

Photoabsorbing Fillers, Optical Response and Cure-Depth Control in Vat Photopolymerisation

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Statement of Significance

Pigments and photoabsorbers alter optical attenuation and cure response. Colour and weathering claims require separate, standardised measurements and are treated here as qualification gates rather than reviewed ageing findings.

Keywords: photoabsorber; pigment; cure depth; optical response; colorimetry; xenon ageing.

Abstract

Three topical studies address photoabsorbing fillers, optical change after thermal treatment and rheological cure-depth measurement. They support optical and cure-response control, but not photochemical-ageing durability. This note narrows the evidence claim and defines optional colorimetry and xenon-exposure gates using current standards. RP-02 supplies the shared qualification method.

1. Evidence boundary

Wieckowski and Erb examine cure depth with photoabsorbing fillers [1]; Filimonova et al. examine optical properties after thermal treatment [2]; Rau et al. develop a rheological cure-depth method [3]. None performs photochemical ageing, so no lightfastness result is inferred.

2. Topic-specific findings

- Photoabsorbing fillers can tune cure depth within the studied formulations and exposure conditions [1].
- Thermal treatment can change optical response of printed objects, but thermal change is not evidence of photochemical ageing [2].
- Rheological cure-depth measurement can supplement geometric working-curve observations for filled systems [3].
- Colour values depend on the declared measurement geometry, illuminant, observer, backing, surface and thickness; this is a measurement requirement under CIE 015:2018, not a finding from references [1-3].

3. Minimum measurement and reporting set

Control	Method and minimum record	Required interpretation
Optical/cure response	spectral transmission/absorbance plus cure-depth or conversion response	Report wavelength, dose, thickness and formulation state
Colour, if claimed	CIE 015:2018; geometry, SCI/SCE, illuminant and observer; CIELAB per ISO/CIE 11664-4:2019	State ΔE^*_{ab} or ΔE_{00} ; they are not interchangeable
Ageing, if claimed	ISO 4892-2:2013+A1:2021 or ASTM G155-25; report cycle, filter, irradiance, temperature and humidity	Measure colour and function together at predefined intervals
Print response	reference geometry across build positions	Separate optical attenuation from printer compensation

4. Interpretation limits

A pigment concentration or colour match does not establish cure completeness, dimensional fidelity or lightfastness. No acceptance threshold transfers between ΔE metrics, geometries or exposure cycles.

5. 3Dresyns implementation examples

Named 3Dresyns coloured or filled grades require exact controlled TDS/IFU revisions and product-specific cure, colour and ageing criteria. Corrected WP-22/WP-25 may provide manufacturer context but do not replace testing.

6. Limitations and priorities

The retained sources use different formulations, exposure systems and optical measurements and do not support pooled numerical thresholds. Priorities are formulation-specific spectral and conversion maps, build-position controls, matched colour/function ageing measurements and declared uncertainty for every colour-difference metric.

7. Conclusions

- The reviewed evidence supports filler-dependent optical and cure-response control.
- Photochemical ageing remains a separate standardised qualification gate.
- Every colour result must state its complete measurement condition and metric.

Declarations

Funding: none. Competing interest: the author is Founder and Scientific Director of 3Dresyns by Resyner

References

- [1] Hunter S. Wieckowski, Randall M. Erb. Tuning depth of cure in resins with photoabsorbing fillers for vat photopolymerization. MRS Communications. 2025;15(3):308-319. <https://doi.org/10.1557/s43579-025-00713-0>
- [2] E. A. Filimonova, A. V. Lozovaya, E. E. Prosyankin, A. R. Mustafina, Pavel Chapala. Thermal treatment influence on optical properties of 3D printed objects by vat photopolymerization. Progress in Additive Manufacturing. 2025;10(4):2703-2713. <https://doi.org/10.1007/s40964-024-00778-8>
- [3] Daniel A. Rau, John P. Reynolds, Jackson S. Bryant, Michael J. Bortner, Christopher B. Williams. A rheological approach for measuring cure depth of filled and unfilled photopolymers at additive manufacturing relevant length scales. Additive Manufacturing. 2022;60:103207. <https://doi.org/10.1016/j.addma.2022.103207>

Standards

CIE 015:2018. Colorimetry, 4th edition. <https://cie.co.at/publications/colorimetry-4th-edition>

ISO/CIE 11664-4:2019. Colorimetry - Part 4: CIE 1976 L*a*b* colour space. <https://www.iso.org/standard/74166.html>

ISO/CIE 11664-6:2022. Colorimetry - Part 6: CIEDE2000 colour-difference formula. <https://www.iso.org/standard/82662.html>

ISO 4892-2:2013+A1:2021. Plastics - Laboratory light sources - Xenon-arc lamps. <https://www.iso.org/standard/55481.html>

ASTM G155-25. Operating xenon arc lamp apparatus for exposure of materials. <https://store.astm.org/g0155-25.html>