Automation helps transform medical plastic waste into a reliable, economical resource

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Plastic can be found everywhere in medical and healthcare settings – in fact, we probably cannot imagine sanitary practices in the sector without it. Given that the material is so ubiquitous, it is no surprise that hospitals and other health centres generate large volumes of plastic waste. However, using data-driven chemical recycling strategies, this can be turned into a valuable resource, supporting circularity while potentially reducing costs.

Martin Gadsby, VP of Optimal Industrial Automation, looks at how industrial automation can support the creation of a circular economy for medical plastic.

Single-use plastic in medical settings can be a life-saving material. It is used for personal protective equipment (PPE), bottles, basins, wrappers and much more as it offers a reliable, economical and sterile solution to prevent cross-contamination. All these attributes help to make hospitals and other healthcare settings safer for patients and staff. In fact, it is thanks to polymer technology that the industry has greatly evolved over the last 50 years.

However, as a result, the sector uses massive volumes of disposable medical plastics. It has been estimated that these represent approximately 25%-30% of landfilled medical solid waste.[1]

[1] Lee, B. K., Ellenbecker, M. J., & Moure-Eraso, R. (2002). Analyses of the recycling potential of medical plastic wastes. Waste management, 22(5), 461-470.

When looking at the UK National Health Service (NHS), 133,000 tonnes of plastic are disposed of every year, with only about 5% of this currently being recovered.[2]

As these products are rarely recyclable at their end of life, they contribute to plastic pollution. Moreover, as most components are made from oil-based virgin raw materials, they are advancing the depletion of non-renewable sources. With this knowledge, how can today's healthcare professionals update their practices in line with the Hippocratic oath to "abstain from all intentional wrong-doing and harm"?

The answer is simple: by favouring recycled products. To get there, though, they require the support of manufacturing, processing and recycling facilities, which should invest in innovative circular solutions.

Good chemistry

Currently, mechanical recycling is the most widely used strategy. However, this comes with key limitations in terms of the types of polymers that can be processed and produced as well as end product quality. Materials produced in this way typically feature inferior physicochemical properties, due to the presence of impurities and other contaminants, the popularity of mixed polymer blends, the presence of multilayer materials and the heterogeneity of the initial waste. As a result, the recycled products are often not suitable for medical use, as they are not able to meet the required specifications of these sensitive applications.

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[2] Percival, A. (2019). Not so fantastic plastic. Available at: https://nhsproviders.org/news-blogs/blogs/not-so-fantastic-plastic [Accessed: 12 July 2022]

Chemical recycling methods, which are typically based on pyrolysis, depolymerisation or solvent-based selective polymer recovery, offer a valid alternative to address these challenges. They can address feedstock variability, remove coatings, dyes and other substances from medical equipment as well as separate the components of mixed materials. As a result, advanced chemical solutions can deliver high-purity monomers and polymers with virgin-like properties.

While these strategies represent the way forward in medical plastic recycling, it is crucial that the processes have a considerably smaller environmental footprint than landfilling. Industrial automation plays an integral role in supporting this goal and driving circularity.

An obvious strategy for recycling facilities is to adopt robotic and/or machine vision systems to perform rapid and accurate sorting of large volumes of waste. When looking at the chemical reaction, separation and purification stages, automated process control strategies should be applied to optimise the operating conditions. As a result, companies can deliver high-quality recycled products in the most efficient manner.

On the PAT watch

A highly effective solution is setting up self-regulating processes driven by Process Analytical Technology (PAT). More precisely, this framework consists of univariate and multivariate analysers that monitor the physicochemical properties of the plastic feedstock and process conditions, preferably via real-time, on-line measurements. Among the most suitable analytical devices that can be used are Raman and mass spectrometers, and nuclear magnetic resonance (NMR) instruments.

These help to gather useful information about the composition of the waste being used as a feedstock, the level of impurities present as well as detecting any thermal degradation of the materials taking place during chemical recycling processes.

The data generated by these analysers is then shared with a PAT knowledge management platform, such as synTQ from Optimal Industrial Technologies. This platform combines the information via data fusion strategies and feeds chemometric and other predictive models to provide in-depth insights. These include determining the expected physicochemical properties of end products, when processes are complete and can move on to the next stage, as well as how the process can be optimised to meet quality and efficiency targets.

In particular, by merging data from different sources and performing a joint analysis of multiple inter-related datasets, a PAT knowledge management software can provide complementary views of the same phenomenon. Thus, businesses can gain insights that are more accurate and precise than those that the analysis of a single dataset can yield. Furthermore, this system supports flexibility, meaning that it is able to effectively address heterogeneities and variabilities in the feedstock.

Based on the output generated by the predictive algorithms, the PAT knowledge management platform can communicate with the controller units of processing equipment to adjust conditions on the fly. While doing this, it can also provide intuitive visualisations for users to have an immediate understanding of the processes and their statuses.

Enabling medical plastic circularity

Ultimately, smart chemical recycling plants can set up automatic feedback and feedforward closed-loop control. This can maximise yield, throughput, recovery rates and product purity while minimizing cycle times, energy usage and solvent utilisation, if the recycling route requires it, as well as reduce waste and reworks. As a result, it is possible to limit the environmental impact of recycling activities and make them commercially viable, delivering monomers or polymers at a cost that can compete with virgin-based counterparts.

A skilled automation specialist with experience in implementing PAT-driven solutions, such as Optimal Industrial Automation, is a key ally in the creation of successful, future-oriented processing facilities for medical plastic waste. By partnering with an expert in the industry, companies can drive forward financially feasible circularity in the sector and benefit customers with economical, high-quality, greener products.

Image Captions

Image 1: Industrial automation can support the creation of a circular economy for medical plastic.

Image 2: A skilled automation specialist with experience in implementing PAT- driven solutions, such as Optimal Industrial Automation, is a key ally in the creation of successful, future-oriented processing facilities for medical plastic waste.

About Optimal Industrial Automation (OIA)

Optimal Industrial Automation has more than 30 years' experience building, integrating and optimising manufacturing automation systems for challenging and highly regulated industries. Projects are typically for the pharmaceutical, life science, chemical, aerospace, green energy, food & beverage and other high-value process sectors. The company's primary aim is to deliver measurable reductions in production costs, while finding substantial improvements in productivity, product quality and business sustainability. Part of its capability in achieving this aim is experience in the implementation of Optimal's print and inspect system product – synTI®, plus sister company Optimal Industrial Technologies' leading PAT based process management software platform synTQ.

The company employs a large technical team qualified in software, electrical, electronic, vision and control hardware disciplines. The team has built and developed individual machines and process skids to meet regulations such as FDA 21 CFR Part 210/211 – Pharmaceutical Industry GMPs, and FDA 21 CFR Part 11 – Electronic Records and Signatures. It is also ISO accredited and has years of experience working within GAMP guidelines.

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