

POMaC Citrate-Containing Photocurable Elastomers: Dual Crosslinking, LCD Vat Printing, Porogen Extraction, Granular Composite Bioinks and Qualification

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ER-120 · Engineering Review · Version 0.3 · 3 September 20

Statement of Significance

Poly(octamethylene maleate (anhydride) citrate), POMaC, is a citrate-containing polyester elastomer whose pendant unsaturation supports photoreticulation while residual hydroxyl and carboxyl groups support further thermal condensation. This dual mechanism means UV dose and heat history jointly define the network. Recent vat-printing formulations add extractable PEG400, TMPTA, TPO and ITX; recent bioinks instead use preformed POMaC microparticles. ER-120 keeps these continuous-network and granular-composite states separate.

Keywords: POMaC; citrate-containing elastomer; dual crosslinking; LCD vat photopolymerisation; PEG400 porogen; porogen extraction; TMPTA; TPO; ITX; granular composite bioink; qualification.

Abstract

Primary evidence defines POMaC as a citric-acid/1,8-octanediol/maleic-anhydride polyester with independent photochemical and condensation crosslinking levers. Early thermosets spanned 0.03-1.54 MPa initial modulus and 48-534% elongation at break across controlled states. A later LCD-vat formulation reduced viscosity from 10 136 to 282 cP with 50 wt% PEG400, used TMPTA to reduce gel time from 11 to 7 s, and printed 80 µm positive features, a nominal 100 µm open channel measured at 110 µm and 100 µm gyroid features. Increasing porogen unexpectedly raised compression modulus from 80 to 790 kPa after extraction while increasing brittleness; residual components required extensive washing, and cell viability remained above 80% only for the tested post-treated specimens. A distinct 2025 route used preformed POMaC microparticles in fibrin, GelMA or alginate to resist cell-driven compaction. Qualification must therefore close backbone ratio, crosslink sequence, soluble formulation, extraction, geometry, degradation and continuous-versus-granular morphology.

1. Scope and boundaries

ER-120 owns POMaC molecular identity, its dual photo/thermal crosslinking, LCD-vat formulation, extractable-porogen state, POMaC-microparticle composite state and associated qualification gates. It does not own all citrate polymers, all soft photoresins, generic hydrogel bioinks, all tissue regeneration, universal biodegradability, clinical implants or proprietary recipes.

ER-06 retains biological response; ER-10 dimensional metrology and geometric fidelity; ER-15 degradation/mechanical evolution; ER-24 soft-network and compliant-elastomer mechanics; ER-26 porous and lattice architectures; ER-33 washing/drying; ER-86 extractables; ER-100 corpus architecture; and ER-119 PG6-A/PGSA [C1,C2,C3,C4,C5,C6,C7,C8,C9]. ER-120 is the POMaC-specific gate.

POMaC is not PGSA: citric acid and maleate/anhydride create a different polyester and a different dual-crosslinking route. Nor is a POMaC microparticle-filled hydrogel equivalent to a continuous POMaC network.

2. Controlled POMaC state chain

State	Minimum identity	Failure if omitted
Prepolymer	Citric acid:1,8-octanediol:maleic anhydride ratio, Mn/dispersity, acid/OH and alkene	POMaC name replaces synthesis state
Vat ink	POMaC, PEG400, TMPTA, TPO, ITX, viscosity, temperature and ageing	Diluent, crosslinker and absorber disappear
Continuous article	Dose/layer, conversion, extraction, thermal history, geometry and degradation	Green and extracted networks are pooled
Granular composite	Particle synthesis/size, source tri-acid identity and discrepancies, hydrogel phase, loading, packing and interphase	Particle effect is assigned to bulk POMaC

Table 1. POMaC identity and morphology chain.

3. Direct primary evidence

3.1 Dual-crosslinking platform

Tran et al. synthesized POMaC from citric acid, maleic anhydride and 1,8-octanediol [1]. Pendant unsaturation enabled UV crosslinking, whereas remaining acid and hydroxyl groups enabled polycondensation. Changing monomer ratio and applying either or both mechanisms tuned thermoset properties and degradation. Reported initial modulus ranged from 0.03 to 1.54 MPa and elongation at break from 48% to 534%. These are a platform envelope across distinct states, not one simultaneous property pair [S1,S2,S6].

Because heat can continue condensation, vat temperature, post-cure temperature and sterilisation heat cannot be treated as neutral handling. A cured article must identify whether it is photo-only, thermally condensed, or sequentially dual-cured [S3,S7,S8].

3.2 LCD-vat formulation and realised geometry

Karamzadeh et al. formulated VP-POMaC for 405 nm LCD and DLP printing [2]. PEG400 served as non-reactive diluent/porogen; 50 wt% reduced viscosity from 10 136 to 282 cP. TMPTA at 1 wt% reduced gel time from 11 to 7 s; the formulation also used TPO and ITX. In the reported LCD process, projected pixel size was $35 \times 35 \mu\text{m}^2$, layer thickness 20 μm and exposure 30-50 s per layer. Realised results differed by feature polarity: 80 μm positive features, a nominal 100 μm open channel measured at 110 μm after the 50 μm design blocked, and gyroid features around 100 μm . No single “resolution” value represents all three [S1,S3,S4].

3.3 Extraction changes structure and mechanics

The printed VP-POMaC was incubated overnight in 70% ethanol to remove PEG porogen and unreacted ink; mechanical specimens used a 48 h ethanol wash [2]. Increasing the nominal porogen from 0 to 50 wt% unexpectedly raised compression modulus from 80 to 790 kPa, storage modulus from 2.94 to 16.42 kPa and maximum reported Young’s modulus to 543 kPa, while increasing brittleness. These values belong to extracted networks whose conversion, shrinkage and porosity co-evolved; PEG input alone is not final porosity [S2,S5,S6].

Unreacted ink components were considered cytotoxic, so extensive washing preceded culture. Viability greater than 80% for fibroblast/endothelial assays belongs to that post-treated formulation and assay. It does not qualify irritation, sensitisation, systemic toxicity, degradation products or implantation [S5,S7,S8,S9].

3.4 Preformed POMaC particles in bioinks

Landau et al. incorporated elastomeric POMaC microparticles into fibrin, GelMA and alginate bioinks for stereolithography or extrusion [3]. Particle packing and stress dissipation improved resistance to cell-driven compaction and handling; cardiac and vascular models and implantation observations were reported for specific composites. This is interphase- and packing-dependent composite evidence, not proof that a neat continuous POMaC resin, every particle size or every hydrogel has the same response [S1,S5,S7]. Note that [3] describes the POMaC tri-acid as citric acid in its introduction but as 1,2,4-butanetricarboxylic acid in its methods; until that discrepancy is resolved at source, particle-composite evidence from [3] is not assumed to concern the identical polyester defined in §3.1.

4. Release matrix

Gate	Minimum evidence	Claim withheld
Chemistry	Monomer ratio, Mn/dispersity, acid/OH/alkene, residual monomers and catalyst	POMaC class equivalence
Crosslink history	UV wavelength/dose/conversion plus every heat and sterilisation step	Photo-only equals dual-cured

Gate	Minimum evidence	Claim withheld
Extracted article	PEG/TMPTA/TPO/ITX input, mass loss, shrinkage, porosity and extractables	Input porogen equals final pores
Granular composite	Particle size/state/loading, matrix, packing, interphase and cell/tissue model	Particle composite equals neat network

Table 2. POMaC release gates.

5. Failure-mode interpretation

- The material is called POMaC: freeze all three monomers, ratio, prepolymer distribution and reactive-group content.
- The article was UV-cured: determine whether heat or sterilisation continued condensation.
- PEG400 lowers viscosity: it is also an extracted porogen whose removal changes dimensions, pores and mechanics.
- A 35 μm pixel is available: report positive, negative and internal-channel capability separately.
- TMPTA is only 1 wt%: it changes kinetics and belongs to final-network identity.
- Viability exceeds 80%: preserve the actual wash, specimen, extract/contact and cell model.
- POMaC particles stabilise a bioink: do not assign matrix/interphase/packing behaviour to neat POMaC.
- POMaC degrades: qualify products and retained mechanics for exact crosslink, geometry and environment.

6. Minimum workflow

- Freeze monomer ratio, synthesis temperature/time, Mn/dispersity, acid/OH/alkene content and batch.
- Freeze PEG400, TMPTA, TPO, ITX, viscosity method, temperature and vat ageing.
- Map wavelength, intensity/dose, layer, separation/recoat settings, conversion and feature polarity.
- Reconcile green, washed, postcured, thermally treated and sterilised mass and dimensions.
- Measure extractables, shrinkage, pore distribution and mechanics on the released article state.
- For particles, control size distribution, crosslink state, loading, matrix chemistry, packing and interphase.
- Track degradation products and time-resolved property retention before biological or implant claims.

7. Conclusions

POMaC is a tunable citrate-containing elastomer whose dual photo/thermal crosslinking prevents any single cure label from defining the network. The LCD-vat route is a multicomponent, extractive manufacturing process, not neat-POMaC printing.

Primary evidence demonstrates positive microfeatures, open channels and gyroids at different realised limits; porogen extraction changes stiffness and brittleness; extensive washing precedes the reported cell result; and preformed POMaC particles create a separate granular-composite mechanism.

ER-120 releases no universal POMaC formulation, resolution, modulus, porosity, degradation rate, cytocompatibility, organ model or implant claim. Qualification must follow chemistry, crosslink sequence, extraction, morphology and final article.

Limitations

This qualitative engineering review is not a systematic meta-analysis. Direct studies use different monomer ratios, crosslink sequences, additives, processes, washes, geometries, particle states and biological models; numerical values are not pooled. No proprietary recipe, universal tissue match, complete toxicology, sterilisation validation, regulatory approval or clinical-performance claim is supplied.

Author contributions

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

Competing interests

The author is Founder and Scientific Director 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 articles and official standards.

Company information

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