

Dextran-Methacrylate Photoresins: Molecular Weight, Degree of Substitution, Solvent State, DLP Hybrid Networks, Washing, Degradation and Qualification

Juan Seguro

3Dresyns by Resyner Technologies S.L.

Registered tax address: General Etxague 15B, 20003 Donostia / San Sebastián, Gipuzkoa, Spain

VAT number: ESB24827511

Correspondence: info@3Dresyns.com · Website: ww

ER-126 | Engineering Review | Version 0.3 | 31 August 2026

Statement of Significance

Dextran methacrylate is not one material or one printable state. Dextran molecular-weight distribution and provenance define the starting polysaccharide; glycidyl-methacrylate attachment and measured substitution define Dex-GMA; solvent, polymer concentration, initiator, absorber and hybrid partner define the photoink; and exposure, extraction, water exchange, swelling and degradation define later articles. ER-126 establishes a qualification chain that prevents DexMA, Dex-GMA, GelMA-DexMA and Dex-GMA/PCL-IEMA constructs from being pooled by acronym.

Keywords: dextran; dextran methacrylate; DexMA; Dex-GMA; molecular weight; degree of substitution; DLP; glycerol; hybrid network; washing; degradation; qualification.

Abstract

Primary studies show that methacrylated dextran is route-, substitution- and state-specific. Glycidyl methacrylate was coupled to dextran in DMSO with DMAP, with substitution controlled by reagent ratio and aqueous radical polymerisation controlled by initiator and macromer concentration. Glycerol changed chain conformation, optical and mechanical behaviour and crosslinking kinetics in DexMA/gellan systems. A 2025 DLP study printed Dex-GMA/PCL-IEMA hybrids across a defined concentration, LAP, tartrazine, dose and wash window; its results belong to that hybrid and solvent state, not to DexMA alone. GelMA-DexMA and degrading dex-MA studies likewise show that substitution, partner network and enzyme exposure alter swelling, mechanics and transport. Qualification must freeze dextran provenance, molecular-weight distribution, modification route, measured substitution, purification, solvent, hybrid composition, photoinitiator, absorber, wavelength, irradiance, working curve, conversion, washing, swelling, dimensions, mechanics, degradation protocol and model-specific biology. Exposure time is not conversion, water exchange is not administrative cleaning and one hybrid result cannot be reassigned to neat DexMA.

1. Scope and boundaries

ER-126 owns material-specific identity and qualification of dextran-methacrylate photoresins and their explicitly declared hybrid networks. It includes Dex-GMA/DexMA synthesis, substitution, aqueous or glycerol/DMSO formulation, photochemical or radical network formation, DLP evidence, washing, hydration, hydrolysis and enzyme-mediated evolution. It does not own native dextran generally, every dextran copolymer, generic drug delivery, universal biodegradation, tissue regeneration or clinical suitability.

ER-06 retains biological response; ER-10 geometric metrology; ER-15 degradation and mechanical evolution; ER-27 conversion; ER-33 washing and drying; ER-67 generic interpenetrating and double networks; ER-86 extractables; ER-100 corpus architecture; and ER-121 to ER-125 the neighbouring silk, collagen, chitosan, hyaluronic-acid and alginate derivative families [C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,C13].

Dextran molecular weight is not degree of substitution. GMA feed is not incorporated methacrylate. Dex-GMA/PCL-IEMA is not neat Dex-GMA, GelMA-DexMA is not a single-polymer network, and glycerol or DMSO formulations are not equivalent to water. A study-specific cytocompatibility observation is not regulatory approval.

2. Controlled DexMA-photoresin state chain

State	Minimum identity	Failure if omitted
Incoming dextran	Biological/industrial source route, grade, molecular-weight distribution, branching, purity, endotoxin/bioburden, storage	The word dextran replaces polymer identity
Photoactive derivative	Attachment reagent and catalyst, solvent, feed, time, purification, measured substitution and retained molecular weight	DexMA acronym or GMA feed is treated as chemistry
Photoink	DexMA concentration, water/glycerol/DMSO, hybrid partner and ratio, initiator, absorber, rheology, temperature and age	Solvent and partner network disappear
Released article	Spectrum, dose, conversion, wash/extraction, swelling medium/time, dimensions, mechanics, residuals and degradation state	Green, washed, wet and degrading articles are pooled

Table 1. Minimum state chain for dextran-derived photocurable networks.

This material/article chain is separate from process and production-site qualification under ISO/ASTM 52920:2023 [S2].

3. Primary evidence and controlled interpretation

3.1 Synthesis and substitution are controlled coordinates

Van Dijk-Wolthuis et al. synthesized Dex-GMA by coupling glycidyl methacrylate to dextran in DMSO with DMAP [1]. NMR showed that substitution could be controlled by the GMA/dextran molar ratio and that GMA incorporation exceeded 90%. Aqueous hydrogels were then produced with APS/TEMED; polymerisation rate depended on APS, TEMED and Dex-GMA concentration, and selected conditions consumed more than 95% of methacrylate groups within 20 min. These are route-specific radical-polymerisation results, not a universal light dose or DLP cure schedule.

The same group subsequently reported that this coupling proceeds by transesterification rather than epoxide ring-opening [1b].

3.2 Direct DLP evidence belongs to a hybrid solvent state

Escobar et al. used approximately 70,000 g/mol dextran, functionalised it with GMA in DMSO and combined Dex-GMA with PCL-IEMA [2]. The selected photoinks contained 20% w/v total polymer at Dex:PCL mass ratios of 25:75, 50:50 or 75:25, with 0.4% w/v LAP and 0.1% w/v tartrazine. DLP used 100 µm layers, 405 nm light at 21 mW/cm² and approximately 19-20 s exposure, followed by one day on absorbent paper and three days in water. The evidence demonstrates printability of the complete Dex-GMA/PCL-IEMA/DMSO/LAP/tartrazine system; it does not establish a neat aqueous DexMA window.

3.3 Solvent is part of the network identity

Zoratto et al. compared glycerol with aqueous media for DexMA and gellan systems [3]. Glycerol altered polysaccharide chain flexibility and affected the mechanical, morphological and optical properties of the hydrogels while improving DexMA crosslinking kinetics and mixture homogeneity. Solvent exchange can therefore change both processability and the released article; glycerol is not an inert label and cannot be deleted from the state record.

3.4 Hybrid-partner effects cannot be assigned to DexMA alone

Wang et al. photocrosslinked GelMA-DexMA copolymer hydrogels and controlled the DexMA glycidyl-methacrylate substitution [4]. Compared with GelMA, the copolymer hydrogels showed lower swelling and higher compressive modulus; pore size decreased as substitution increased, and encapsulated NIH-3T3 fibroblasts remained viable in that model. These observations belong to the declared GelMA-DexMA composition and culture protocol, not to neat DexMA or universal biocompatibility.

3.5 Degradation changes transport and mechanics together

Meyvis et al. studied bovine serum albumin and immunoglobulin G release from dex-MA hydrogels during dextranase-driven degradation and correlated release with evolving rheological properties [5]. Enzyme identity, activity, specimen geometry, mesh evolution and cargo size therefore belong in the degradation record. Enzyme-accelerated release is not a universal hydrolysis rate or an in-vivo resorption prediction.

4. Photochemistry, washing and article state

Dextran molecular weight, substitution, concentration and solvent change viscosity and optical transport. Hybrid fraction, initiator, absorber, oxygen, wavelength and temperature change radical generation and cure. Working curves must be measured on the exact vat state; exposure time alone is not conversion, cure depth does not establish x/y/z fidelity and a hybrid formulation cannot transfer its window to neat DexMA [S1,S3,S4,C2,C4].

The DLP study's one-day solvent-removal step and three-day water wash are material-state transformations. They can change DMSO and dye content, mass, dimensions, swelling and mechanics. Release therefore requires measurements after the declared extraction and equilibration history, not only on the green print.

5. Hydration, degradation and biological boundaries

Evidence block	What it can show	What it cannot establish alone
Solvent/water exchange	Protocol-specific mass, dimensions, optical state and residual reduction	Complete extraction, conversion or in-use dimensions
Hydration/equilibration	Medium- and time-specific swelling and wet mechanics	Green-state fidelity or universal service behaviour
Hydrolysis/dextranase	Protocol-specific mass, mesh, rheology and transport evolution	Universal in-vivo resorption
Cell model	Response of the exact released hybrid in the declared assay	Universal safety, efficacy or approval

Table 2. Evidence blocks that must remain separate for DexMA photo-networks.

ISO 10993-12:2021/Amd 1:2025 and ISO 10993-18:2020/Amd 1:2022 anchor sample preparation and chemical characterisation [S5,S6]. ISO 10993-1:2025 frames biological-safety evaluation within risk management [S7]. ISO 10993-13:2010 addresses identification and quantification of degradation products from finished non-resorbable polymeric devices and has replacement work under development [S8]. Research-cell observations do not constitute approval.

6. Release matrix

Gate	Minimum evidence	Claim withheld
Dextran identity	Source/grade, molecular-weight distribution, branching, purity, endotoxin/bioburden and storage	Generic dextran equivalence
Functionalisation	GMA route, catalyst, solvent, reaction conditions, purification and measured substitution	Feed ratio or DexMA acronym as identity
Photoink	DexMA concentration, solvent, hybrid partner/ratio, initiator, absorber, rheology and age	Transfer of a hybrid DLP window
Photochemistry	Spectrum, irradiance, working curve, conversion, gel fraction and spatial state	Exposure time as complete cure
Released article	Extraction, water exchange, swelling, x/y/z dimensions, mechanics and residuals	Green values as wet-duty properties
Degradation/biology	Defined hydrolysis/enzyme and model protocols on the released state	Universal safety, resorption or efficacy

Table 3. Minimum release architecture for dextran-methacrylate photoresins.

7. Failure-mode interpretation

- A DexMA lot becomes more viscous: verify dextran molecular-weight distribution, substitution, concentration, solvent, temperature and ageing before changing exposure.
- A higher GMA feed does not improve cure: measure incorporated substitution and conversion; do not treat reagent feed as network density.
- The DLP hybrid prints but neat DexMA does not: retain PCL-IEMA, DMSO, LAP and tartrazine as causal formulation variables rather than transferring the window.
- A print shrinks during washing: map x/y/z through solvent removal, water exchange and equilibration; do not call washing administrative.
- Dextranase accelerates cargo release: track enzyme activity, mesh/rheology and cargo size rather than assigning one degradation constant.
- Cells remain viable in a GelMA-DexMA construct: retain the exact hybrid, substitution, exposure, wash and assay state; do not convert one model into universal biocompatibility.

8. Minimum workflow and research priorities

- Freeze dextran source/grade, molecular-weight distribution, branching, purity, endotoxin/bioburden and storage.
- Report GMA route, catalyst, solvent, feed, temperature, time, purification and measured substitution with its calculation basis.
- Map rheology, optical response and working curves across solvent, temperature and the complete build-duration window.
- Measure conversion, gel fraction and residual Dex-GMA, initiator, absorber, solvent and hybrid partner on matched states.
- Track mass and x/y/z dimensions through green, extraction, water exchange, swelling, drying and rehydration.
- Use neat-DexMA, partner-only and hybrid controls before assigning reinforcement or degradation to one component.
- Report degradation medium, enzyme/activity, pH, temperature, replenishment, geometry, time and property evolution.
- Separate model-specific cell observations from biological safety, efficacy and regulatory conclusions.

9. Conclusions

Dextran-methacrylate photoresins are a family of controlled polysaccharide, derivative, formulation, network and article states. Molecular-weight distribution defines the starting dextran; attachment route and measured substitution define Dex-GMA; solvent and hybrid composition define the photoink; and exposure, extraction, hydration and degradation define later articles.

Primary evidence supports controlled substitution and radical polymerisation, solvent-dependent DexMA/gellan networks, direct DLP of a Dex-GMA/PCL-IEMA hybrid and substitution-sensitive GelMA-DexMA mechanics. It also shows why a DLP result, exposure time, water wash or cell assay cannot serve as complete material identity.

Release therefore requires traceability from dextran source through molecular weight, functionalisation, substitution, purification, solvent, hybrid formulation, photochemistry, washing, hydration, dimensions, residuals, mechanics, degradation and model-specific biology. No single print, modulus, swelling ratio or viability result closes that chain.

Limitations

This paper is a qualitative engineering review, not a systematic meta-analysis. The cited studies use different dextran grades, molecular weights, substitution routes, solvents, concentrations, initiators, absorbers, hybrid partners, wavelengths, exposures, washing schedules, geometries, hydration states, degradation protocols and biological models. Numerical results are not pooled or ranked. No proprietary formulation, universal DLP window, medical-device qualification or clinical claim is provided.

Author contributions

Juan Seguro: conceptualisation, evidence synthesis, boundary definition, engineering interpretation, manuscript preparation and final author verification.

Competing interests

The author is founder and CEO of 3Dresyns by Resyner Technologies S.L., which develops photopolymer materials. This relationship is declared for transparency. No commercial product claim is evaluated in this paper.

Data and source availability

This review uses publicly identifiable primary articles, indexed abstracts and official standards catalogue records. The supporting review package contains a source/boundary ledger, QA report and manifest. No proprietary formulation data are disclosed.

Independent-review and release status

ER-126 v0.3 received APPROVE in the consolidated independent review dated 31 August 2026. No blocking scientific, bibliographic, standards, source, boundary or visual gate remains.

References - independent scientific evidence

- [1] van Dijk-Wolthuis, W.N.E., Franssen, O., Talsma, H., van Steenberg, M.J., Kettenes-van den Bosch, J.J. and Hennink, W.E. Synthesis, Characterization, and Polymerization of Glycidyl Methacrylate Derivatized Dextran. *Macromolecules* 28(18) (1995) 6317-6322. DOI: 10.1021/ma00122a044. <https://doi.org/10.1021/ma00122a044>
- [1b] van Dijk-Wolthuis, W.N.E., Kettenes-van den Bosch, J.J., van der Kerk-van Hoof, A. and Hennink, W.E. Reaction of Dextran with Glycidyl Methacrylate: An Unexpected Transesterification. *Macromolecules* 30(11) (1997) 3411-3413. DOI: 10.1021/ma961764v. <https://doi.org/10.1021/ma961764v>
- [2] Escobar, I.C.P., Chaves, L., Paula, C.T.B., Pereira, P., Serra, A.C. and Coelho, J.F.J. Development of a Tunable Dextran-PCL Biomaterial Photoink for High-Resolution DLP 3D Printing in Biomedical Applications. *ACS Applied Materials & Interfaces* 17(46) (2025) 63272-63285. DOI: 10.1021/acsami.5c18856. PMID: 41194746; PMCID: PMC12818721. <https://doi.org/10.1021/acsami.5c18856>
- [3] Zoratto, N., Matassa, R., Montanari, E., Familiari, G., Petralito, S., Coviello, T., Di Meo, C. and Matricardi, P. Glycerol as a Green Solvent for Enhancing the Formulation of Dextran Methacrylate and Gellan-Based Semi-Interpenetrating Polymer Networks. *Journal of Materials Science* 55 (2020) 9562-9577. DOI: 10.1007/s10853-020-04732-1. <https://doi.org/10.1007/s10853-020-04732-1>
- [4] Wang, H., Zhou, L., Liao, J., Tan, Y., Ouyang, K., Ning, C., Ni, G. and Tan, G. Cell-Laden Photocrosslinked GelMA-DexMA Copolymer Hydrogels with Tunable Mechanical Properties for Tissue Engineering. *Journal of Materials Science: Materials in Medicine* 25 (2014) 2173-2183. DOI: 10.1007/s10856-014-5261-x. <https://doi.org/10.1007/s10856-014-5261-x>
- [5] Meyvis, T.K.L., De Smedt, S.C., Stubbe, B.G., Hennink, W.E. and Demeester, J. On the Release of Proteins from Degrading Dextran Methacrylate Hydrogels and the Correlation with the Rheologic Properties of the Hydrogels. *Pharmaceutical Research* 18(11) (2001) 1593-1599. DOI: 10.1023/A:1013038716373. PMID: 11758768. <https://doi.org/10.1023/A:1013038716373>

Standards and measurement references

- [S1] ISO/ASTM 52927:2024. Additive manufacturing - General principles - Main characteristics and corresponding test methods. Edition 1. <https://www.iso.org/standard/81802.html>
- [S2] ISO/ASTM 52920:2023. Additive manufacturing - Qualification principles - Requirements for industrial additive manufacturing processes and production sites. Edition 1. <https://www.iso.org/standard/76911.html>

- [S3] ISO/ASTM 52902:2023. Additive manufacturing - Test artefacts - Geometric capability assessment of additive manufacturing systems. Edition 2. <https://www.iso.org/standard/79683.html>
- [S4] ISO 1101:2017. Geometrical product specifications (GPS) - Geometrical tolerancing - Tolerances of form, orientation, location and run-out. Edition 4. <https://www.iso.org/standard/66777.html>
- [S5] ISO 10993-12:2021 with Amendment 1:2025. Biological evaluation of medical devices - Part 12: Sample preparation and reference materials. Edition 5. <https://www.iso.org/standard/75769.html>
- [S6] ISO 10993-18:2020 with Amendment 1:2022. Biological evaluation of medical devices - Part 18: Chemical characterization of medical device materials within a risk management process. Edition 2. <https://www.iso.org/standard/64750.html>
- [S7] ISO 10993-1:2025. Biological evaluation of medical devices - Part 1: Requirements and general principles for the evaluation of biological safety within a risk management process. Edition 6. <https://www.iso.org/standard/10993-1>
- [S8] ISO 10993-13:2010. Biological evaluation of medical devices - Part 13: Identification and quantification of degradation products from polymeric medical devices. Edition 2; confirmed 2019; replacement ISO/AWI 10993-13 under development. <https://www.iso.org/standard/44050.html>

Related Engineering Review boundaries

- Qualification Constraints in Dental and Biomedical Applications. ER-06. Zenodo (2026). chemistry, Workflow Variables and
- [C2] Seguro, J. Metrology of Vat Photopolymerisation: Resolution, Trueness, Precision and Geometric Fidelity Across Scales. ER-10. Zenodo (2026).
- Qualification. ER-15. Zenodo (2026). al Evolution in Vat-Printed Tissue-Engineering Scaffolds: Coupled Design and
- eterogeneity in Vat Photopolymerisation: From Exposure to Network State. ER-27. Zenodo (2026).
- g-Induced Extraction, Property Change and Dimensional Response in Vat-Printed Photopolymers. ER-33. Zenodo (2026).
- gels in Vat Photopolymerisation: Microgel Reinforcement, Interpenetration and Energy Dissipation. ER-67. Zenodo (2026).
- opolymers: Specimen State, Extraction Design, Analytical Coverage and Cross-Study Comparability. ER-86. Zenodo (2026).
- ence Architecture Across Engineering Reviews ER-01 to ER-99. ER-100. Zenodo (2026).
- , GMA Functionalisation, Aqueous DLP, Hydration, Mechanics, Biological State and Qualification. ER-121. Zenodo (2026).
- Triple-Helix State, Low-Temperature DLP, Hydration, Enzymatic Degradation and Qualification. ER-122. Zenodo (2026).
- n, Methacrylation, Acid-Neutral State, Hybrid PEG Networks, SLA/4D Printing and Qualification. ER-123. Zenodo (2026).
- Substitution, DLP Hybrid Networks, Hydration, Hyaluronidase Degradation and Qualification. ER-124. Zenodo (2026).
- ovalent-Ionic Dual Networks, Hydration, Degradation and Qualification. ER-125. Zenodo (2026).

Version note

v0.3 closes the standards, reference and disclosure findings and incorporates the independent-review corrections. The consolidated independent review dated 31 August 2026 returned APPROVE with the remaining primary-source verification closed from the enclosed full texts.

SHA-256