

Washing- and Drying-Induced Extraction, Property Change and Dimensional Response in Vat-Printed Photopolymers

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Statement of Significance

Washing is a material-processing step, not proof of residue removal. Solvent identity, exposure, geometry and drying state can alter elution, conversion, mechanics and dimensions, so apparently clear rinse liquid is not a quantitative endpoint.

Keywords: washing; extraction; residual monomer; drying; solvent exposure; dimensional response; VPP.

Abstract

Three topical studies show that postwashing conditions can change residual-monomer elution, degree of conversion, mechanical properties and dimensional or strength outcomes in printed dental materials. They do not establish a universal swelling or drying-gradient model. This note therefore separates evidenced outcomes from qualification requirements. For body-contact articles, chemical characterisation belongs within the applicable biological-evaluation risk process, including ISO 10993-12:2021 with Amendment 1:2025 and ISO 10993-18:2020 with Amendment 1:2022. RP-02 defines the shared qualification method.

1. Evidence boundary

Jin et al. directly measured residual-monomer elution, conversion and mechanical response after postwashing [1]. Choudhary et al. assessed compressive strength after chemical post-processing [2]. Tayeb et al. studied solvent effects on mechanical properties of printed definitive-crown materials [3]. These sources support solvent- and workflow-dependent outcomes, but they do not directly quantify drying-induced concentration gradients in arbitrary geometries.

2. Topic-specific findings and requirements

- Postwashing conditions can affect residual-monomer elution, degree of conversion and mechanical properties; the wash cannot be assessed from appearance alone [1].
- Chemical post-processing can alter a measured mechanical response, and the direction or magnitude cannot be transferred between material systems without testing [2,3].
- The post-cure state remains conditional on the preceding wash and residual-solvent state when those variables affect conversion or mechanics [1].
- Solvent uptake, extraction and drying gradients are qualification concerns for thick walls, channels and soft networks; the present source set does not quantify a universal gradient model.

3. Minimum reporting set

Measurand/control	Minimum method record	Required report
Wash process	Solvent identity/purity, bath age, agitation, part-to-liquid ratio, time and temperature	All parameters plus number of stages and carry-over control
Mass/dimensions	Gravimetry and dimensional metrology at fixed wet, dried and post-cured time points	Geometry, registration, timing and uncertainty
Residuals	Validated extraction followed by GC-MS, HPLC or quantitative spectroscopy	Solvent, ratio, temperature, time, recovery, LOD and LOQ
Body-contact chemical characterisation	ISO 10993-12:2021/Amd 1:2025 and ISO 10993-18:2020/Amd 1:2022 within the applicable risk process	Article state, extraction rationale and toxicological context
Mechanical state	Application-relevant test on matched wet, dried and post-cured specimens	Conditioning, specimen, failure mode and statistical unit

4. Failure interpretation

- Clear wash solvent does not demonstrate absence of residual monomer or extractables.
- Mass recovery after drying does not by itself prove restoration of network state or dimensions.
- Cracking, whitening or strength loss may reflect solvent exposure, drying stress, cure state or their interaction.
- Internal channels and thick sections require geometry-specific endpoints because surface dryness can precede internal equilibration.

5. 3Dresyns implementation examples

3Dresyns cleaning products and water-removable systems are manufacturer-controlled implementation candidates. Each requires a formulation- and geometry-specific washing window. WP-06 and WP-12 may provide workflow context, but neither establishes automatic residue removal, body-contact suitability or dimensional invariance. Any product-specific implementation must verify the current exact product, TDS and IFU revisions.

6. Limitations and priorities

The evidence is concentrated in dental materials and does not justify universal claims for all VPP networks. The current title has therefore been narrowed from general swelling and drying-induced dimensional change to evidenced extraction, property and dimensional response. Priorities are quantitative wash endpoints, solvent-condition monitoring and time-resolved measurements in representative internal geometries.

7. Conclusions

- Washing must be treated as a controlled material-processing step.
- Residual-monomer and chemical-characterisation claims require quantitative methods, not visual endpoints.
- Drying-gradient statements remain qualification requirements unless supported by geometry- and time-resolved evidence.

Declarations

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