

Extended-Producer-Responsibility and Product-Passport Models for Photopolymer Products: Data, Collection and Accountability

Connecting product identity, end-of-life responsibility and auditable circularity data across photopolymer value chains

Juan Seguro

3Dresyns by Resyner Technologies S.L.

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

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Abstract

Extended producer responsibility and digital product passports can connect design, material identity, collection, repair, recycling and end-of-life accountability, but only if the data model corresponds to physical recovery pathways. Photopolymer products pose additional challenges because formulations are proprietary, materials can be crosslinked or composite, and useful recovery may depend on disassembly or specialised chemical processing. This review defines a qualification framework for EPR and product-passport models applied to photopolymer products, including data scope, identifiers, responsibility transfer, collection evidence, recovery outcomes and protection of confidential formulation information.

Keywords: extended producer responsibility; digital product passport; photopolymer; circular economy; traceability; collection; accountability; product data

1. Significance and scope

Extended producer responsibility shifts end-of-life obligations upstream and is widely used to connect product design with collection and treatment. Reviews of plastic EPR show that policy effectiveness depends on how responsibility, financing, collection and processing are implemented [1].

This review owns the information and accountability architecture for photopolymer products. It does not prescribe legal compliance in a jurisdiction; it defines the technical data chain needed for collection, sorting and recovery claims to be auditable.

2. Responsibility must map to a physical end-of-life route

An EPR scheme should identify the producer role, covered product, handover points and approved end-of-life routes. Paying a fee is not equivalent to demonstrating that a photopolymer product reaches an appropriate recovery process.

Crosslinked photopolymers may require different handling from thermoplastics. Product category, resin family, fillers, embedded components and hazardous additives can determine whether reuse, disassembly, chemical recycling or controlled disposal is feasible.

The data model should distinguish mandatory public fields from restricted technical data and from evidence retained for audit. A passport can support routing without exposing proprietary formulation percentages if the recovery class is sufficiently specific.

Passport governance should define who is authorised to create, amend and retire data fields. Traceability is weakened if downstream actors can overwrite material identity or recovery instructions without preserving provenance and version history.

3. Product passports require controlled data fields

Digital product passports are being developed as lifecycle information carriers for circular systems. Work on DPP models emphasises traceability, material information, maintenance and end-of-life data rather than a single sustainability score [2].

A photopolymer passport should contain only fields that have a defined user and action. Useful examples include product identifier, material family, disassembly guidance, known incompatible streams, collection route, repair instructions and recovery status.

4. Identity must survive ownership and processing changes

Proprietary formulation detail does not need to be public if recovery can be supported by a controlled material class, hazard declaration and machine-readable routing code. Confidentiality and circularity should be designed together rather than treated as opposites.

Identity must persist through repair, resale, remanufacture and component replacement. The passport should record versioned changes so that the end-of-life actor does not receive stale material information.

Collection data should distinguish units placed on market, units returned, units sorted, units actually recovered and residual waste. A high return rate does not prove material recovery.

Accountability should survive changes in corporate ownership and service providers. Persistent identifiers, data escrow or governance rules are needed so a product does not become informationally orphaned before its physical end of life.

End-of-life evidence should distinguish an instruction from an outcome. A passport may state that chemical recycling is preferred, but EPR performance requires evidence that returned units reached that route and what fraction was actually recovered or rejected.

5. Confidentiality and interoperability are engineering constraints

EPR and DPP can reinforce one another by linking producer accountability to product-specific data. Recent work explicitly analyses these synergies and the opportunity to move responsibility upstream into design and information management [3].

Interoperability is a technical requirement because manufacturers, service providers, recyclers and regulators use different systems. Stable identifiers, controlled vocabularies and data ownership rules should be defined before deployment.

Data quality matters as much as data presence. Unverified recycled-content claims, outdated repair instructions or generic disposal labels can create a passport that is digitally complete but operationally misleading.

Axis	Measurement	Failure mode
Responsibility	producer, scope, handover	fee payment treated as recovery
Passport	identifier and actionable fields	data volume treated as usefulness
Material routing	class, hazards, recovery path	generic plastic label used
Lifecycle updates	repair/version history	stale passport retained
Outcome	return, sorting, treatment evidence	collection treated as circularity

Table 1. Domain-specific qualification matrix for EPR and product-passport models applied to photopolymer products.

6. Device-level verification of the information chain

Device-level verification should follow a sample product through manufacture, sale, service event, return, sorting and final treatment. Confirm that the identifier resolves, the correct data are available to each actor and the physical outcome is recorded.

The audit should compare claimed and measured flows. Where mass-balance attribution is used, the passport should identify that accounting model rather than implying physical recycled content in a specific unit.

Failure modes include orphaned identifiers, inaccessible data after producer exit, incompatible schemas, unverifiable end-of-life claims, missing update history and a collection scheme that cannot route the actual material.

Device-level verification should include a failure-recovery test of the information infrastructure. Identifier resolution, access permissions and recovery instructions should remain available after ownership transfer, service replacement and a simulated change of data-platform operator.

7. Minimum qualification framework

Report product identifier, producer/responsibility entity, material/recovery class, disassembly or repair data, collection channel, data-access rules, version history and retention period.

Report units placed, returned, sorted and treated; recovery route; residual waste; verification method; and how confidential information is separated from the minimum data needed by downstream actors.

8. Engineering conclusions

EPR and product passports become meaningful for photopolymers only when digital accountability closes on a physical outcome. The information system should make responsibility, collection and recovery auditable without confusing data availability with circular performance.

References

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Competing interest

Juan Segurola is founder, CEO and CTO of 3Dresyns by Resynr Technologies S.L., which develops and commercialises photopolymer materials and related additive-manufacturing technologies. This review is an engineering analysis and does not constitute a product-performance claim or a device qualification.