

Team First Report

Flow Visualization MCEN 5151-001

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Objective

The purpose of the image is to showcase the changes in viscosity of resin when curing in ultraviolet light. We wanted to explore the way resin reacts when curing and how it affects the flow when it is still in liquid form. Special thanks to Aria Pathak and Brody Rosch for helping to set up the experiment and take the photos.

Procedure

First, materials were collected. We used clear Formlabs photoactive resin. This resin is typically used as material for SLA printers, it reacts to UV light by polymerizing from a liquid to a solid. This is the effect we wanted to characterize. A piece of clear packing tape was used to create a small mold. The packing tape creates a smooth surface that is flexible enough to remove from the resin after it cures. The packing tapes was folded into a rectangular box as shown in Figure 1,

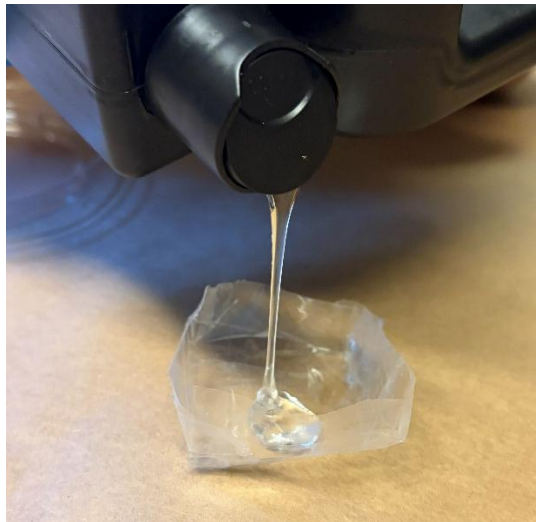


Figure 1: Image of the packing tape mold.

The resin was then poured into the mold and held under UV light. We used a UV flashlight to activate the resin. This resin was left to cure for about 2 minutes to ensure that the outer layers were cured but the inside resin remained liquid. The cured shell was then removed from the tape mold and stood on it side to allow for a better camera angle to capture the internal flow. Figure 2 shows this set up.

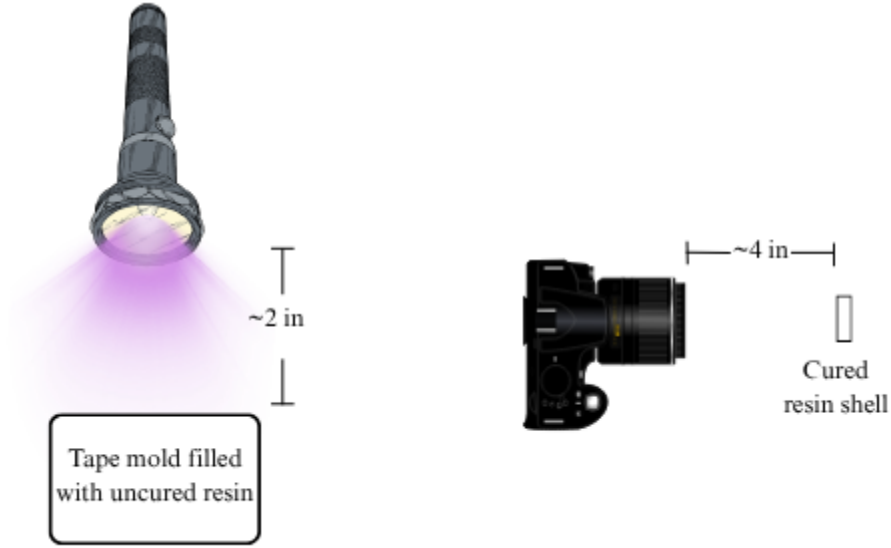


Figure 2: Diagram of curing set up (left) and camera set up (right)

Technical Analysis

Although we were unsuccessful in capturing the different viscosities and flow rates taking place in the image, it was observed that the flow demonstrated the changing behavior of a photopolymer resin as it transitions from a liquid to a solid. When the uncured resin is exposed to UV light, photopolymerization causes monomers and oligomers to react and form an increasingly cross-linked polymer network (Polymer Testing, 2022). As the degree of cure increases, this growing molecular network increasingly restricts molecular motion, causing the resin's viscosity and elastic response to increase until it approaches gelation and eventually behaves as a solid (Polymer Chemistry, 2023). Because viscosity represents a fluid's resistance to deformation and flow, the progressively increasing viscosity causes the resin to respond more slowly to the forces driving its motion. We can use Reynolds number to quantitatively describe this behavior.

$$Re = \frac{\rho LU}{\mu} \quad (1)$$

Where ρ is resin density, U is characteristic flow velocity, L is characteristic length, in this case the width of the channel, and μ is the time dependent viscosity. In this experiment, as curing progressed viscosity increased which in turn decreases the Reynolds number. So, the Reynolds number directly captures the increasing importance of viscous resistance relative to the motion of the fluid. Early in curing the resin has a lower viscosity and therefore a higher Re , later, as the resin cured and become more viscous, Re decreases and the flow becomes increasingly dominated by viscous effects. The calculations below are estimates based on observational information. Since the resin's viscosity is changing continuously during curing, we will look at

two instances of the curing process. The first instance is when the resin has undergone no curing. Approximate values can be seen in Table 1.

ρ	1210 kg/m^3
L	0.0254 m
U	0.001 m/s
μ	$1.1 \text{ Pa} \cdot \text{s}$

Table 1: Approximate experimental values before curing (Form labs, 2025)

The density and viscosity values are taken from the Formlabs website for uncured resin at room temperature. The calculated Reynolds number before curing using equation 1 is

$$Re_{uncured} = \frac{(1210 \text{ kg/m}^3)(0.001 \frac{\text{m}}{\text{s}})(0.0127\text{m})}{1.1 \text{ Pa} \cdot \text{s}} = 0.014$$

Now we can take a look at the Reynol number after partial curing. We are assuming the density change is negligible. Table 2 shows the approximate. (Form labs, 2026)

ρ	1210 kg/m^3
L	0.0254 m
U	0.0001 m/s
μ	$0.9 \text{ Pa} \cdot \text{s}$

Table 2: Approximate experimental values after partial curing. (Form labs, 2026)

The dynamic viscosity of partial cured resin is calculated based on the assumption that the resin is now in a “green state” where it has not undergone the final post cure. The calculated Reynolds number after partial curing using equation 1 is

$$Re_{uncured} = \frac{(1210 \text{ kg/m}^3)(0.0001 \frac{\text{m}}{\text{s}})(0.0127\text{m})}{0.9 \text{ Pa} \cdot \text{s}} = 0.0017$$

This is much lower than the uncured resin Reynolds number which reflect the expected result observed in the experiment. The resins’ motion becomes progressively slower as the viscosity rises.

Techniques

Visualization Techniques

The material used for this visual is the Formlabs clear resin V5 sourced from the Idea Forge SLA printing lab. The light used to cure the resin is a standard UV flashlight also borrowed from the Idea Forge. The soft lighting for the visual is a yellow toned camping light provided by Aria Pathak. The light was held straight above the subject, resulting in a soft yellow glow.

Photographic techniques

The camera used was a Canon EOS Rebel T2i provided by Brody Rosch. The photo was taken with a standard zoom with flexible focal length of 18-55mm, an aperture of f3.5-5.6, and image stabilization. The exposure specs include an aperture of 5.6, a shutter speed of 1/100 and an ISO of 1000. The image before post processing was 5184 x 3456 pixels and after was 1300 x 900 pixels. The photo was taken at a distance of around 4 inches away from the subject.

In Dark Table the photos exposure was brought up slightly, the image was cropped, and some of the smaller bright spots were removed using the heal functionality. The before and after editing can be seen below in Figure 3.



Figure 3: Before (left) and after (right) editing in Dark Table

Conclusion

The image reveals an artistic representation of the changing properties of resin as it cures. I liked how beautiful the image turned out and how it brings out a curiosity from the audience. I disliked that I wasn't able to clearly show my intent. I wanted the image to show an interesting visual of the resin changing properties but this proved to be difficult. If I were to do this experiment again I would use a smoother mold that would result in a smoother shell so you can easily identify the boundary between the two phases of resin. I would also take more measurements and have a more controlled experiment so I did not have to approximate so heavily in my calculations.

References

Form labs. (2025). Materials Library.

Form labs. (n.d.). Density of selected Formlabs SLA resins. *Form labs support*.

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Polymer Testing. (2022). Analysis of UV-Assisted direct ink writing rheological properties and curing degree. *Science Direct*.