pHigment: Designing Biodegradable Single-Use Cosmetics for On-body Chemical Sensing

Interactive Organisms Lab

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1. Overview

This document details the process for preparing a biodegradable pH-responsive biofilm for use in cosmetic sensing applications. All wording and steps are preserved from the original lab notes.

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2. Materials & Measurements

Component	**Amount**	**Notes**
Red cabbage powder	0.25 g	Natural purple dye
Titanium dioxide	0.1 g	Opacifier
Glycerine	5 g	Plasticizer
Sunflower oil	2.5 g	Emollient
Water (main mixture)	100 g	Solvent
Calcium chloride	10 g + 100 g water	Bonding agent (dissolve in hot water)
Sodium alginate	3 g (added slowly)	Added at the end using an immersion blender
Disposable Boats	2	To pour oil and glycerine, each into one
Glass Jar	150 g - 200 g max capacity	To pour the mixture in
Immersion Blender		To make sure the mixture has minimal clumps

Component	Amount	Notes
Cameo		To cut the shapes out of film
Long Spoon		To stir mixture and scoop ingredients
Vacuum Chamber		
Double-sided sticker paper		

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3. Preparation Steps

NOTE: Provided example images at of each step at the end of the documentation

3.1 Calcium Chloride Solution

- This is the bonding agent (do this step first, so we have it ready)
- 10g calcium chloride
- 100g water
- Use hot water to make sure it’s dissolved
- Takes a while to cool
- Put in a spray bottle once cool

3.2 Measuring & Mixing

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- From the pink sticky note image at the end of this documentation, go bottom up, best to do dyes last, measure, and put straight in water
- First, put the glass jar on the scale and hit the zero (tare) button to set the scale to zero
- Measure the water and pour it into the glass jar until 100 grams
- Next, the dyes are added to water before adding anything else
- Measure 0.1 titanium dioxide onto tracing paper, and pour it into the jar with the water in it
- Measure 0.25 red cabbage powder onto tracing paper, and pour it into the jar
- Mix the solution with a spoon until a solid purple color
- NOTE: For the Red cabbage and titanium dioxide: the small weight makes it hard to get an accurate reading so instead of boats use tracing paper
    - Pinch a slight fold on one side of the tracing paper so it is easier to grab
- Next, add the sunflower oil first and then glycerine—order doesn't matter that much
    - Measure 2.5 grams of sunflower oil into a boat, and pour it straight into jar
    - Measure 5 grams of glycerine into a boat, and pour it straight into jar
- Mix the solution again with long spoon

- Lastly, add 3g sodium alginate slowly (must be the last ingredient added in)
    - Think about adding 1 gram at a time
    - Use immersion blender either pulsing and then holding it down to blend until you see it start to bubble
    - Once you get thick enough after 2 grams of sodium are added and blended, you can switch to turbo mode on the blender
    - After adding the 3rd gram, blend again
- Once there are no more clumps, it's good
- Keep the entire batch of this solution under 200g, preferably 150g in the glass container so that it does not bubble over the to of the jar when in this chamber
    - When we tested it, it did not bubble over, just stayed at the top

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4. Degassing in Vacuum Chamber

- To use the vacuum chamber, place the jar in the middle (without a lid), and put the top of the chamber on
- Hit the on button and hit the AI button (on the left of the lid) to change the time
    - Hit AI button to auto-change time (5, 10, 15 minutes—usually does 15 min)
    - Press the AI button until it says 15
- Need to watch it while it is on to make sure the solution doesn't bubble over the top of the jar
- If you think it will overflow because the bubbles are getting too high, you can pause the machine by hitting the button with the go/pause symbols (on the right side of the lid)

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5. Film Casting & Curing

- While the chamber is running, you can prepare the double-sided sticker paper
- Get a sheet of sticky paper and peel off the non-sticky side, and put the sticky side up
    - Lay the sheet away from you
    - Once you start, just keep going to spread the sheet out as best as you can
- Use your hand to swipe away from you to make the sticker lie flat with minimal air bubbles
- Cut off the excess sticker paper that the film did not cover

6. Pouring & Spreading

- Once the vacuum chamber is done, you can depressurize the vacuum
- Pull the plug in the back to let pressure out slowly
- If there are clumps, then use a spoon to scoop them out
    - The air bubbles push the clumps to the top, so they are very easy to see and scoop out

- Stir the mixture with a spoon
- Pour the solution onto the acrylic black metal rectangle (it should be thick enough to stay on the acrylic without having to worry about it spilling off)
- Spread out with folded paper or smoothing tool (whatever will help level it and spread it thin works)
- Spray the calcium chloride solution we made in step #1 all over the sheet
    - Douse it a lot
    - Watch it shrink after a few seconds
- As it shrinks, the edges are exposed (you will see they are wetter and a lighter color)
- Respray the edges so that the solution will shrink evenly in the end

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7. Drying

- After spraying the bonding agent, you leave it to dry for **7 days**
- In summer, you could leave it outdoors and it dries in ~3 days
- A drying machine could work, but better to use less electricity to lower carbon emissions
- Final product should be face mask consistency, paper-like

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8. Cutting & Shaping

- Turn on the Cameo (cutting machine)
- Put the material side up and place it at the entrance of the machine
- Plug in Cameo (connect directly to the computer via USB dongle)
- Use Silhouette Studio (light blue circle icon with white "S")
- Get shape (e.g., butterfly)
    - Use a filled shape so it is easier to trace and cut out
    - Import image
    - Trace it so that only the image outline is visible
    - Make sure to load the paper in the machine
    - Press the Send button to send the outline to the machine
- If it doesn’t work:
    - Paper may not be held in
    - When we tested it, it didn’t cut right both times
    - Could try Cricut (Olivia never used it, but it is the same type of machine)

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9. Final Cleanup

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- Easy to clean at home with hot water
- You can borrow equipment and even take the scale home if needed

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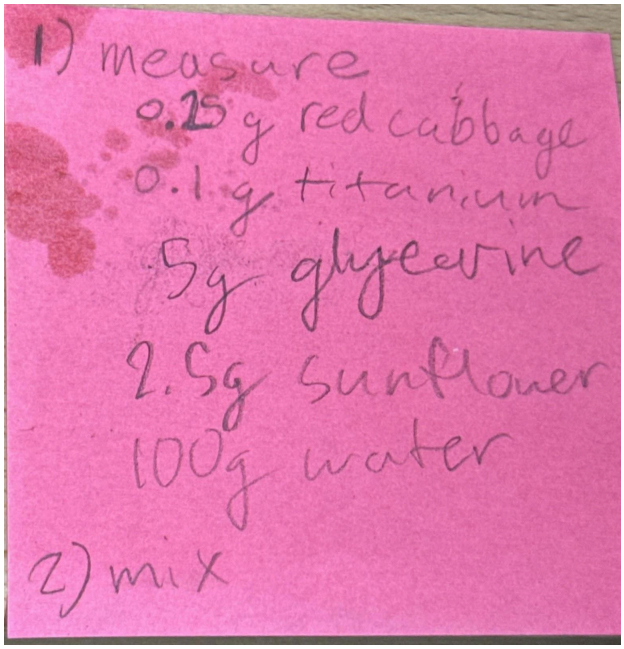
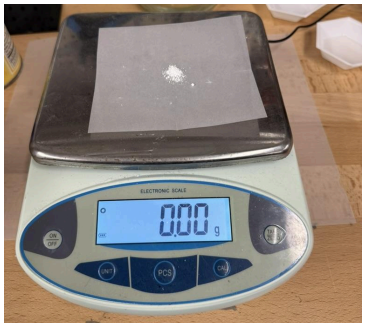
Measurement Olivia wrote down (excluding the 3g of sodium alginate)



Example showing how much titanium dioxide is 0.1 g:



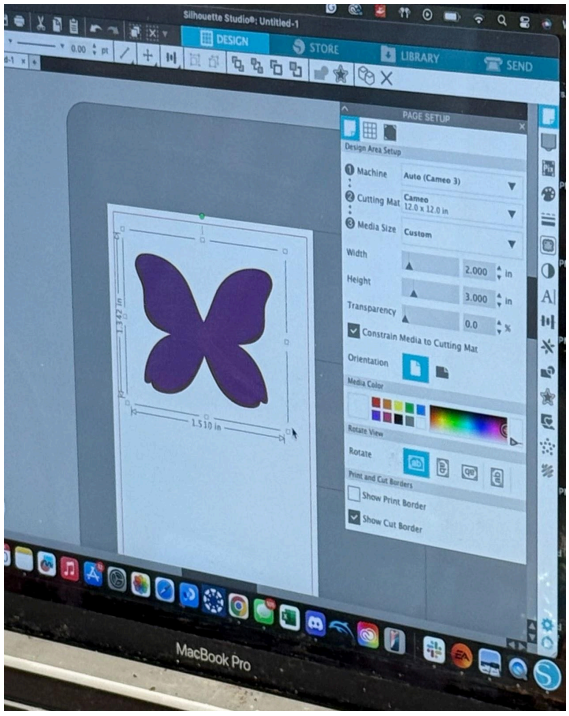
Example showing how much red cabbage powder is 2.5 g:

Disposable boats used to pour the measured out sunflower oil and glycerine into each one:

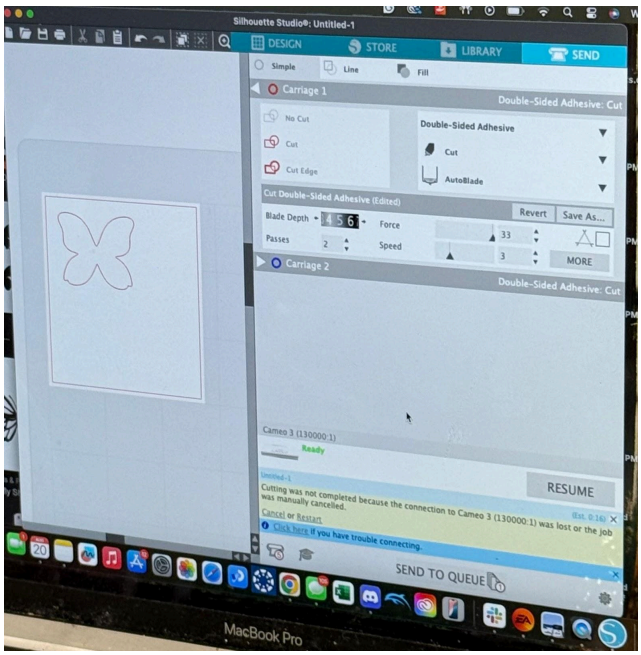
Vacuum Chamber with the jar inside, in the process already activated for 15 minutes:

Loading the Cameo with the film-side up of the sticky paper:

Example of using Silhouette Studio after importing an image in:



Example of using Silhouette Studio after tracing the image before sending to Cameo:



Here is the ingredient list in order from left to right:

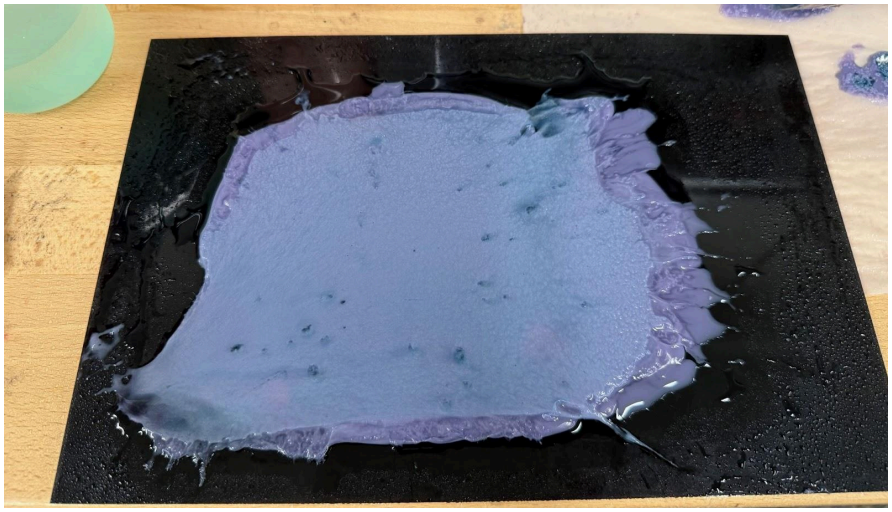
Cameo Cutter:

After peeling off when dry, the result looks like this paper-thin material. The material will want to rip when peeling, so peel carefully:

Here are 2 different results, the left one (lighter) is better than the right (darker) one:

Here is an example of why the lighter (top) one is better, easier to see the difference in color change than the darker (botton) one:

This is what the solution looks like after being spread out on an acrylic metal rectangle and sprayed with bonding agent. See how it shrinks, and the sides are visible, looking wetter and a different color; this is when you respray the bonding agent over those sides so it shrinks evenly



Example of what all ingredients look like after, before cleanup: