

Oxygen Inhibition and Free-Surface/Interfacial Cure in VPP: A Qualification and Minimum-Reporting Note

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Statement of Significance

Oxygen exposure can produce a depth-dependent surface or interface state rather than a simple pass/fail tack response. Qualification must therefore measure conversion, mechanical response and interface integrity under a documented oxygen boundary.

Keywords: oxygen inhibition; free surface; interlayer interface; conversion gradient; VPP; qualification.

Abstract

Competition between radical generation, oxygen transport and radical quenching can alter conversion, cure depth and near-surface mechanical response in vat photopolymerisation. Oxygen-permeable interfaces can also be used deliberately to maintain a liquid region. Filled formulations introduce additional optical, rheological and transport effects. This note maps seven verified sources to a minimum reporting architecture. It does not assign a universal inhibition-zone thickness or infer interface integrity from nominal exposure. The shared evidence-to-decision method is defined in RP-02 and is not reproduced here.

1. Evidence boundary

The evidence covers oxygen-inhibited surface mechanics, controlled oxygen-permeable interfaces, ceramic-filled acrylate inks, radical-photopolymerisation modelling and interlayer mechanics [1–5]. General reviews [6,7] provide terminology and process context only. Results are conditional on chemistry, atmosphere, spectral exposure, geometry, filler state and post-processing.

2. Topic-specific findings

- Competition between radical generation, oxygen diffusion and radical quenching establishes an inhibition response governed by chemistry, irradiance, exposure time, viscosity and boundary conditions [1,4].
- A controlled oxygen-permeable boundary can deliberately maintain a liquid interface; this mechanism must not be equated with uncontrolled free-surface oxygen exposure [2].
- Ceramic-filled acrylate inks can require a formulation-specific response to oxygen inhibition because fillers, additives and viscosity alter the coupled optical and transport state [3].
- Interlayer strength depends on the state of the interface and subsequent exposure; nominal layer count or dose alone does not establish interface integrity [5].

3. Minimum reporting set

Measurand/control	Minimum method record	Required report
Surface conversion	ATR-FTIR, Raman or a validated conversion proxy at stated depth and position	Atmosphere, delay, wash and post-cure state
Near-surface mechanics	Instrumented indentation or another calibrated depth-sensitive method	Depth profile, uncertainty and censoring rule
Interface strength	Geometry-specific tensile, shear or fracture method	Separate cohesive, adhesive and mixed failure
Oxygen boundary	Controlled atmosphere or oxygen-permeable interface record	Do not equate purge gas with zero oxygen
Optical/material state	Spectrum, irradiance/dose, viscosity, filler and absorber state	Working curve plus the exact formulation and temperature

4. Failure interpretation

- A tacky surface indicates an incompletely resolved surface state, not a quantified conversion or extractables result.
- A strong bulk coupon does not establish adequate interlayer or free-surface performance.
- Compensatory overexposure can change dimensions while masking the original inhibition response.
- Filled and unfilled formulations cannot be interchanged without a new optical and surface-state check.

5. 3Dresyns implementation examples

The following are manufacturer-controlled implementation candidates, not independent evidence:

- Fine Tuners, photoaccelerants and Light Blockers may shift cure kinetics or optical confinement. Each change requires a new working curve and surface/interface-state check.
- Curing Rate Tables can organise exposure screening but do not demonstrate finished-surface safety, conversion or adhesion.

Any product-specific implementation must identify and verify the current exact product name, TDS/IFU revision and public link at the time of use.

6. Limitations and priorities

The literature uses formulation-specific chemistries, atmospheres and mechanical methods. Numerical results must not be pooled as universal product constants. Priorities are depth-resolved conversion/mechanics, interlaboratory interface tests and oxygen-transport measurements in filled resins under production-relevant histories.

7. Conclusions

- Oxygen inhibition must be reported as a bounded surface or interface state, not as a binary material label.
- Interlayer integrity requires a mechanical method that distinguishes the failure location [5].
- The seven sources are retained, but only the five topical sources support the topic-specific findings.

Declarations

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