From Impossible to Circular:
Unlocking Recycling Pathways for Pharmaceutical Packaging

The pharmaceutical and healthcare packaging sector has reached a defining moment. Packaging formats such as blister packs, bottles, tubes, pouches, sachets, cartons and protective wraps are indispensable for ensuring sterility, dose accuracy and patient safety. Yet, once used, the overwhelming majority of this packaging follows a linear trajectory towards disposal or destruction.

This linearity now stands in direct conflict with regulatory, environmental and societal expectations. Under the EU Green Deal, pharmaceutical packaging is no longer viewed as an exceptional category insulated from sustainability obligations. Instead, it is increasingly scrutinised as part of the broader packaging waste system – subject to Extended Producer Responsibility (EPR), recycled content expectations, and net-zero healthcare ambitions.

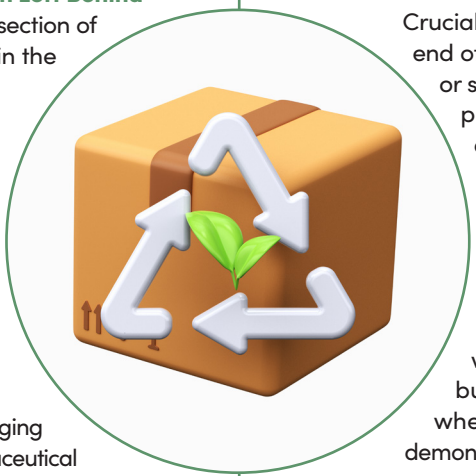
Despite this shift, recycling rates remain alarmingly low. Estimates suggest that only around 14% of blister packs – enter any form of dedicated recycling stream.[1] For many other primary and secondary pharmaceutical packaging formats, effective recycling pathways barely exist. Most materials are still incinerated or landfilled, often by regulatory default rather than by design.

The question facing the industry is no longer whether pharmaceutical packaging must become circular, but how this can be achieved without compromising safety, compliance or performance.

Why Pharmaceutical Packaging Has Been Left Behind

Pharmaceutical packaging sits at the intersection of some of the most complex requirements in the packaging world.

This starts with material complexity. Blister packs combine aluminium with multi-layer polymers. Tubes and pouches rely on laminated structures, adhesives and barrier layers. Bottles, closures and dispensers may incorporate pigments, additives and functional components to meet regulatory and performance standards.



Second, there is contamination risk. Packaging that has come into contact with active pharmaceutical ingredients (APIs) cannot be treated in the same way as consumer packaging waste. Conventional mechanical recycling processes are not designed to guarantee the level of decontamination required for high-value or regulated reuse.

Third, regulatory conservatism plays a role. Once a packaging format has been validated and approved, change is costly and time-consuming. This has historically favoured proven linear materials over innovative circular solutions.



These constraints help explain why pharmaceutical packaging has remained largely outside mainstream recycling systems. However, they do not justify inaction or the lack of development of innovative processes – particularly in light of evolving EU policy.

PPWR and the End of "De Facto Exemptions"

The EU Packaging and Packaging Waste Regulation (PPWR) represents a fundamental shift in how packaging is regulated. Unlike previous directives, PPWR introduces harmonised, binding requirements across Member States, with a strong emphasis on waste reduction, recyclability and recycled content.

Crucially for pharmaceuticals, PPWR signals the end of implicit exemptions based on complexity or safety concerns. While certain medical and pharmaceutical packaging will require exemptions many more could become much more sustainable and the overall direction is clear: most packaging must be designed for circularity, and producers must take responsibility for its end of life.

Under PPWR, claims of "non-recyclability" will increasingly require justification. The burden is shifting from regulators asking whether recycling is possible, to producers demonstrating why it is not.

This regulatory reality demands new thinking – not just about packaging design, but about the new systems that will support collection, sorting, decontamination and recycling.

Extended Producer Responsibility: From Cost to Catalyst

Extended Producer Responsibility has historically been viewed by many pharmaceutical companies as a compliance cost rather than a strategic lever. That perception is rapidly changing.

As EPR schemes evolve, fees are increasingly modulated based on recyclability, recycled content and environmental performance. Packaging that lacks viable recycling pathways is likely to attract higher costs, greater scrutiny and reputational risk.

Conversely, packaging formats that are supported by credible, scalable recycling systems can benefit from lower fees, regulatory confidence and long-term material security.

EPR therefore has the potential to act as a catalyst for innovation, encouraging pharmaceutical companies to invest collectively in infrastructure and technologies that unlock circularity – rather than bearing escalating costs for linear solutions.

Learning from "Impossible" Materials

Working with some of the world's most difficult-to-recycle materials consistently demonstrates that circularity in primarily a materials challenge – it is a systems challenge. Flexible food packaging, cosmetic packaging and high-performance medical plastics share many of the same challenges as pharmaceutical packaging: multi-material construction, contamination risk and demanding end-quality requirements.

Traditional recycling systems were designed for conventional waste streams. Pharmaceutical packaging does not fit this model and never will. Expecting it to conform to municipal recycling norms is neither realistic nor necessary.

Instead, the sector requires bespoke recycling pathways designed specifically to handle complexity, manage contamination and deliver compliant outputs.

Supercritical CO_2: Enabling Pharmaceutical-Grade Recycling

One of the most critical barriers to circular pharmaceutical packaging is decontamination. Without robust, scalable methods to remove chemical residues and absorbed substances, recycled polymers cannot safely re-enter regulated applications.

Solvent-assisted COtooCLEAN™ technology addresses this challenge directly.

The process uses supercritical carbon dioxide to extract contaminants from polymers at a molecular level. In its supercritical state, CO_2 combines the penetration properties of a gas with the solvating power of a liquid, allowing it to potentially remove APIs, additives, oils and odours without degrading the polymer itself.

Unlike solvent-based or high-temperature processes, COtooCLEAN™ leaves no residual chemicals, preserves polymer performance and has a low carbon footprint. This enables recycled materials to meet demanding quality and safety thresholds – opening the door to high-value, regulated re-use.

For pharmaceutical packaging, this represents a step-change: materials previously deemed unsuitable for recycling can potentially be purified to a level compatible with circular systems.

Beyond Blister Packs: A System-Wide Challenge

Blister packs are often highlighted as the emblem of pharmaceutical packaging waste but focusing solely on blisters risks overlooking a broader opportunity.

The pharmaceutical sector generates a diverse stream of plastic and fibre-based packaging, including bottles, tubes, pouches, sachets, cartons and protective films. Collectively, these materials represent a significant environmental footprint – and a significant opportunity for circularity.

Achieving meaningful progress requires addressing this entire ecosystem, rather than treating each format in isolation.

SusPack: A Blueprint for Circular Healthcare Packaging

This systems-led approach underpins SusPack, an Innovate UK-backed collaborative project bringing together Nextek, University of Nottingham and University of Kent through to NPL for materials science and measurement, Sealeo Ltd for packaging solutions, CPI for pilot-scale innovation, Bridge Farm Bioscience Ltd for biotech expertise, The Naked Pharmacy Ltd for pharmaceutical packaging insight, Impact Recycling Ltd and ReVentas Ltd for recycling operations, Alga (Seaweed) Ltd for sustainable biomaterials, and Impact Solutions Ltd for consulting and systems integration.

Collectively, they are developing scalable, compliant recovery pathways for a wide range of pharmaceutical packaging formats.

The project focuses on real-world implementation. Its objectives include:

- Developing advanced sorting and separation processes for complex healthcare packaging
- Applying supercritical CO_2 decontamination and delamination processes to achieve pharmaceutical-grade recycled polymers
- Demonstrating alignment with regulatory and safety requirements
- Creating replicable models that can support EPR compliance and PPWR objectives

SusPack illustrates how cross-sector collaboration can overcome challenges that no single organisation can solve alone.

Redefining Recyclability in a Regulated Context

A persistent misconception in sustainability debates is that packaging must be compatible with household recycling to be considered recyclable. For pharmaceutical packaging, this assumption has been deeply limiting.

Pharmaceutical packaging requires controlled, traceable systems that reflect the sector's regulatory realities and keep it separate from domestic waste streams.

Such systems already exist in other regulated industries, from medical devices to industrial chemicals. Applying similar thinking to pharmaceutical packaging is both logical and necessary.

Net-Zero Healthcare and Material Responsibility

With healthcare accounting for 4–7% of national greenhouse gas emissions in many developed economies, healthcare systems across Europe have committed to ambitious net-zero targets, and pharmaceuticals are a major lever for change.



In the UK, the NHS has committed to net-zero for directly controlled emissions by 2040, and for the full supply chain by 2045. EU health systems have aligned with the European Green Deal and Fit for 55, focusing on decarbonising public procurement, medical supply chains and waste.

Packaging, while only one component of healthcare emissions, is a visible and addressable contributor.

Incineration and landfill not only represent a loss of material value but also generate avoidable carbon emissions. Circular packaging systems, by contrast, reduce reliance on virgin polymers and lower lifecycle emissions.

For pharmaceutical companies, investing in circular packaging is therefore not just an environmental imperative, but a strategic contribution to net-zero healthcare goals.

From Incremental Change to Systems Transformation

The pharmaceutical industry is rightly risk-aware. Patient safety must always come first. However, safety and sustainability are not mutually exclusive.

The technologies, policy frameworks and collaborative models needed to unlock circular pharmaceutical packaging now exist. What is required is the willingness to move beyond incremental change and embrace systems-level transformation.

A Call to Action

The transition from linear to circular pharmaceutical packaging is underway – and it will accelerate under PPWR, EPR reform and net-zero commitments.

Pharmaceutical leaders must engage early, collaborate across value chains and invest in solutions that address end-of-life challenges directly.

Packaging designers and sustainability teams must focus not only on design for recyclability, but on creating pathways that function in practice.

Policymakers and regulators must continue to recognise and enable advanced recycling and decontamination technologies that make circularity possible.

Materials that protect patient health should not compromise planetary health. By rethinking how pharmaceutical packaging is recovered, decontaminated and re-used, the industry can move from impossible to circular – and help deliver a genuinely sustainable healthcare system.

REFERENCES

1. https://pmarketresearch.com/chemi/pharmaceutical-recyclable-blister-packaging-market/

Edward Kosior



For over four decades, Edward has been at the forefront of innovation in polymer technology, driving change across recycling ventures and as the visionary Founder and Managing Director of Nextek. A holder of multiple patents in plastic recycling, he has played a pivotal role in bringing recycled PET, HDPE, and PP into mainstream food packaging across Europe, Asia, Australia and the Americas. Beyond packaging, he is deeply committed to tackling plastic pollution in our oceans and championing science-based solutions and best practices to address the environmental challenges faced by developing nations.