. I pressed the two pieces together, checking to see that they were parallel to each other by holding the cell under monochromatic light and making sure the interference fringes were not too close together. Since I wanted my cells to be sealed so that the water in the solutions

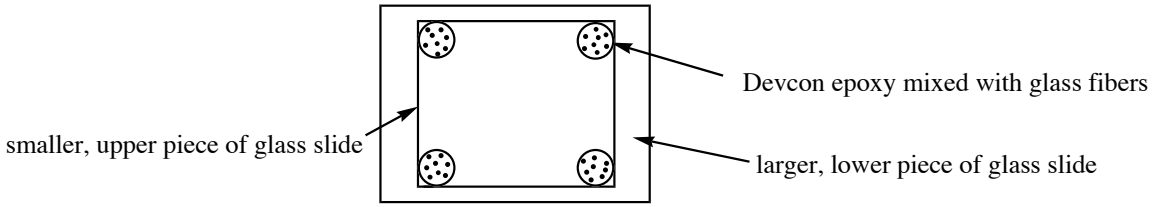

Figure 1: For the unsealed homemade cell, two pieces of a glass slide are glued together, spaced apart by 10-μm diameter glass fibers.

would not evaporate, I then sealed the edges of the cell together with more Devcon epoxy, this time without any glass fibers. I left two gaps around the edge so that later there would be space to fill the cell with Sunset Yellow in solution. Several types of glue were tried before I decided to use Devcon epoxy, since this epoxy was better able to seal the cell to prevent evaporation. When I filled the cell, I would seal the gaps with critoseal and immediately take measurements for the phase diagram.

Filling the cells could take a few minutes as the capillary action slowly drew solution further into the cell. During this time, the solution was open to the air and would evaporate. To prevent this, I always filled the cells inside a humidity chamber. This was, in fact, an oven with open plates of water. The humidity was generally between 90% and 100%, but it could fall to 60% if the door was open too long, so I left the cells inside the closed chamber while they were filling.

I taped each cell into a heating stage and placed it in a microscope between crossed polarizers. ramping the heating stage at 0.4°C per minute. I observed the phase changes while ramping up, noting the temperature where the isotropic phase first appeared and the temperature where the nematic phase completely disappeared. Similarly, while ramping down I noted the temperature

where the nematic phase first appeared and the temperature where the isotropic phase completely disappeared. The coexistence region was determined to be between the two temperatures for each ramping procedure. Figure 2 shows how the coexistence region looks in the microscope, between crossed polarizers.

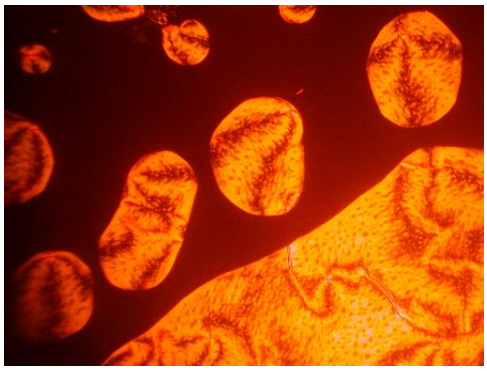

Figure 2: As the solution of Sunset Yellow passes between the isotropic phase and the nematic phase, patches of the solution are isotropic and patches are nematic. This is the coexistence, or two-phase, region. The colorful patches are nematic while the darker areas are isotropic. This picture shows a cell that had evaporated until it was in the coexistence region at room temperature.

The Sunset Yellow phase diagram, shown in Fig. 3, illustrates how the phase of Sunset Yellow varies with temperature and concentration in water.

While the heating stage was ramping up or down, the sample of Sunset Yellow did not quite keep up with the temperature of the stage. Temperatures measured while heating were higher than temperatures measured while cooling. Each data point on the phase diagram actually represents two measured data points: the top of the error bar and the bottom of the error bar. The top of the error bar is the temperature of the heating stage when the solution changed phase while heating, whereas the bottom of the error bar is the temperature of the heating stage when the solution changed phase while cooling. I assumed that the average of these two points was a more accurate measurement of the phase transition temperature.

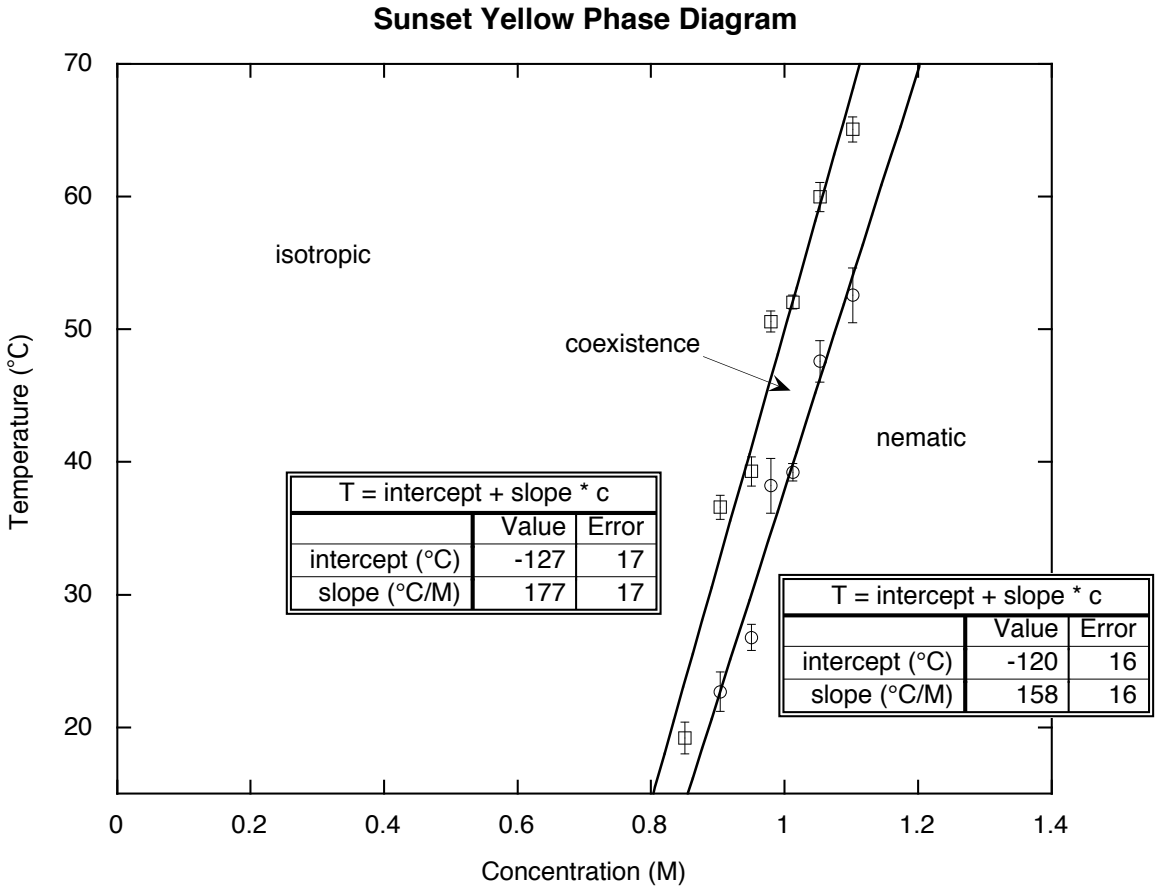

Figure 3: The phase diagram for Sunset Yellow FCF shows how the phase of the solution depends on the concentration and the temperature.

A comparison to Robert J. Luoma's dissertation[1] shows that this phase diagram agrees with previous measurements. In Fig. 3, the coexistence region occurs at approximately 0.5 M higher concentration than Luoma's diagram. This is probably due to a different sample purity, water content of solid, and amount of evaporation during filling.

[1] *X-ray scattering and magnetic birefringence studies of aqueous solutions of chromonic molecular aggregates.* Luoma, Robert J., Brandeis University, 1995.