

# Methacrylated Konjac-Glucomannan Photoresins: Botanical Identity, Acetylation, Oxidation, Substitution, Extrusion, Microspheres, Wound Composites, Hydration and Qualification

**Juan Seguro**

3Dresyns by Resyner Technologies S.L.

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

VAT number: ESB24827511

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

ER-133 · Engineering Review · Version 0.4 · 1 September 2026

## Statement of Significance

Konjac-glucomannan photoresins are not defined by KGMMMA alone. Species and cultivar, tuber fraction, extraction and purification, glucose:mannose composition, native acetylation, molar-mass distribution and moisture define the feedstock. Oxidation and methacrylation add independent coordinates; formulation, light, washing and hydration define the article.

*Keywords: konjac glucomannan; methacrylated KGM; acetylation; oxidation; extrusion bioprinting; microspheres; photocrosslinking; wound hydrogel; qualification*

## Abstract

Photocurable konjac-glucomannan systems span methacrylated KGM (KGMMMA) extrusion bioinks, photocrosslinked 3D-culture hydrogels, light-curable microspheres for subcutaneous filling and oxidised KGMMMA wound composites. Qin et al. established KGMMMA printability; Redondo et al. reported KGM photocrosslinked hydrogels for in-vitro 3D cell culture; Wang et al. reported light-curable methacrylated KGM microspheres for subcutaneous tissue filling; Li et al. combined KGMMMA with zinc-induced glycyrrhizic-acid assembly; and Pan et al. used methacrylated oxidised KGM with drug-bearing components. This review separates parent identity, acetylation, oxidation, substitution, cure, article state and claims.

## 1. Scope and boundaries

ER-133 owns material-specific identity and qualification of photocurable konjac-glucomannan derivatives. It covers botanical and process source, composition and acetylation, molar mass, oxidation and methacrylation, precursor rheology, extrusion, emulsified microspheres, composite networks, washing, hydration, mechanics, degradation and biological boundaries.

ER-06 retains biological-response methodology; ER-10 geometric metrology; ER-15 degradation and mechanical evolution; ER-27 conversion; ER-33 washing and drying; ER-67 network architecture; ER-86 extractables; ER-100 corpus architecture; and ER-123 to ER-132 other photocurable biopolymer derivatives. [C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18].

General AM characteristics and geometric test artefacts should follow the declared ISO/ASTM standards [S1,S3].

Native, deacetylated, oxidised, methacrylated and methacrylated-oxidised KGM are not interchangeable. Methacrylic reagent feed is not measured substitution. Extruded bulk hydrogels are not emulsified microspheres. Zinc/glycyrrhizic acid, peptide, UiO-66, sodium ferulate or deferoxamine effects cannot be assigned to KGMMMA alone.

## 2. Controlled konjac-glucomannan photoresin state chain

| State                  | Minimum identity                                                                                                                                             | Failure if omitted                                  |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| Incoming KGM           | Species/cultivar and tuber fraction, extraction/purification/deacetylation, lot, glucose:mannose, acetylation, molar mass, purity, ash, moisture and storage | KGM name replaces feedstock identity                |
| Photoactive derivative | Oxidation and MA route, reaction/purification, measured carbonyl/substitution, residuals, dry state and storage                                              | Feed ratio or KGMMMA acronym is treated as identity |
| Ink or precursor       | Derivative, initiator, co-monomer/peptide/metal/supramolecular component/payload/cells, solids, pH, optical state and age                                    | Chemistry and formulation states disappear          |

| State   | Minimum identity                                                                                                                                         | Failure if omitted                                                    |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| Article | Extrusion or emulsion process, light/post-cure, wash, conversion, soluble fraction, residuals, payload, hydrated dimensions or sphere size and mechanics | Printed, particulate, cured, washed and hydrated states are conflated |

Table 1. Minimum state chain for photocurable konjac-glucomannan constructs.

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

### 3. Primary evidence and controlled interpretation

#### 3.1 Botanical, compositional and acetyl states precede derivatisation

KGM is extracted from *Amorphophallus* tubers and contains a beta-1,4-linked glucomannan chain with native acetyl substituents. Species/cultivar, plant age and tuber fraction, milling, extraction, purification and deacetylation, glucose:mannose ratio, acetyl content, molar-mass distribution, protein, ash and moisture govern dissolution, viscosity, alkali gelation and degradation. These coordinates must be frozen before oxidation or methacrylation.

#### 3.2 KGMMMA substitution tunes extrusion and hydrated properties

Qin et al. modified KGM with methacrylic anhydride and reported UV-crosslinked KGMMMA with shear thinning, printable lattices, hexagons and flower geometries, and MA-content-dependent strength, swelling and degradation [1]. Chondrocyte-loaded constructs supported growth under the stated culture. Those results establish formulation-specific extrusion feasibility, not a universal substitution-performance relationship or general cartilage efficacy.

#### 3.3 Photocrosslinked and biofunctional networks require matched controls

Redondo et al. reported konjac-glucomannan photocrosslinked hydrogels for in-vitro 3D cell culture [2]. The accessible publisher metadata contains no abstract, so process, mechanical, degradation, peptide and biological specifics are not reproduced here. Network architecture, functionalisation route and unmodified controls must remain distinct test objects.

#### 3.4 Microsphere processing creates a separate geometry and exposure problem

Wang et al. reported light-curable methacrylated KGM microspheres for subcutaneous tissue filling [3]. The accessible publisher metadata contains no abstract, so phase ratios, stirring conditions, sphere-size ranges and biological results are not reproduced here. Microsphere formation, phase removal, size distribution, internal conversion and injection damage require controls that a bulk disk or printed lattice does not provide.

#### 3.5 Oxidised and supramolecular wound composites change network ownership

Li et al. combined KGMMMA with zinc-induced glycyrrhizic-acid assembly and a photoinitiator, reporting in-vitro gelation below 5 s and testing mechanical, haemolysis, cell, immune and diabetic-mouse wound endpoints [4]. Pan et al. crosslinked methacrylated oxidised KGM with an additional monomer and incorporated UiO-66/sodium ferulate plus deferoxamine [5]. Oxidation, covalent cure, metal/supramolecular assembly and drug effects require separate component and full-formulation controls; animal findings do not establish clinical efficacy.

### 4. Formulation and optical-process control

Parent lot, composition, acetylation, molar mass, oxidation and methacrylation, solids, pH, initiator, co-monomer, peptide, metal, supramolecular component and payload define the precursor. Extrusion or emulsion settings, wavelength, irradiance, exposure, oxygen, depth and geometry define article formation. These variables require monitoring on the complete formulation over age, processing and post-cure.

Parent KGM, oxidised-only, methacrylated-dark, initiator-light, derivative-light and complete controls are required. Composite studies additionally need matched peptide, zinc, glycyrrhizic acid, carrier, drug and co-monomer controls. Without them, native association, oxidation, covalent conversion, supramolecular assembly and active-agent response are conflated.

### 5. Hydration, degradation and biological boundaries

| Evidence block             | What it can show                                                                         | What it cannot establish alone                           |
|----------------------------|------------------------------------------------------------------------------------------|----------------------------------------------------------|
| Parent/derivative identity | Method-specific acetyl, oxidation, substitution, molar mass and solution state           | Conversion or article performance                        |
| Process window             | Formulation-, extrusion/emulsion-, optical-system- and geometry-specific formation       | Transferable printing, sphere or cure settings           |
| Hydration/degradation      | Medium-, payload-, geometry-, temperature- and time-specific mass, mechanics and release | Universal degradation or service life                    |
| Biological model           | Response of the exact construct, extract, composite, payload or cell-loaded formulation  | General safety, clinical efficacy or regulatory approval |

Table 2. Evidence blocks that must remain separate for KGM photoresins.

ISO 10993-12:2021/Amd 1:2025 and ISO 10993-18:2020/Amd 1:2022 anchor sample preparation and chemical characterisation [S4,S5]. ISO 10993-1:2025 frames biological safety within risk management [S6]. Cell viability, haemolysis, immune markers or one mouse wound model does not establish universal biocompatibility, clinical efficacy or approval.

## 6. Release matrix

| Gate                | Minimum evidence                                                                                                                   | Claim withheld                                                  |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| Parent identity     | Botanical/process source, tuber fraction, extraction, lot, composition, acetylation, molar mass, purity, ash, moisture and storage | Generic KGM equivalence                                         |
| Derivatisation      | Oxidation/MA reaction and purification, measured carbonyl/substitution, residuals, stability and dry state                         | Feed or acronym as derivative identity                          |
| Process             | Complete formulation, extrusion/emulsion hardware, spectrum, irradiance, exposure and geometry/size distribution                   | Transferable deposition, sphere or cure settings                |
| Network attribution | Conversion plus parent, oxidised-only, dark, initiator-light, derivative-light and matched composite controls                      | Unverified covalent, supramolecular, metal or payload ownership |
| Article state       | Green, post-cured, washed, hydrated and dried x/y/z or sphere-size, mass, payload, residuals, mechanics and conditioning           | Unqualified dimensions, mechanics, release or stability         |
| Biological boundary | Exact derivative, formulation, wash/extract, payload, model, dose, endpoint, duration and statistics                               | Universal biocompatibility or clinical suitability              |

Table 3. Minimum release architecture for photocurable KGM constructs.

## 7. Failure-mode interpretation

- The nominally same KGMMMA has different viscosity: check species/process, lot, glucose:mannose ratio, acetylation, molar mass, purity, moisture, oxidation, substitution, solids, pH and age.
- A lattice prints but swells or loses strength: separate deposited geometry, conversion, soluble fraction, wash, hydration medium, mass loss and mechanical conditioning before changing exposure.
- Microsphere size or integrity drifts: audit phase ratio, viscosity, surfactant, vessel and impeller, stirring, temperature, droplet residence, light penetration, oil removal and size sampling.
- A peptide-functionalised network improves cell spreading: retain matched parent, unmodified derivative, peptide-route and network controls and report the exact article state.
- A zinc/glycyrrhizic-acid or drug-loaded composite changes inflammation: retain component-dose, release, metal speciation, payload and full-network controls; KGMMMA is not sole claim owner.
- A wound model closes faster: retain animal strain/model, wound geometry, infection or diabetes state, comparator, dose, dressing schedule, blinding, duration and endpoint; withhold clinical claims.

## 8. Minimum workflow and research priorities

- Freeze Amorphophallus species/cultivar, plant and tuber fraction, milling, extraction, purification, deacetylation, lot, glucose:mannose ratio, acetylation, molar mass, purity, ash, moisture and storage.
- Report oxidation and methacrylation reagents/feed, pH, time, temperature, purification, drying, measured carbonyl and substitution methods/results, residuals and storage.
- Map derivative, initiator, co-monomer, peptide, metal, supramolecular component, carrier and payload composition, pH, viscosity, optical attenuation and conversion over formulation age.
- Record extrusion nozzle, pressure/flow, speed, layer and geometry or emulsion phase ratio, mixing, surfactant and size distribution, plus spectrum, irradiance, exposure and post-cure.
- Measure conversion, insoluble and soluble fractions, residual reagents/initiator, metal and payload retention, and x/y/z or sphere-size state before and after wash, hydration and drying.
- Use parent, oxidised-only, dark, initiator-light, derivative-light and complete controls, plus matched peptide, supramolecular, metal, carrier, drug and co-monomer controls.
- Test swelling, mass loss, payload release and mechanical retention in defined media over time; distinguish dissolution, hydrolysis, oxidation-state effects and enzymatic cleavage.
- Separate extract cytotoxicity, direct contact, cell loading, haemolysis, immune assays, subcutaneous implantation and wound models from safety, efficacy and regulatory conclusions.

## 9. Conclusions

Photocurable KGM materials are controlled botanical/process-feedstock, acetyl, oxidation, methacrylation, formulation, optical-process, washing and article states.

Primary evidence supports KGMMMA extrusion and oxidised or supramolecular wound composites. Publisher records additionally establish a KGM photocrosslinked 3D-culture paper and a light-curable methacrylated KGM microsphere paper, without importing unread process or biological details. Their process physics, network owners and biological models are not interchangeable.

Release requires traceability through source, composition, acetylation, molar mass, oxidation, substitution, formulation, process, conversion, washing, soluble fraction, residuals, hydration, dimensions, mechanics, payload and biological model.

## Limitations

This paper is a qualitative engineering review, not a systematic meta-analysis. The cited studies use different parent KGM, derivatisation routes, formulations, geometries, article states and biological models. Numerical values are study-specific evidence, not universal design values.

## Author contributions

Juan Segurola: 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. No comparative product recommendation is made.

## Data availability

No new experimental dataset was generated. Scientific statements derive from the cited primary literature and official standards. The review package includes QA and source-boundary controls.

## Company information

3Dresyns by Resyner Technologies S.L. | General Etxague 15B, 20003 Donostia / San Sebastian, Gipuzkoa, Spain | VAT ESB24827511 | [info@3Dresyns.com](mailto:info@3Dresyns.com) | [www.3Dresyns.com](http://www.3Dresyns.com)

## References - independent scientific evidence

- [1] Qin, Z., Pang, Y., Lu, C., Yang, Y., Gao, M., Zheng, L. and Zhao, J. Photo-Crosslinkable Methacrylated Konjac Glucomannan (KGMMMA) Hydrogels as a Promising Bioink for 3D Bioprinting. *Biomaterials Science* 10(22) (2022) 6549-6557. DOI: 10.1039/D2BM00832G. <https://doi.org/10.1039/D2BM00832G>
- [2] Redondo, M., Presa, R., Granja, P. L., Araujo, M. and Sousa, A. Konjac Glucomannan Photocrosslinked Hydrogels for In Vitro 3D Cell Culture. *Materials Today Chemistry* 34 (2023) 101761. DOI: 10.1016/j.mtchem.2023.101761. <https://doi.org/10.1016/j.mtchem.2023.101761>
- [3] Wang, H., Zhang, W., Chen, W., Zhou, Q., Zhu, Q., Wu, C., Liu, W., Luo, X. and Tang, S. Light-Curable Methacrylated Konjac Glucomannan Microspheres for Subcutaneous Tissue Filling. *ACS Applied Polymer Materials* 7(6) (2025) 3728-3738. DOI: 10.1021/acsapm.4c03992. <https://doi.org/10.1021/acsapm.4c03992>
- [4] Li, J., Wu, D., Su, Z., Guo, J., Cui, L., Su, H., Chen, Y. and Yu, B. Zinc-Induced Photocrosslinked Konjac Glucomannan/Glycyrrhizic Acid Hydrogel Promotes Skin Wound Healing in Diabetic Mice through Immune Regulation. *Carbohydrate Polymers* 348(A) (2025) 122780. DOI: 10.1016/j.carbpol.2024.122780. PMID: 39562061. <https://doi.org/10.1016/j.carbpol.2024.122780>
- [5] Pan, X., Zong, Q., Fu, B., Wang, Y., Feng, X., Sun, W. and Zhai, Y. The Preparation of Methacrylated Oxidized Konjac Glucomannan Hydrogel System and Its Treatment for Diabetic Wounds. *International Journal of Biological Macromolecules* 298 (2025) 140005. DOI: 10.1016/j.ijbiomac.2025.140005. <https://doi.org/10.1016/j.ijbiomac.2025.140005>

## 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 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/88205.html>
- [S5] 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>
- [S6] 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>

---

## Related Engineering Review boundaries

- [C1] Segurolo, J. Biological Response in Photopolymer Additive Manufacturing: A Review of Formulation Chemistry, Workflow Variables and Qualification Constraints in Dental and Biomedical Applications. ER-06. Zenodo (2026).
- [C2] Segurolo, J. Metrology of Vat Photopolymerisation: Resolution, Trueness, Precision and Geometric Fidelity Across Scales. ER-10. Zenodo (2026).
- [C3] Segurolo, J. Transport, Degradation and Mechanical Evolution in Vat-Printed Tissue-Engineering Scaffolds: Coupled Design and Qualification. ER-15. Zenodo (2026).
- [C4] Segurolo, J. Conversion Metrology and Spatial Cure Heterogeneity in Vat Photopolymerisation: From Exposure to Network State. ER-27. Zenodo (2026).
- [C5] Segurolo, J. Washing- and Drying-Induced Extraction, Property Change and Dimensional Response in Vat-Printed Photopolymers. ER-33. Zenodo (2026).
- [C6] Segurolo, J. Hierarchical and Double-Network Hydrogels in Vat Photopolymerisation: Microgel Reinforcement, Interpenetration and Energy Dissipation. ER-67. Zenodo (2026).
- [C7] Segurolo, J. Analytical Extractables and Leachables from Vat-Printed Photopolymers: Specimen State, Extraction Design, Analytical Coverage and Cross-Study Comparability. ER-86. Zenodo (2026).
- [C8] Segurolo, J. From Individual Reviews to a Qualification Corpus: Evidence Architecture Across Engineering Reviews ER-01 to ER-99. ER-100. Zenodo (2026).
- [C9] Segurolo, J. Chitosan-Derived Photocurable Hydrogels: Molecular Weight, Degree of Deacetylation, Methacrylation, Acid-Neutral State, Hybrid PEG Networks, SLA/4D Printing and Qualification. ER-123. Zenodo (2026).
- [C10] Segurolo, J. Hyaluronic-Acid Methacrylate/Methacryloyl Photoresins: Source, Molecular Weight, Substitution, DLP Hybrid Networks, Hydration, Hyaluronidase Degradation and Qualification. ER-124. Zenodo (2026).
- [C11] Segurolo, J. Alginate-Methacrylate Photoresins: Source, M/G Composition, Methacrylation Route, Covalent-Ionic Dual Networks, Hydration, Degradation and Qualification. ER-125. Zenodo (2026).
- [C12] Segurolo, J. Dextran-Methacrylate Photoresins: Molecular Weight, Degree of Substitution, Solvent State, DLP Hybrid Networks, Washing, Degradation and Qualification. ER-126. Zenodo (2026).
- [C13] Segurolo, J. Methacrylated-Starch Photoresins: Botanical Source, Amylose/Amylopectin Composition, Gelatinisation, Substitution, Aqueous DLP, Hybrid Bioinks and Qualification. ER-127. Zenodo (2026).
- [C14] Segurolo, J. Photocurable Cellulose-Derived Photoresins: Cellulose and CMC Identity, Carboxymethyl and Methacrylate Substitution, Nanocrystal Functionalisation, Aqueous DLP/TPP, Hydration and Qualification. ER-128. Zenodo (2026).
- [C15] Segurolo, J. Photocurable Pectin-Derived Hydrogels: Botanical Identity, Esterification, Methacrylation and Norbornene Routes, Ionic-Photo Dual Networks, Hydration, Degradation and Qualification. ER-129. Zenodo (2026).
- [C16] Segurolo, J. Methacrylated Kappa-Carrageenan Photoresins: Algal Source, Sulfation, Methacrylation, Thermo-Ionic-Photo Networks, Extrusion and DLP, Hydration and Qualification. ER-130. Zenodo (2026).
- [C17] Segurolo, J. Methacrylated Gellan-Gum Photoresins: Microbial Identity, Acyl State, Methacrylation, Thermo-Ionic-Photo Networks, Extrusion, Hydration and Qualification. ER-131. Zenodo (2026).
- [C18] Segurolo, J. Photocurable Pullulan-Derived Photoresins: Microbial Identity, Methacrylate and Norbornene Routes, Inkjet, SLA-TPP, DLP, Hydration and Qualification. ER-132. Zenodo (2026).