SLA Additive Manufacturing: A Review of Resin Formulations and Patterning's Impact on Abrasiveness.

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Introduction:

Additive manufacturing (AM) via stereolithography (SLA) enables rapid fabrication of complex components using ceramics and resins. This study investigates how surface modifications—through patterning and top-layer doping with ceramic or metal additives—affect the wear resistance, abrasiveness, and sliding friction of AM-fabricated disks. Specimens were produced using a DLP resin printer with commercial ceramic and denture resin materials. Surface patterns and additive compositions were tested. Wear tests were conducted using a Universal Micro-Tribometer (UMT-2) with the Pin-on-Disk method against 52100 steel balls.

Background:

Digital Light Processing (DLP) is a method of 3D printing that uses ultraviolet light to cure liquid resin into a solid. The software takes in a .stl file and slices the object into layers. A projector then shines an image of each layer into the resin from the bottom. The object is attached to a build plate that lowers into the resin, so as each layer cures, it moves up and back down to eventually result in a finished 3D object. The resin was sourced from TETHON and DENTCA.

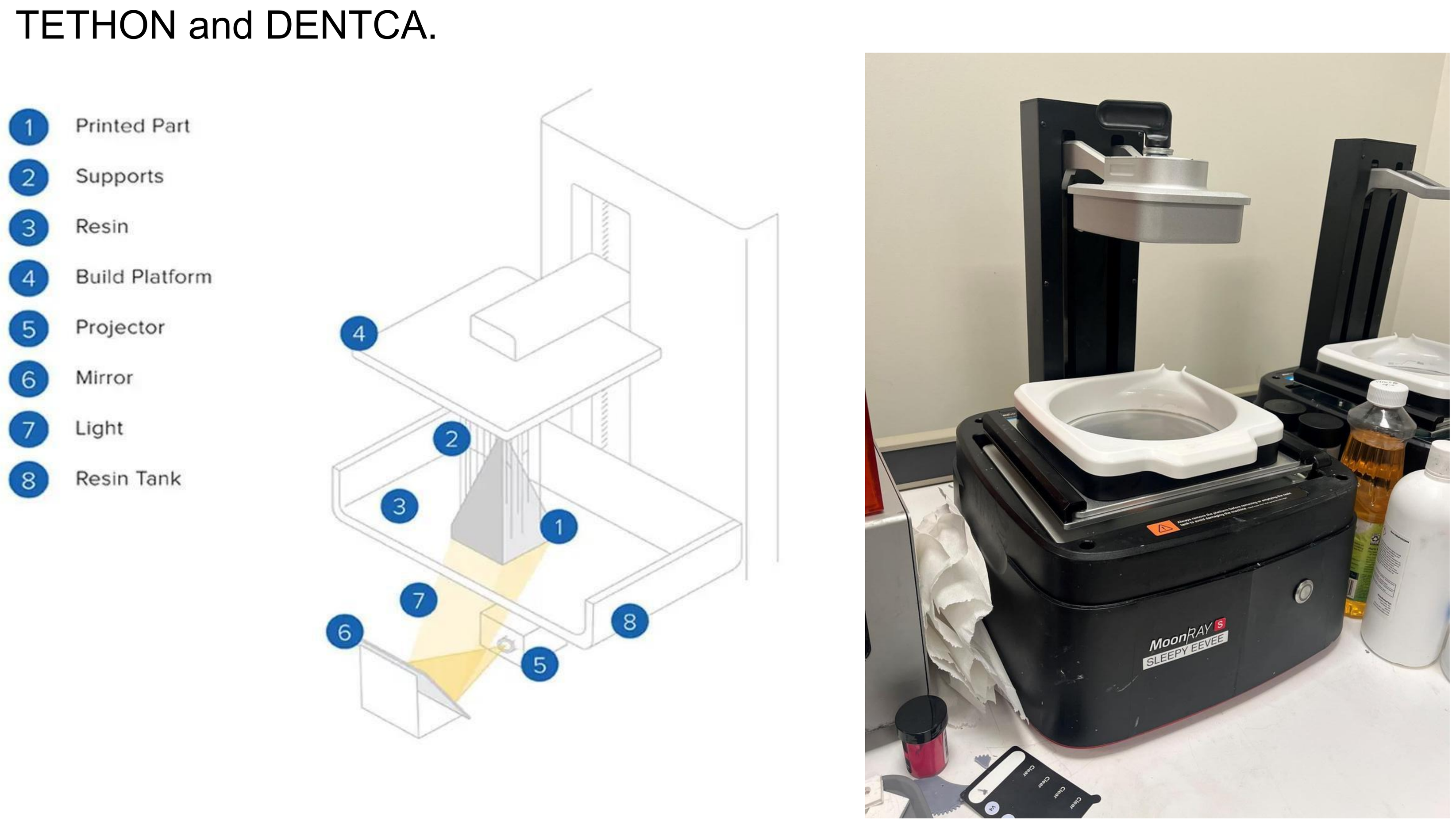

Figure 1: Exploded view of DLP resin printer (left) and MoonRay DLP Resin printer (right).

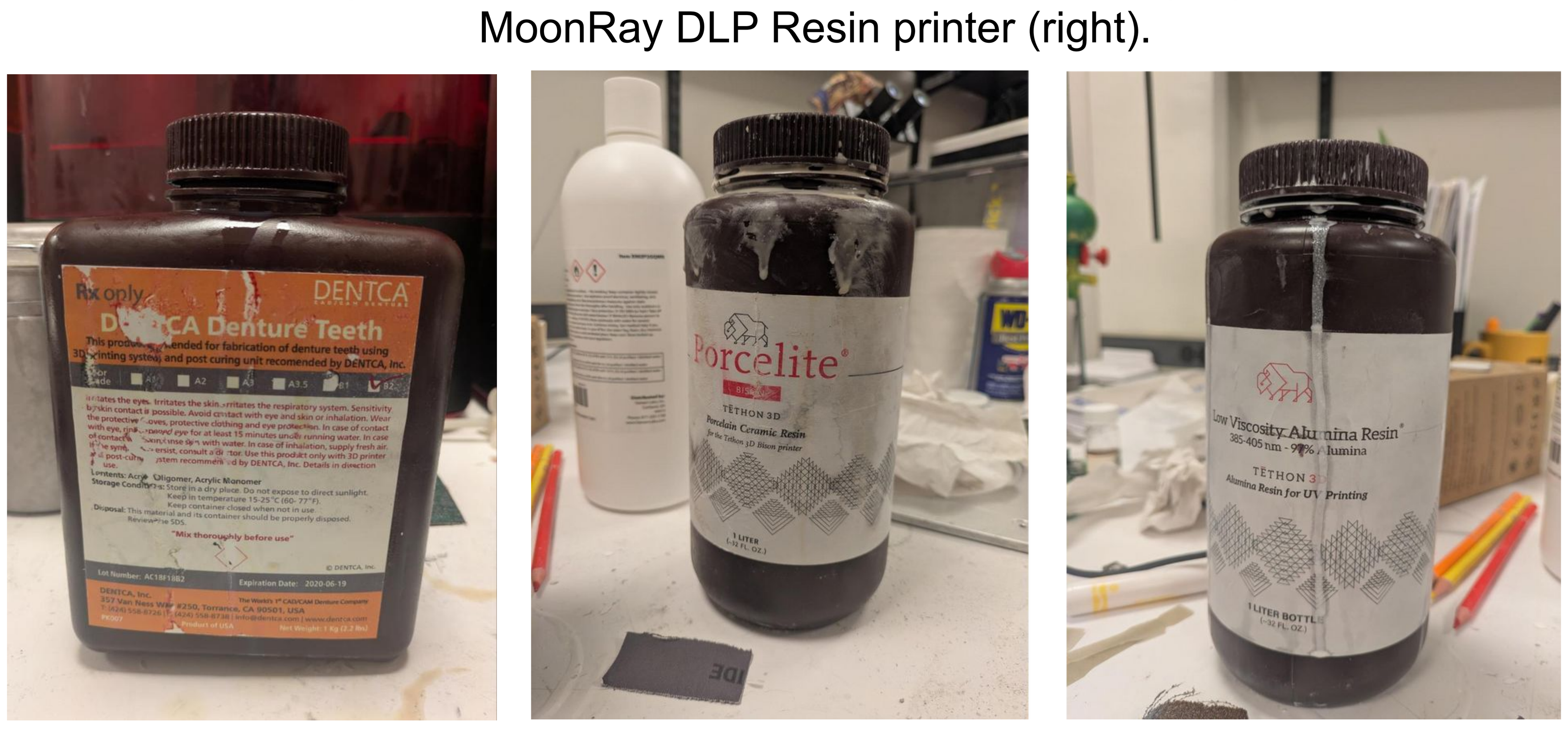

Figure 2: Denture Resin (a), Porcelain Ceramic Resin (b), Alumina Resin (c).

Methods:

The disks were printed in a SprintRay MoonRay S100 printer with alumina and porcelain ceramic resin, as well as denture resin. The disks were printed to be 50mm in diameter with a 6.5mm hole in the center. After printing, the denture resin disks were cured in a glycerin solution. The ceramic disks were placed into a FIREBOX 8x4 LT Kiln and fired according to a specific firing sequence. Patterns were made using sandpaper. Additive compositions were varied through gradients and top-layer doping.

Testing:

To test the abrasiveness of the disk, a standard pin-on-disk test in the UMT was used. A ¼'' ball of 52100 steel was pressed onto the surface of the disk with a force of 1 N. The disk was then rotated so that the ball traveled along the surface of the disk at varying radii per second. The resulting friction between the disk and ball produced a scar on the ball's surface. After the revolutions completed, the scars were examined and measured using a microscope. From the size of the scar, the wear volume was calculated.

References

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Figure 3: UMT (left), Ceramic Disk in UMT (right)

Results:

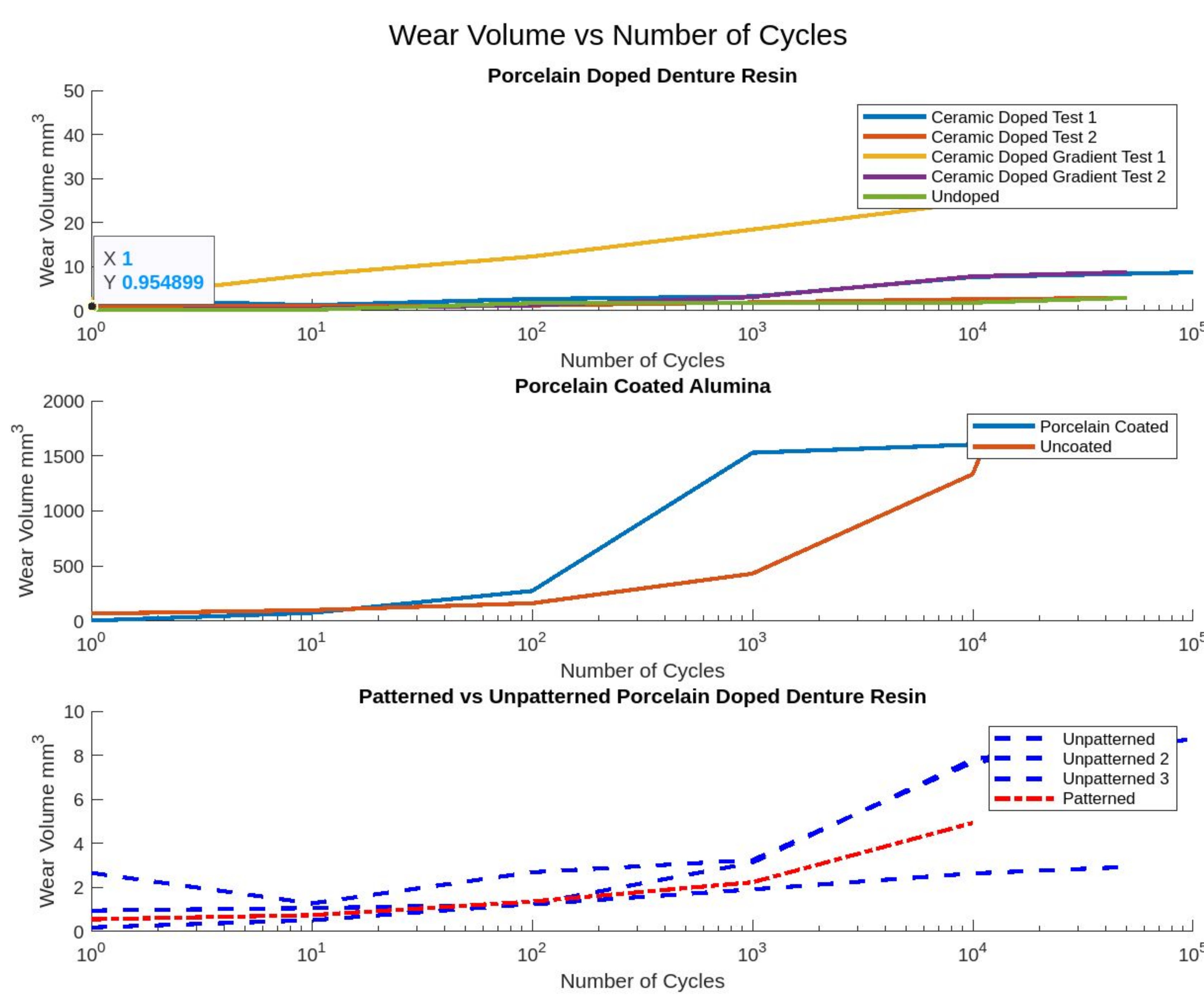
The wear volume of the ball was calculated using the following equation where R is the radius of the ball:

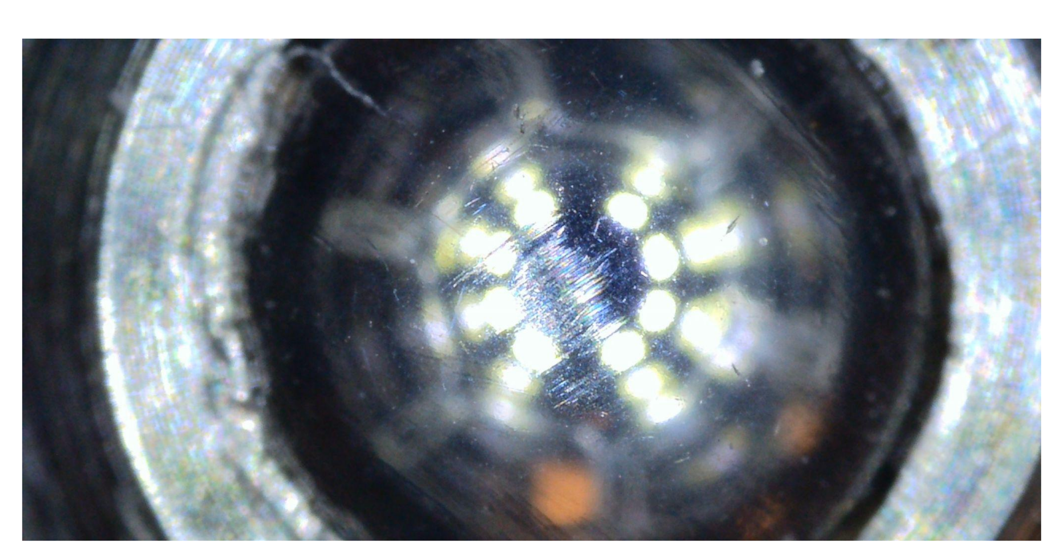
$$V = \pi * \left[h * R^2 - \frac{R^3}{3} + \frac{(R-h)^3}{3} \right]$$

h is the height of the scar given by the Pythagorean theorem,

$$h = R - \sqrt{R^2 - s^2}$$

s is the radius of the scar.





Conclusion:

Based on the results, the porcelain is more abrasive than the alumina ceramic. When porcelain is added to the denture resin, it becomes more abrasive. The results from the graph above do not show a significant difference between the gradient vs. fully doped samples, as well as the patterned vs. unpatterned disks. These findings highlight the abrasiveness differences in two different materials, but not patterning/gradients for enhancing surface durability in AM parts.

Future Works:

Additional data collection would help further characterize the effects of resin formulations and surface patterning on abrasiveness. Incorporating more distinct, nanometer-scale patterns may yield clearer insights into the role of patterning on wear behavior. Further testing should also be conducted on compositional gradients, as it is hypothesized that varying the proportions of the two materials will produce noticeable differences in abrasiveness.