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White Paper

The State of Plastics Recycling in BioPharma

Key Challenges for Manufacturers and How MilliporeSigma is Leading Industry-Wide Change

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Introduction

The pharmaceutical industry produces life-changing and life-saving drugs daily. Now, our industry is looking for how we can simultaneously have a positive impact on patients, while also making a more positive impact on the planet. Many biomanufacturers have begun to examine how they can reduce their greenhouse gas emissions and address their environmental impact. But modern-day pharma manufacturing faces a particularly problematic environmental dilemma: plastic.

Every year, it is estimated that more than **5.5 million tons of laboratory plastics** are sent to incinerators and landfills around the world, and the biopharmaceutical industry, with its heavy reliance on single-use plastics, contributes to this problem. Facilities that rely on single-use plastics can significantly **reduce water consumption, energy use, and therefore CO_2 emissions** when compared with stainless steel counterparts. They also avoid the harsh chemical cleaners required to sterilize multi-use equipment, making them overall, an attractive solution for companies on a sustainability journey. But there is no denying that single-use facilities produce significant amounts of plastic waste.

From a sustainability perspective, the ideal destination for plastic waste is not incinerators or landfills, but a return to supply chains. However, the plastics discarded in biomanufacturing are uniquely difficult to recycle. Challenges of circularity, quality, and infrastructure abound, but despite the odds, change is underway for the industry, and is being spearheaded by industry leaders like MilliporeSigma.

Key challenges for recycling in biopharma

#1: Achieving Circularity

The best outcome for any plastics recycling program is *upcycling*, also referred to as *circular recycling* or *plastic-to-plastic recycling*. Upcycling brings recycled plastics back into supply chains as raw materials, creating equal or greater value in the new products, thus helping to build a **'circular economy'**. In theory, a single plastic polymer could be used many times over – even infinitely – dramatically lowering its environmental footprint. The alternative method of recycling is *downcycling*: degrading the quality, in turn lowering the value of and demand for the material. Downcycling is the fate of recycled plastics in biopharma today.

Why is an industry like Biopharma, known for its innovation and scientific breakthroughs, so behind on plastics recycling? Regulatory constraints currently prohibit the reuse of plastics in single-use equipment in biopharma, but there are several opportunities for the industry to welcome its recycled plastics back into the supply chain, whether in packaging or in other products such as recycled plastics where there is no contact with drug substance, such as the outer layers of buffer containment bags.

Why circularity matters

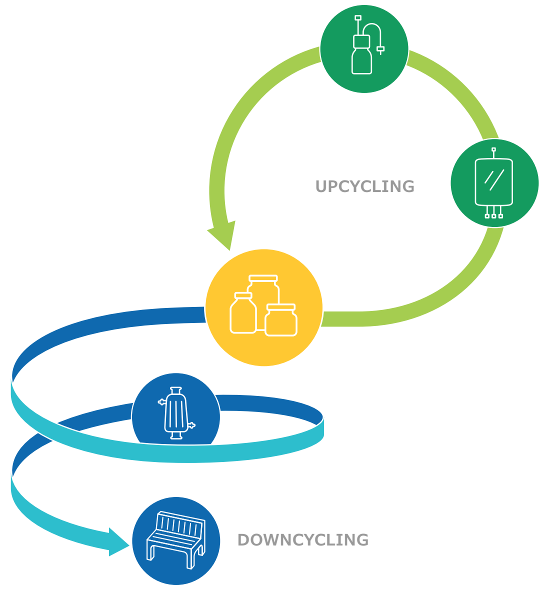
Historically, plastic waste has comprised a relatively small part of our industry's carbon footprint. However, as more companies invest in clean energy facilities to cut down on Scope 1 and 2 emissions, attention will soon turn to the next biggest emitter. And for facilities employing single-use technologies, plastic could be next. A net-zero future requires that the biopharmaceutical industry start looking for ways to bring their plastic waste back into their supply chains.

#2: Ensuring Quality

Truly circular recycling requires a higher quality of plastic than can be produced by **mechanical recycling**. Mechanical recycling places mechanical stress on plastic; each time a polymer is recycled, it is degraded.[1] This results in a low-quality product that ends up downcycled rather than upcycled and will always need an addition of virgin polymer. Therefore, even in the best mechanical recycling systems, we will never reach 100% recycled polymer. In contrast, **chemical** or **advanced recycling** creates entirely new plastics with the potential to be recycled infinitely. This solves the quality problem but introduces another: both systems rely on highly sorted and cleaned plastics which in turn can be energy intensive. Although advanced recycling was originally designed to process mixed plastics, getting an early-stage proof of concept still requires a better understanding of the chemicals present in the plastics, which can cause issues in recycling systems. Thus, both recycling systems require a single, clean stream of plastic to be successful – and the infrastructure required for sorting and cleaning at scale is still years away for biopharma.

#3: Developing Infrastructure

Without appropriate infrastructure to collect, sort, and clean plastic waste, we can't take advantage of the advanced recycling methods required to achieve circularity. There are individual examples of facilities being built to commercial-scale capacity, such as **the recently launched advanced recycling plant** in Baytown, Texas, but the broader infrastructure of advanced recycling is not yet ready to accommodate commercial volume. Yet, the Biopharma industry is too small to solve the infrastructure problem alone. A **JRC technical report** assessing the environmental and economic impact of plastic waste recycling revealed that advanced recycling for mixed plastic waste does not yet have the capacity required for commercial scale.



How lack of volume contributes to infrastructure challenges

MilliporeSigma estimates that the biopharma industry disposes of 94,000-200,000 metric tons of plastic per year. Though this is no small amount, it only accounts for less than 1% of the annual **350 million metric tons** of plastic disposed of globally. As such, biopharma's plastic waste has failed to attract recyclers, who are unwilling to fund advanced recycling on such a small scale. Additionally, output variability across sites creates problems for third-party recyclers – these partners need consistent and predictable input to operate efficiently and cost-effectively.

How mixed components contribute to infrastructure challenges

The plastic waste that exits biomanufacturing facilities is far from a clean stream: biopharma waste contains mixed components e.g., (multilaminate film, silicone tubing, filtration membranes and resins, clamps, magnets, and more), which pose significant processing, melting, and blending challenges. The waste can often be also classified as biohazardous, presenting another challenge. Approximately 50% of the waste that enters the Triumvirate recycling program (see below) is classified as biohazardous. This mixed waste stream requires custom sorting and separation, in addition to sophisticated decontamination – something that advanced recyclers may be willing to undertake for large-volume clients but are reticent to agree to at our smaller industry volumes.

How MilliporeSigma is leading the biopharma industry on recycling

There is hope. Industry leaders such as MilliporeSigma have taken action towards industry-wide recycling. Our successful **Triumvirate partnership** from 2015-2020 is still diverting large quantities of plastic from landfill – since 2015, the program has recycled 9,380 metric tons of biopharmaceutical plastic, equating to an estimated reduction of 6,000 metric tons of CO_2 equivalents. This successful partnership with the Triumvirate mechanical recycling program is currently the only program of its kind available to biomanufacturers within the U.S.

MilliporeSigma is now building on the success of the program and looking to establish more global advanced recycling opportunities to enable industry-wide circularity. In our quest to bring plastics full circle, we have identified four key components needed for successful plastics recycling in biopharma.

#1: Partnership and collaboration

Our industry's relatively small volume of plastic waste has made it difficult to find advanced recyclers willing to work with biomanufacturers. To overcome the volume problem, we must **work collaboratively with our customers, our peers, and organizations outside of the industry, including third-party recyclers.**

#2: Enduring market

A critical component of any recycling system is a **robust and enduring market** for the recycled product. If the product offers little value to buyers, achieving circularity of materials is virtually impossible. MilliporeSigma is currently testing several types of plastics to determine their end values and potential markets. We are also testing in different regions to work on providing recycling solutions outside of the U.S., designing a truly global recycling infrastructure to increase our impact as much as possible.

What's the difference between mechanical and advanced recycling?

Mechanical recycling involves washing, grinding, and melting plastic into pellets. Meanwhile, **advanced recycling** uses heat to break plastic down to its individual chemical components, which can then become the building blocks for new plastic. Both can be used to produce reusable, more sustainable polymers, but the biopharma industry requires a high-quality, high-performing plastic. For this, the industry needs to explore advanced recycling methods.

#3: Better infrastructure

The complex waste streams emerging from biopharma facilities will require sophisticated, **industrial-scale sorting and segregation infrastructure**, in addition to better **decontamination** of biohazardous materials. Better infrastructure is possible, but is predicated on **adequate volume**, which will only be possible through partnerships and collaboration.

#4: Better data

Progress in plastics recycling is hampered by poor data. Advanced recyclers need **detailed data** on the **format and types of plastics** in our waste streams. We also need a more accurate picture of the **total volume of biopharma plastic waste** available for recycling, which can only be obtained through partnerships and collaboration with the end users and generators of the waste. Finally, we need **auditing capabilities** and **traceability**. Without these data elements and capabilities, it will be impossible to build **transparency and trust** with a public highly attuned to 'greenwashing'. Some recycling companies have recently **come under fire** for **misleading claims** about recycling capabilities. Meanwhile, other brands' recycling initiatives have been **called into question** by journalists, reflecting mounting public suspicion about sustainability claims and what goes on behind closed doors. Better data and traceability would give biomanufacturers, their customers, and consumers a more comprehensive understanding of the recycling process, improving **environmental impact** and protecting companies against **reputational risk**.

Where is MilliporeSigma starting?

When embarking on a recycling journey, manufacturers should first look to **find advanced recyclers** with whom they can partner to run pilots **in single locations**. The focus on single locations is crucial; solving the plastics problem at a regional level will be the fastest and most effective way to expand nationally or even globally.

MilliporeSigma is currently evaluating trial-run locations in high-waste areas around the world. We recommend device manufacturers **partner with their customers** to aid with collection (as customers contract with collection companies). From there, it will be easier to **determine logistics** and calculate environmental impact. Since plastic is in universal demand, companies should also look for alliances and opportunities **outside of the biopharmaceutical industry.**

Eventually, we need advanced recycling capabilities for all types of plastic, but we recommend focusing on the **largest component** in a waste stream before moving on to materials present in smaller volumes. Aim for **big wins on a small scale** – this is how successful recycling programs start.

Conclusion: Less talk, more action

There is no one silver bullet that will enable wide-scale plastics recycling in biopharma, and no solution we can implement overnight. Problems of **circularity**, **quality**, and **infrastructure** make plastics recycling in our industry difficult, but progress is possible.

To make upcycling of plastics a reality at scale, the industry needs **intra- and inter-industry collaboration**, an **enduring market**, **better data**, and **stronger infrastructure**.

The industry needs less talk and more action. MilliporeSigma is working toward solutions that we can pilot today and implement tomorrow. By collaborating with proactive partners, our industry can accelerate advanced plastics recycling, lower our greenhouse gas profile, and reduce our burden on the planet – all while introducing innovation and scientific breakthroughs around the world.

References

1. Mechanochemical Degradation and Recycling of Synthetic Polymers, Dr. Junfeng Zhou, Tze-Gang Hsu, Prof. Dr. Junpeng Wang, First published: 01 April 2023 https://doi.org/10.1002/anie.202300768

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