3-D Printing

Pre-Lab Preparations

Before the lab, a photosensitive solution must be prepared and the projection setup must be completed. The solution should be prepared at least three days before the lab. If pre-made cross-sectional slides are not being used, cross-sectional slides should be made of the objects to be printed using PowerPoint or other computer program.

Pre-Lab Materials

- Poly(ethylene glycol) diacrylate [CAS 26570-48-9 ; Sigma Aldrich # 437441]
- Phenylbis (2,4,6-trimethylbenzoyl)phosphine oxide (Irgacure 819) [CAS 162881-26-7; Sigma Aldrich #511447]
- Sudan I [CAS 842-07-9; Sigma Aldrich # 103624]
- 100 mL graduated cylinder
- Amber bottle (125 mL or larger)
- Scale
- Weighing boats
- Spatulas
- Stir plate and stir bar
- Data Projector
- Computer (with PowerPoint)
- Converging lens (magnifying glass)
- First surface mirror
- Ring stands, clamps, and clamp holders
- Staging device
- Gloves
- Goggles

Pre-Lab Procedure

Photosensitive Polymer Solution Preparation

1. In a 100 mL graduated cylinder, measure 98 mL of Poly(ethylene glycol) diacrylate and pour into the amber bottle.

2. Using a spatula, measure 2.00 g of Irgacure 819 into a weigh boat. Add the measured Irgacure 819 into the bottle.

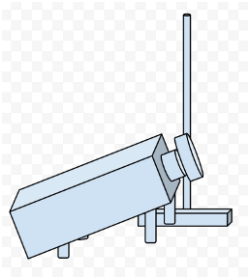
3. Weigh out 0.02 g of Sudan I and pour into the bottle. The concentration of Sudan I can be adjusted to make thinner or thicker layers. Adding more Sudan I will make thinner layers because more UV light will be absorbed.

4. Place the mixture on a stir plate and stir with a magnetic stir bar until well mixed. It takes several days for the solution to dissolve. Store in a dark place to avoid interactions with light.

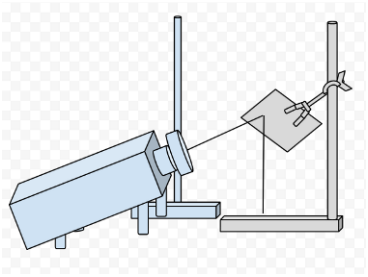
Projection Setup

1. On a large, flat surface near a power supply, hook up a computer with PowerPoint capabilities to a data projector.

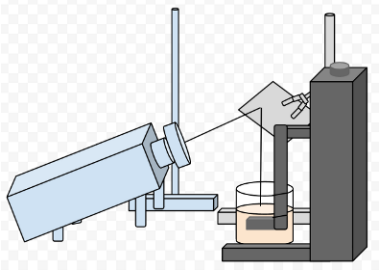
2. Using a ring stand and clamp, place a converging lens (magnifying glass) in front of and as close as possible to the data projector lens.



3. Position a mirror, attached to a ring stand using a 3pronged clamp, at a 45^{o} angle so the light from the data projector will be reflected downward.



4. Place the staging device under the mirror.



5. Turn on the computer and projector. Using a PowerPoint slide with red text, adjust the placement of the magnifying glass, mirror, and stage (up and down) and/or the focus of the projectors lens until the image is focused on the stage.

Creating PowerPoint File

1. Decide on the object that will be printed.
2. A PowerPoint slide should be made for each cross-section of the object. Areas of the slide representing the cross-section of the object (the area that will be solidified when exposed to light) should be white to allow light transmission. The background of the slide should be black to prevent interactions of the chemical and light.
3. Test the size of the cross-sections on the slides with the projector setup to ensure they correspond correctly to the projection size onto the stage.
4. For each cross-sectional slide made, duplicate the slide. Change the color of the cross-section in the duplicated slides from white to red. Red light will allow for the stage to be moved down while preventing UV light penetration and solidification of the polymer.
5. Recheck the position of the cross-sections and refocus the image as needed while the slide with the red cross-sections is in place.

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Materials

- Photosensitive solution
- 50 mL beaker
- Data projector
- Computer (with PowerPoint)
- PowerPoint file
- Magnifying glass
- First surface mirror
- Ring stands, clamps, and clamp holders
- Staging device
- Distilled water
- Razorblade
- UV light
- Goggles
- Gloves

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Pre-Lab Questions

What do you think is the purpose of the PowerPoint slides with red lettering?

Safety

This lab should be done in a well-ventilated area. Wear gloves and goggles during the lab. Take care when using the UV lamp. Never look into UV or projector light. Make sure the UV light is switched off when you are finished or before you hand it to another person. All waste should be disposed of in an organic waste container.

Procedure

Printing Setup

1. Load the correct PowerPoint File on the computer that is hooked up to the data projection setup.
2. In order to prevent unwanted light from being projected and polymerizing the solution before ready, make sure that PowerPoint is in Slide Show mode and projecting a slide with only black and/or red before placing the polymer solution.
3. Gently maneuvering the stage, place a 50 mL beaker under the stage setup. To keep the focus, do this without adjusting the height of the stage. This will help to limit the amount of refocusing that must be done after the initial setup of the equipment.
4. Pour the polymer solution into the beaker so that it leaves a slight layer on top of the stage.
5. Using a slide with red lettering, make sure that the setup is properly place and the image is in focus on the stage. Make adjustments as necessary.

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1. Advance the PowerPoint to the first slide with a white cross-section of the object being printed for 5-10 seconds.
2. Advance the PowerPoint to a slide that has only black or red showing.
3. Lower the stage just enough to allow for the solution to cover the previous layer.
4. Repeat steps 1-3 of this process until each cross-section of the object is complete.

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5. Once complete, remove the stage with the 3-D object from the beaker.
6. Return any unused solution to the amber vial.
7. Hold the stage with the object over a waste container and rinse off excess polymer using a wash bottle of distilled water.
8. Very carefully, use a razorblade to remove the 3-D printed object from the stage.
9. Expose the object to UV light to make sure that any remaining liquid is polymerized.