Competitive accelerated weathering study between HP 3D High Reusability PA 12 W and SLS materials

Introduction

This white paper examines the impact of accelerated weathering on the new HP 3D High Reusability (HR) PA 12 W material printed on the HP Jet Fusion 5420W 3D Printing Solution, comparing it with two main SLS competitor materials. The goal of this experiment is to accelerate the aging of 3D printed parts to understand which material ages the best (with the best property retention over time). Throughout this experiment, we tracked changes in color, mechanical properties, and dimensional properties.

Test description

For this study, 3D printed parts using HP 3D HR PA 12 W material and two PA 12 SLS materials (referred to as “SLS material 1” and “SLS material 2”) have been exposed to a combination of fluorescent UV light, temperature, and condensation following the standards ASTM G154/ASTM D4329. The UV source lamp used was a Q-Panel UVA-340 at 0.89 W/m2 and the cycle used was:

- 8-hour UV light uninsulated black panel temperature controlled at 60 ± 3°C
- 4-hour condensation with uninsulated black panel temperature controlled at 50 ± 3°C

The color of the samples was measured according to ASTM E1347-06 and ASTM D2244-16, using illuminant and observer F2/10. Color changes were reported using ΔEcmc. ΔEcmc is used to quantify the color difference between a target color and a specimen color. A ΔEcmc of 0 means the target color and the specimen color are identical; the greater the ΔEcmc, the greater the color difference between the target and the specimen. In this study, the target color was the color of the sample before the study started; specimen colors were measured over time and used to calculate ΔEcmc. As a reference, a ΔEcmc of 1 starts to be perceivable by the human eye; a ΔEcmc of 2 is still considered an acceptable color change.

Mechanical properties were measured according to ASTM D638-14 using 5 XY/YX orientated ASTM D638 Type I Tensile Bars per data points. The following data are reported:

Elongation at break (%), which shows ductility and how much the material can stretch before breaking.

Young’s modulus (MPa), also known as modulus of elasticity, which measures the stiffness of the material.

Tensile strength at break (MPa), which measures the maximum stress a material can withstand before breaking.

Charpy impact properties were measured according to ISO 179-1:2010(E) with a modified number of tested specimens, using 5 XY/YX oriented ISO 179 Charpy Impact Bars.

The changes in dimensions were measured using the Charpy impact specimens; no specific standards were used. We reported a linear length change (%), and linear thickness change (%).

Materials tested and printing conditions

Three different materials were tested: HP 3D HR PA 12 W, SLS material 1, and SLS material 2. Each material was printed on a different platform, with an intended packing density of 7 - 8%, and using a different refresh ratio according to the supplier's usage, see Table 1.

Material	Powder ratio used/New	Intended packing density	Build height
HP 3D HR PA 12 W	75%/25%	7.22%	380 mm
SLS 1	NA	7–8%	NA
SLS 2	NA	7–8%	NA

Table 1: Printing conditions.

It is important to note that the thermal history of the recycled powders used to print the PA 12 SLS competitor parts was unknown. The recycled powder used to print HP material had been through 30+ printing cycles before being used to print the specimens in this study.

Results

Summary of the data after 1,000 hrs.

The table below summarizes the data after 1,000 hours of accelerated weathering testing.

In an accelerated test, HP 3D HR PA 12 W retains 80 - 90% of its initial mechanical properties and doesn't show any visible aesthetic changes after extensive exposure to the conditions described above. Overall, HP 3D HR PA 12 W performance is better than typical PA 12 SLS competitors.

Based on our testing, parts printed with HP 3D HR PA 12 W material may be functional for select outdoor applications.

	Color		Mech prop				Dimensions	
	ΔEmc after 1,000 hrs	b* after 1,000 hrs	% of change elongation at break	% of change Young's modulus	% of change tensile strength	% of change Charpy Impact	% change length	% change thickness
HP PA 12 W	3.5	- 1.0	- 9%	- 9%	0%	- 12%	+ 0.09%	- 0.55%
SLS 1	19.2	10.8	- 89%	+ 6%	- 22%	- 93%	+ 0.05%	+ 0.30%
SLS 2	22.9	15.3	- 71%	- 2%	- 45%	- 61%	- 0.24%	- 0.44%

Table 2: Summary of the data after 1,000 hours of exposure for the different materials.

Color changes

The graphs below show the evolution of the ΔEcmc of each material over time.

After only 200 hours of accelerated testing (around 8 days), **SLS materials show a drastic color change compared to HP 3D HR PA 12 W material.** After 1,000 hours of accelerated testing (around 41 days), SLS materials have a ΔEcmc that's at least 3 times higher than HP 3D HR PA 12 W material, resulting in obvious yellowing of the parts.

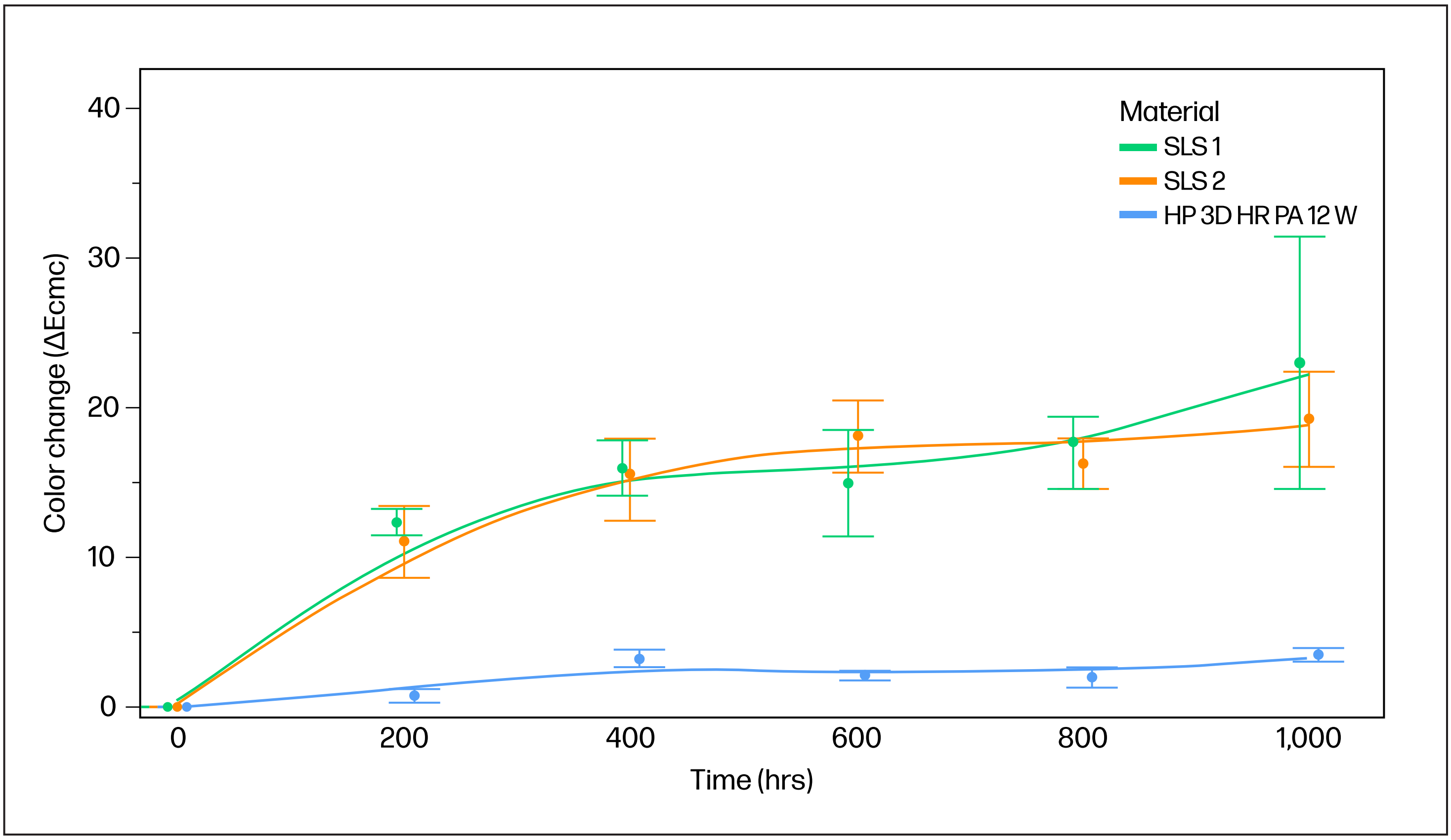


Figure 1: Change in color as shown by the increase in ΔEcmc.

The pictures below show the outstanding color stability of HP 3D HR PA 12 W material compared to SLS materials.

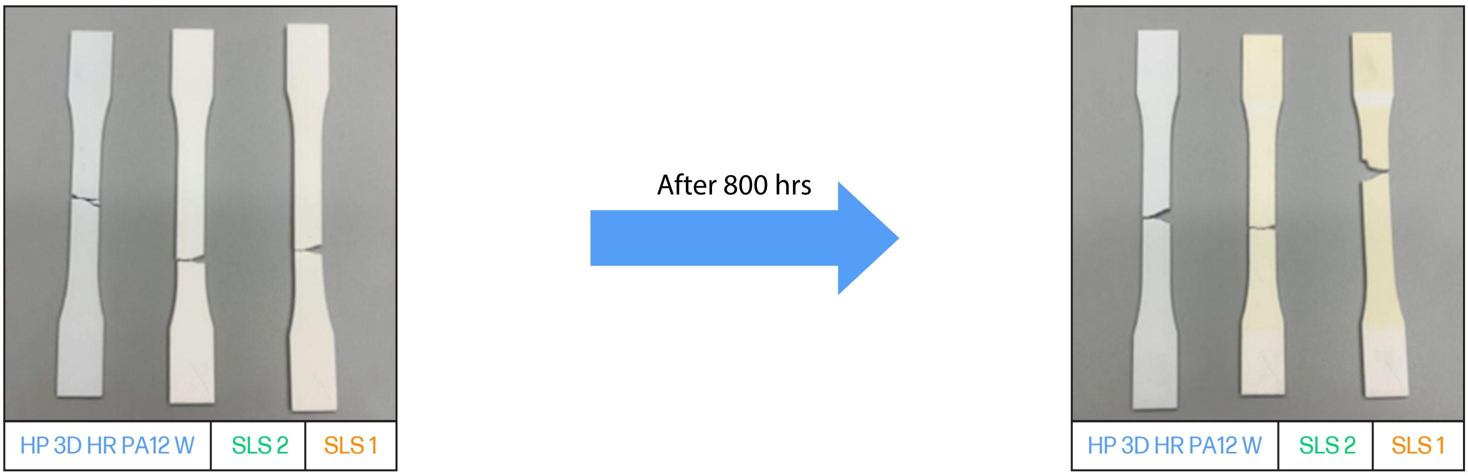
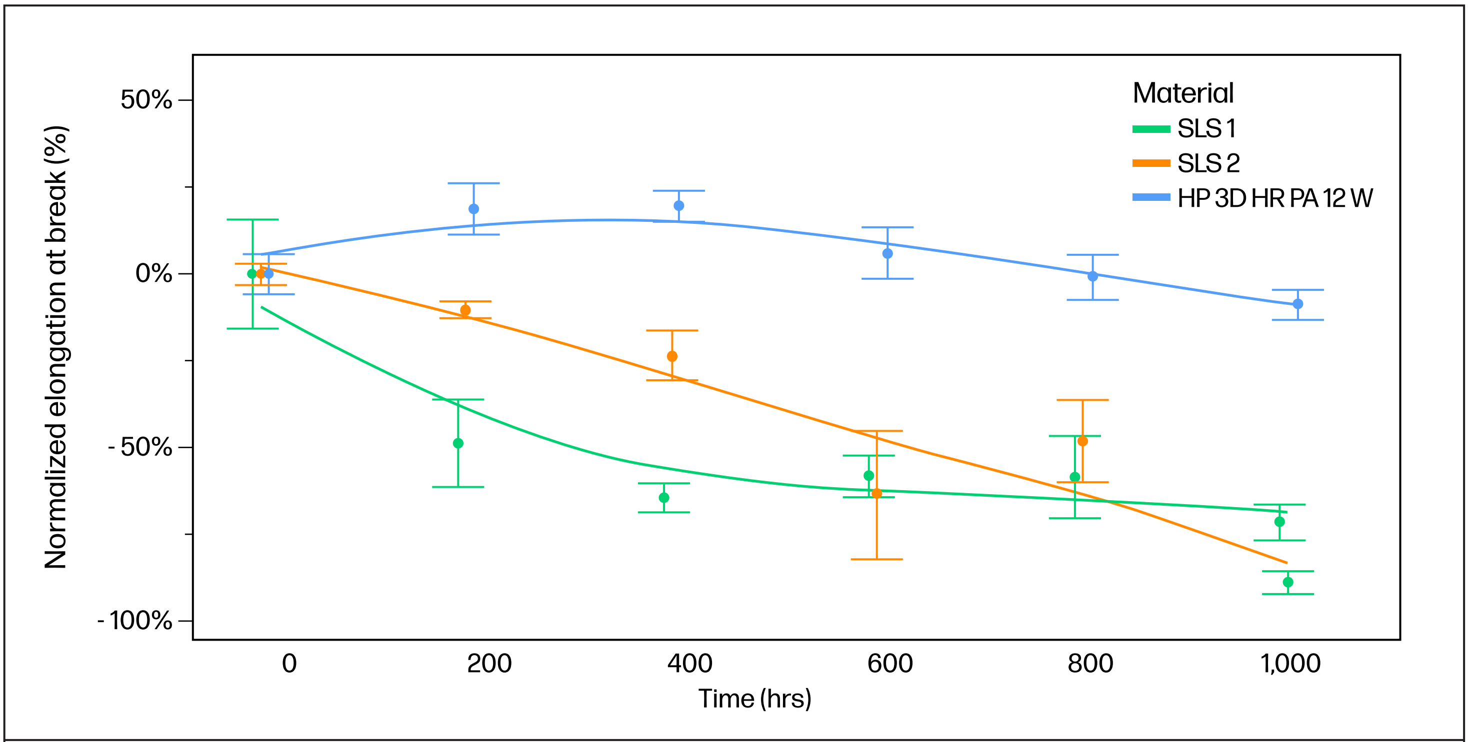


Figure 2: Each picture from left to right: HP 3D HR PA 12 W, SLS 2, and SLS 1.

Mechanical properties

The graphs below show the evolution of the mechanical properties of HP 3D HR PA 12 W and SLS materials during accelerated weathering testing.

All materials exhibit relatively stable stiffness over time. **HP material exhibits stable ductility and strength properties over time while SLS materials show significant degradation** compared to the HP HR PA 12 W. The parts printed with this material are more likely to keep their functionalities compared to the two SLS materials presented in this report.



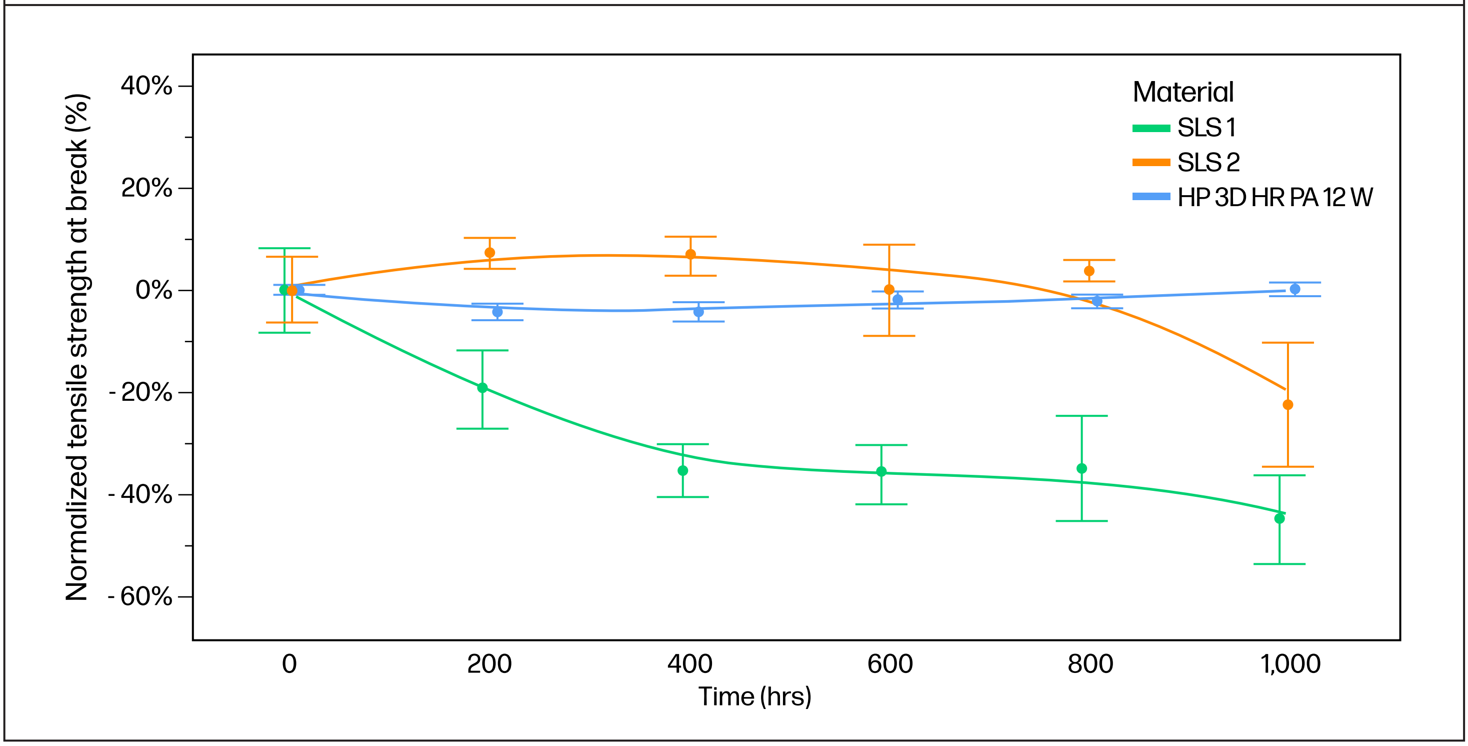
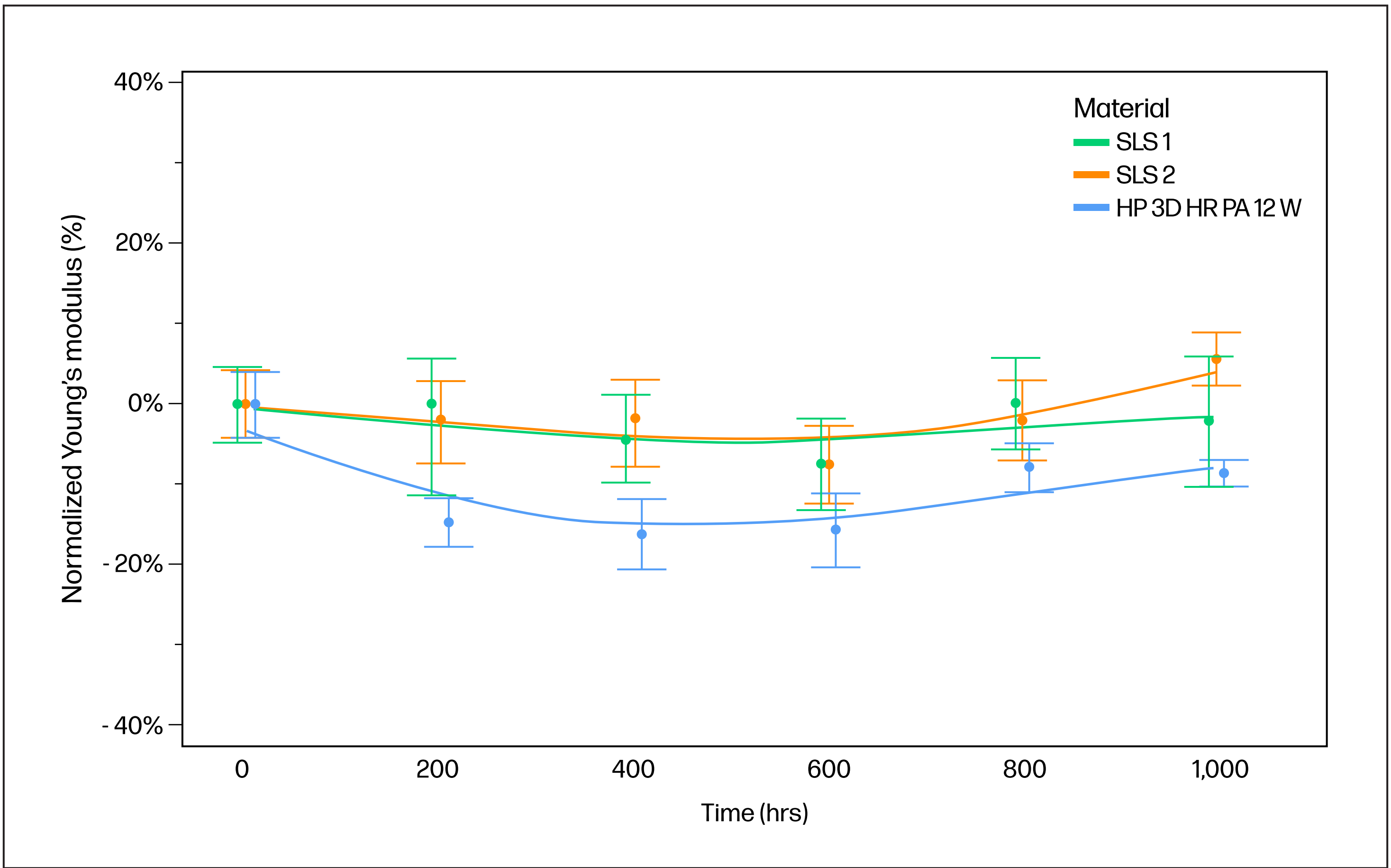


Figure 3: Top, change in elongation at break as a function of time. Bottom, change in tensile strength at break as a function of time.



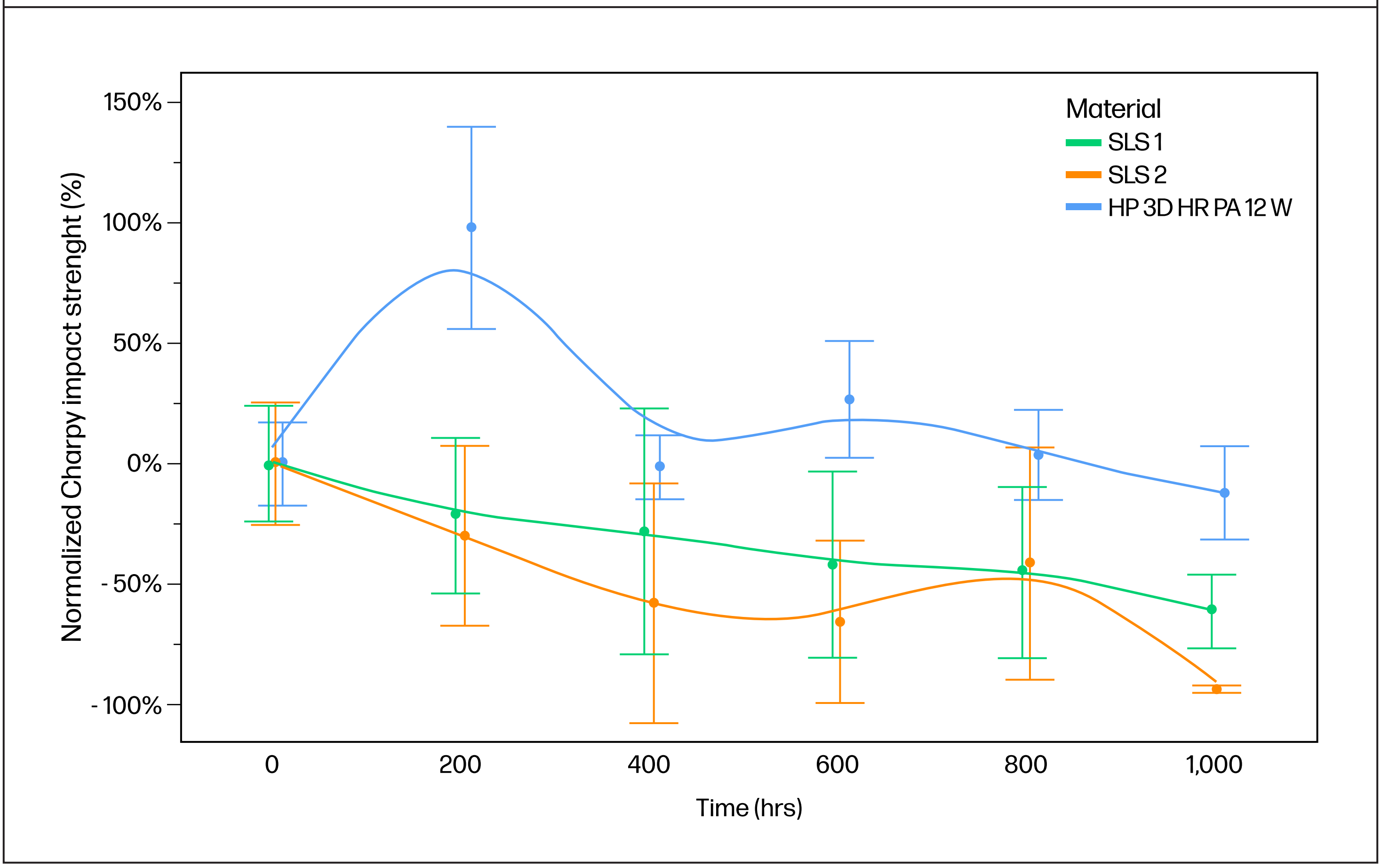
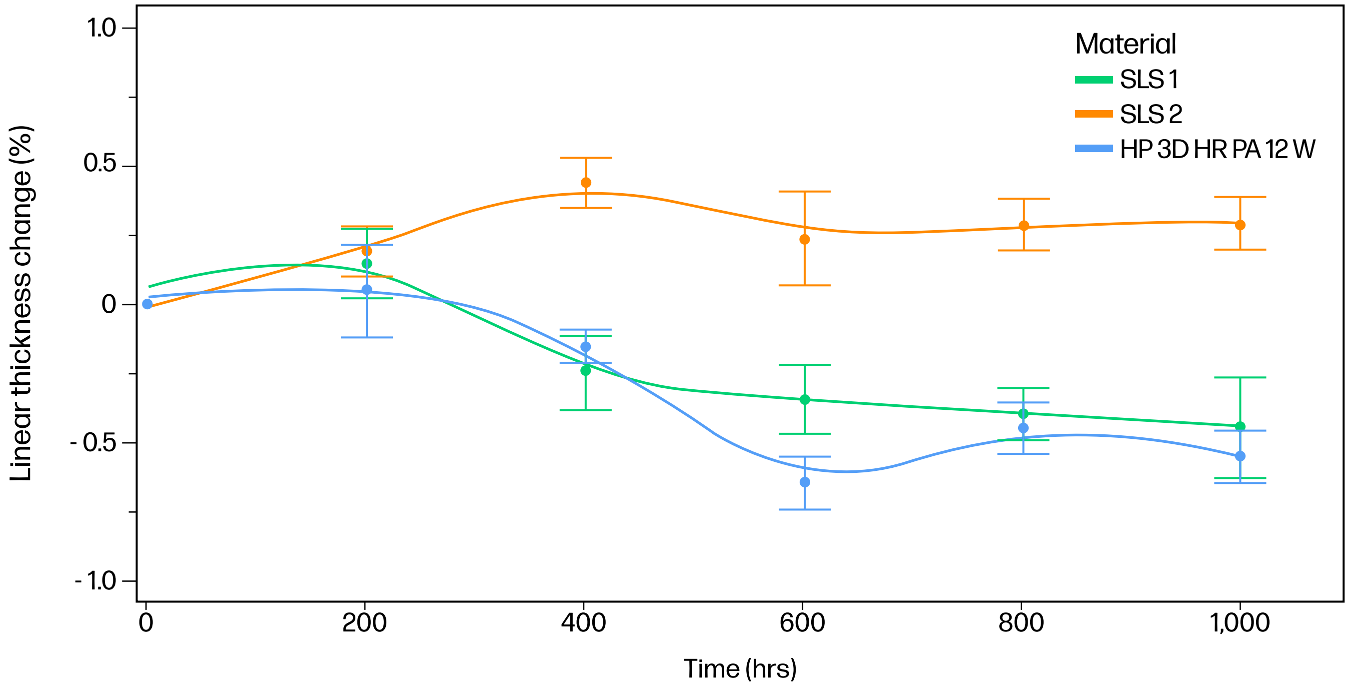


Figure 4: Top, change in Young's modulus as a function of time. Bottom, change in Charpy impact strength as a function of time.

Dimensional changes

The dimensions of the Charpy impact bars were measured over time, and the percentage of change was calculated using the value at the beginning of the test as a reference.

All materials show very little change in their dimensions over time—the variations being mostly between +0.5% and -0.5%.



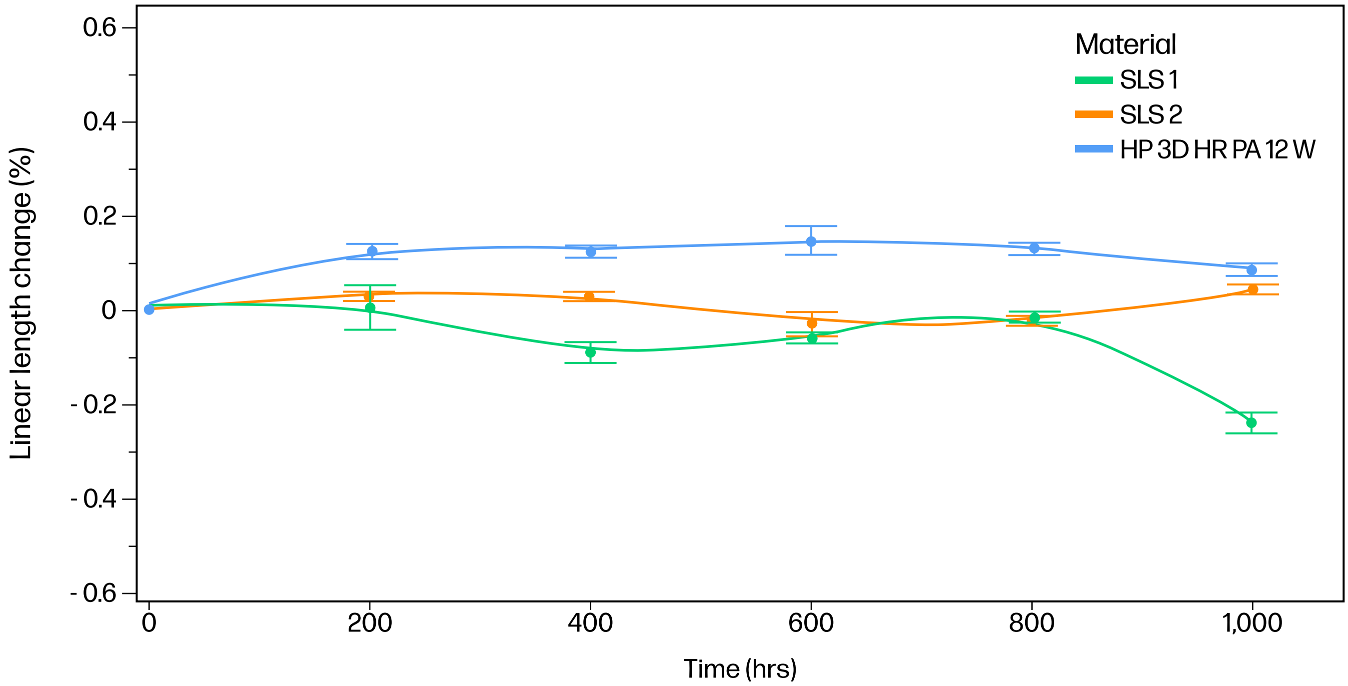


Figure 5: Change in linear thickness as a function of time and change in linear length as a function of time.

Conclusion

HP material stands out from competitors in color retention and ductility.

Based on the data presented in this report and our engineering judgment, we can assume that parts printed with the HP 3D HR PA 12 W material will be more stable over time than the SLS materials tested. HP 3D HR PA 12 W material shows great color stability, while also retaining 80 – 90% of its ductility after accelerated conditions.

Based on customer feedback, HP HR PA 12 W material properties stability opens the door to applications previously out of reach, such as medical devices where white color consistency is essential for cosmetic parts. The HP material also simplifies supply chain logistics, significantly extending the shelf life of parts.

Disclaimer: These results are based on test conditions described above and the following specific printing conditions: 7.22% packing density, with a ratio of 75% used powder and 25% new powder. SLS parts were printed and provided by external vendors. Testing was performed by a third-party laboratory.

4AA8-2654EEW, March 2023