

Lab activity: Build your own phase diagram

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Preparation of the starting mixtures.

The lab activity was initially designed for a course organized as weekly module. We determined that a 3-hour lab period is too short for the students to have time to prepare the mixtures and run the experiments. This is why we preconize to prepare the mixture in advance.

Reusing mixtures obtained from fully melted components from a previous lab session allows to generate a single solid material once solidified. The coloring help for visualizing variations of mass proportions between the two acids, but it could also be beneficial for the students to understand how the mixtures were prepared and bringing the colored acid powder used before mixing could help.



Figure 1. Colored acid powders used to prepare the mixtures.

If time allows, the instructor may choose to use two lab periods (3 hours each) for this activity and let the students prepare their own mixtures. We added instructions and lab questions for this (see below).

Tip: Water temperature:

The range of 60-65°C was chosen so the instructor can be certain that all experiments start well above the liquidus temperature of the tested mixture but at a temperature low enough that the hot water does not become a safety hazard for potential burns in case of spilling. Using a kettle to boil the water is both safer and quicker than trying to warm up the water using the hot plate at the beginning of the lab. The use of the hot plate is only meant to keep the water above 60 °C. If hot plates are not available, alternatively, students can add boiling water to their beaker to re-increase the temperature above 60 °C.

Keys and Rubrics:

In the keys provided in this lab activity, we include the results obtained in four lab sessions in the Department of Geology and Geophysics at the University of Utah (Fall 2023, Spring 2024, Fall 2024, and a test conducted by Dr. Lambart in Summer 2023).

Rubrics are also provided for each part in the corresponding spreadsheets.

References:

- Zhixuan Fan, Yunchao Zhao, Xuying Liu, Yu Shi, and Dahua Jiang (2022), Thermal Properties and Reliabilities of Lauric Acid-Based Binary Eutectic Fatty Acid as a Phase Change Material for Building Energy Conservation. ACS Omega 2022 7 (18), 16097-16108, DOI: 10.1021/acsomega.2c01420

- Bjorn Joos, Marlies K. Van Bael, and An T. Hardy (2020). Construction of a Room-Temperature Eutectic Binary Phase Diagram by Use of Differential Scanning Calorimetry, Journal of Chemical Education 2020 97 (8), 2265-2272, DOI: 10.1021/acs.jchemed.0c00204

Instructions for starting material preparation

Before the lab, the instructor should color the two acid powders. To this goal, the instructor should use non-water, oil-based food coloring.

You can find these products online (prices listed are prices on 03/31/2025):

\$28.5: [HiMedia GRM830-500G Myristic Acid, Extra Pure, 500 g](#)

\$16.88: [HiMedia GRM7187-500G Lauric Acid, Pure, 500 g](#)

\$9.49: [oil-based food coloring](#)

Each tube contains 1.5 g of material, a sufficient mass for preparing the starting powder for all the experiments.

For about 20 g of acid, add 1 or 2 drop of food coloring. An excess of coloring hampers the clear observation of new forming crystals. Mixing properly the acid and the food coloring favors a relatively homogeneous color of the mixture.

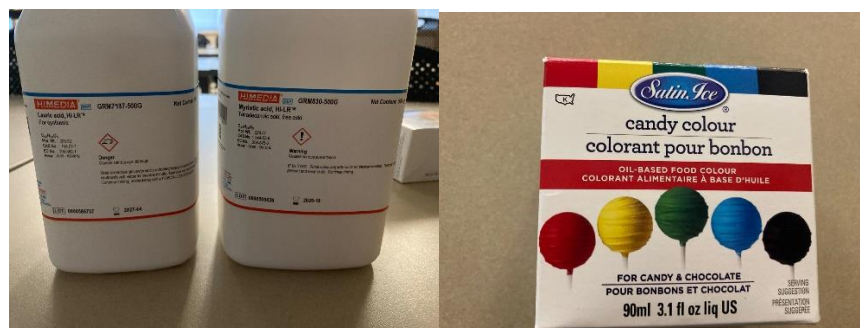


Figure 2: Acid powder and food coloring used in the lab.

Once in the lab, the instructions below describe the preparation of the mixtures:

Material:

- 1) A scale
- 2) A spatula
- 3) Three transparent sealed test tubes and a holder
- 4) Paper towels
- 5) Weighting paper
- 6) A watch glass
- 7) About 5 g of lauric acid and about 5 g of myristic acid previously prepared by your instructor.



Figure 3. Material needed for the lab at each station: Digital thermometer, a hot plate, a tube holder with three test tubes, and a large beaker. Additional material for the mixture preparation: scale, weight paper, hour glass, and spatula.

Sample preparation:

1a. Mix the lauric and myristic acids using these proportions:

Note that you will need about 1.5g total in each mix.

- In **Table 2** of your spreadsheet, for each mix, place the name of the mix in the corresponding column (e.g., 10:0 LA:MA) and calculate the weight of both acids you need (report in column Target).
- Place the watch glass on the scale and make sure to zeroing the scale.
- Using a spatula, add the target amount of lauric acid. Report the actual weight of lauric acid present in your watch glass.
- Zero the scale again and add the target amount of Myristic acid and report the actual weight in the corresponding column.
- Slowly mix the two acids. At this point, you mix does not have to be very homogeneous yet.
- Pour the mix on a weighting paper that you will have previously folded and unfolded in half, so it's easier to grab.
- Open the 1st test tube. Write the name of the mix on the test tube with a marker. Carefully grab the weighting paper with the acid mix and pour the mix in the first test tube. Then use the spatula to properly mix the two acids inside the tube such has the mixture appear homogeneous.
- Close the test tube and place it back on the holder (make sure to remember which tube correspond to which mix).

At this point, you can unplug the scale and put it on the side, you won't use it anymore, unless you want to test another mixture.



Figure 4: Test tubes containing the mixtures that have been melted and solidified several times.

You can modify the *PIE_part1* spreadsheet to include the starting material preparation by adding:

Starting material preparation

For each mix, place the name of the mix in the corresponding column (9:1 LA:MA) and calculate the weight of both acids you need (report in column Target) to have a total weight of 1.5 g. Report the actual weight for each oxide you obtained in the column "Actual".

Table 2. Target and actual bulk compositions of the mixture: please replace "Mix1" by the actual mixture (8:2 LA:MA)

	Mix 1:		Mix 2:		Mix 3:	
	Target	Actual	Target	Actual	Target	Actual
Lauric						
Myristic						

We recommend grading this section on 15 points (rather than 5 without the preparation of the mixture), making the 1st part of the lab 100 points. The assessment is: weight measurements and calculations were performed correctly.

Author contributions: Teaching material created by Dr. **Sarah Lambert** [University of Utah, Department of Geology and Geophysics], Dr. **Juan Carlos de Obeso** [University of Utah, Department of Geology and Geophysics] and Dr. **Mattia Pistone** [University of Georgia, Department of Geology]. SL designed the original version of this activity and tested it in class. JCdO tested the activity in class twice. All authors contributed in the submission of the activity.

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