Xampla

Regulatory Landscape for Single-Use Plastics and Microplastics in the UK and Europe

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1. Executive Summary

Plastics and microplastics are increasingly recognised as having potential long-term negative impacts on the environment and health, with no safe threshold for their release. Recent and incoming regulations in the UK and EU therefore vitally seek to curb the use of and reliance on plastics. These regulations include bans on single-use plastics, taxes and levies on plastics, limits on intentionally added microplastics, and proposed Extended Producer Responsibility for packaging, which makes the producer responsible for the costs of recycling and waste disposal. Further regulations are expected soon given the importance of the reduction of plastics production and waste to the successful delivery of key UN environmental targets around plastics pollution, water security, and net zero by 2050.

There are a multitude of different materials being explored and touted as sustainable alternatives to plastic, but it is critical to understand how each of these alternative materials is affected by current and anticipated future regulations. For example, the European Commission has made it clear that current category-leading alternative materials polylactic acid (PLA) and polyhydroxyalkanoates (PHA) do not provide a “plastic-free” alternative, since although they are bio-based, they are considered to be chemically modified. Indeed, significant concerns remain around their biodegradability in case of accidental release into the natural environment.

Plastic-free materials would ideally be 100% manufactured from natural, non-chemically modified polymers, relying on sustainable, abundant, and renewable feedstocks that are not in competition with food production at scale. Preferably they should provide a drop-in solution for manufacturers and converters, delivering the performance requirements of plastic in use, yet safely biodegrading at their end-of-life (whether in home-composting conditions or in wastewater treatment plants), or in case of accidental release into the natural environment (soil, ocean), with no risk of harm.

Originally spun out from the University of Cambridge with Deep Tech expertise in the engineering of natural polymers including plant proteins, Xampla has developednatural, high-performance, and scalable alternatives that provide an ideal biodegradable replacement for plastic in multiple commercial applications. Xampla’s core focus is on developing natural solutions for the most polluting plastics, where reducing, reusing, and recycling are not viable alternatives. These applications include eliminating single-use plastics, intentionally added microplastics, water-soluble polymers (WSPs), and polymers in liquid formulations (PLFs) with natural, non-chemically modified, biodegradable polymer-based alternatives. Xampla’s high-performance, plant-based range of Morro materials deliver truly plastic-free solutions for consumers and have been designed to support companies to future-proof themselves against the expanding body of regulations around plastics and microplastics production, use, and disposal.

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Please note that this document is intended as a guide to the regulatory landscape around plastics and microplastics in the UK and Europe and does not constitute legal advice. This guide is accurate as of 1 November 2023 and will be updated to reflect future changes in regulations.

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2. Regulatory Landscape for Single-Use Plastics and Microplastics in the UK and Europe

(i) Single-Use Plastics Ban

Single-use plastics are items made of plastic which are intended to be used only once or very briefly and then thrown away. They include common and practical items associated with food and drink consumption (cutlery, plates, straws, stirrers, cups, containers), personal hygiene (wet wipes, sanitary items), and certain kinds of packaging and plastic bags. Many of these items have been identified as a major component of marine litter (Break Free from Plastic, 2022). Across the UK and the EU, various regulations have been designed and announced in recent years with a view to reducing the waste and environmental damage associated with single-use plastics.

The EU Single-Use Plastics Directive 2019/904 aims to reduce or ban specific single-use plastic products. At present items banned in the EU include cotton bud sticks, cutlery, plates, straws, stirrers, balloon sticks, and food and beverage containers made of expanded polystyrene. These items have been selected because they are commonly found as litter in the environment and plastic-free alternatives are widely available (European Parliament, 2019).

Currently lacking widely available alternatives, plastic food containers and beverage cups (excluding those made of expanded polystyrene) are not yet the subject of market restriction measures. However, under the Single-Use Plastics Directive EU member states must achieve an ambitious and sustained reduction in the consumption of these products by 2026, with the possibility to adopt market restrictions once alternative plastic-free materials become widely available.

In the UK there are currently differences in single-use plastics regulations across the devolved nations. Scotland and Northern Ireland were the first UK nations to ban certain single-use plastics, through regulations which came into force in 2022. In England, a ban on particular single-use plastics came into force on 1 October 2023. These bans prohibit the supply or sale of plastic cutlery, plates, straws, beverage stirrers, and balloon sticks, as well as food and beverage containers made of expanded polystyrene. Wales has introduced its ban in two phases, with the majority of items banned as in England from October 2023, and a further ban announced for 2024 onwards to include plastic single-use carrier bags and polystyrene lids for cups and takeaway food containers.

It is worth highlighting here that the single-use plastics regulations define plastic as both traditional petroleum-derived plastics and natural polymers that have been chemically modified, and also includes polymers that are biodegradable or compostable. There is no de minimis threshold for the plastic content within a single-use plastic item; thus, for example, single-use plastic-coated paperboard packaging used for food containers and beverage cups would sit within the regulatory framework of the single-use plastics regulations.

Material	What is it? Where is it used?	Is it considered a plastic under the Single-Use Plastics Directive?
Polyethylene terephthalate (PET)	Petroleum-derived, non-biodegradable; most common thermoplastic polymer, widely used in single-use food and beverage applications including drinks bottles	Yes – PET is the archetypal plastic
Polyethylene (PE)	Petroleum-derived, non-biodegradable; thermoplastic polymer, widely used in films and coatings for single-use food and beverage packaging applications	Yes – even in coating applications, such as single-use PE-coated paperboard packaging
Polylactic acid (PLA)	Bio-based polymer alternative material, industrially compostable; often used in films and containers for single-use food and beverage packaging applications	Yes – even though PLA is produced from natural feedstocks, it is considered to be chemically modified
Polyhydroxyalkanaotes (PHAs)	Bio-based polymer alternative material, some of which are biodegradable; sometimes used in films and containers for single-use food and beverage packaging applications	Yes – even though PHAs are produced by natural processes (fermentation), they are considered to be chemically modified

(ii) Plastics Tax

A Plastic Packaging Tax (PPT) was introduced in the UK on 1 April 2022. It applies to importers of finished plastic packaging components into the UK as well as to manufacturers of the same within the UK. The tax only applies to packaging that is made of less than 30% recycled plastic. It comes into force in cases where the amount of packaging produced is 10 tonnes or more per year. The initial charge of the tax when it was introduced was £200 per tonne. From 1 April 2023 this increased to £210.82 per tonne. Future price increases in this tax are expected but have not yet been publicly announced. Importers and manufacturers are liable for the tax, but of course these additional costs may be passed onto retailers and consumers through product price increases.

In Europe, discussions within national governments are still ongoing as to the introduction of possible taxes on the production and importation of plastic packaging. However, the EU as a whole has introduced a levy on non-recycled plastic packaging waste produced by each Member State. Since 1 January 2021 the charge is €800 per tonne of non-recycled plastic packaging waste. The levy is known as the “plastics own resource” for the contribution it is designed to make to the 2021-2027 EU budget and is part of the European Plastics Strategy and the EU’s Green Deal.

(iii) Intentionally Added Microplastics Regulation

Primary or intentionally added microplastics are defined by the European Chemicals Agency (ECHA) as less than 5 mm in size, solid, particulate, water-insoluble, and non-biodegradable (i.e., persistent) chemically modified or synthetic polymeric particles that are deliberately manufactured and added to product formulations for specific purposes. Intentionally added microplastics are found in a range of products including adhesives and sealants, agricultural products, household cleaning products, inks and coatings, lubricants, paints and coatings, and personal care and cosmetics applications. In the EU, over 42,000 metric tonnes of intentionally added microplastics are released into the environment each year, via either down-the-drain, municipal solid waste, or direct release pathways (ECHA, 2020). Their environmental release is a concern because of their persistence and accumulation within ecosystems and food chains, with exposure linked to potential (eco)toxic and physical effects on surrounding living organisms.

Consequently, in use cases where intentionally added microplastics are inevitably released to the environment, the ECHA proposed a ban, designed to avoid the environmental release of more than 90% of the 42,000 metric tonnes of intentionally added microplastics released into the environment in the EU each year. The Commission adopted the restriction on 25 September 2023 and the restriction entered into force on 17 October 2023. Companies will have to report on the use, identity, and quantity of intentionally added microplastics released into the environment within 36 months from the date of entry into force. Market restrictions on intentionally added microplastics apply from the date of entry into force for products with widely available alternatives (e.g., microbeads, mainly used in rinse-off cosmetic products or detergents, whose use has largely already been phased out by industry) and with extended transition periods of up to 12 years from the date of entry into force for products that currently lack widely available alternatives, to ensure sufficient time to develop suitable alternatives and limit the costs for industry.

The UK government introduced a world-leading ban on plastic microbeads in cosmetics and personal care products in 2018 and continues to review expansion of this ban to other intentionally added microplastics. This may result in market restrictions similar to those described in the proposed ECHA microplastics ban.

(iv) Extended Producer Responsibility

Extended Producer Responsibility (EPR) for packaging is a waste management regulatory scheme which makes the producer responsible for the cost of the collection, sorting, and recycling of their packaging, thereby shifting costs from the consumer and/or the taxpayer onto the producer.

In the UK EPR for packaging regulations were announced in 2022. These regulations apply to individual UK businesses with an annual turnover of £1 million or more who were responsible for more than 25 tonnes of packaging in 2022. Under these new regulations, businesses must report packaging data starting with the 2023 calendar year and will also be subject to disposal costs fees from October 2025. The waste management fee pricing system has not yet been published but is expected to vary depending on the recyclability of the packaging.

In the EU, EPR for packaging is part of the Single-Use Plastics Directive and will cover the cost of collection, transport, and treatment, litter cleanup, and awareness-raising measures

for food containers and cups for beverages. EU Member States are required to implement EPR for packaging by 31 December 2024.

(v) Perspectives on Future Regulations

Plastic pollution is a global concern that intersects with other current socio-environmental challenges including water security and net zero targets. The UN Environment Programme has established an Intergovernmental Negotiating Committee on Plastic Pollution tasked with creating a globally binding legal agreement to address the issue, with the goal of stopping itworldwide by 2030 (UNEP, 2023a). The UN 2023 Water Conference also addressed the problem of plastics from a variety of perspectives, with the target of achieving resilience to increasing water stress by 2050 (UNEP, 2023b). The EU's commitments at this Conference include promised reductions of at least 50% for plastic litter and at least 30% for microplastics. It also recommended strategies including: widening single-use plastic bans; making producers responsible for the costs of recycling packaging; government targets for the reduction of incineration of plastic waste; and the development of sustainable alternatives to plastic packaging.

The UN goal of net zero by 2050 – eliminating greenhouse gas emissions to combat global warming – also raises a challenge to the continued reliance on plastics, given their high carbon footprint throughout their lifecycle from production to disposal. Plastics production already consumes as much oil as the aviation sector and, by 2050 plastics manufacturing and processing could account for 20% of petroleum consumption and 15% of the annual carbon emission budget (World Economic Forum, 2016), threatening the declared net-zero targets.

While Europe and the UK have developed world-leading regulations to tackle the plastics crisis, the definition of single-use plastic and microplastics currently excludes key product categories such as water-soluble polymers (WSPs) and polymers in liquid formulations (PLFs). Hence, products containing WSPs and PLFs are often currently marketed as "plastic-free". Yet, there are increasing calls to expand the ECHA definition of microplastics to include WSPs and PLFs (Plastic Soup Foundation, 2022). Further research is also needed into the environmental impacts of persistent WSPs, which in fact often share similar concerns to those of water-insoluble plastics and microplastics (Arp and Knutsen, 2020). Globally, over 36.3 million tonnes of PLFs are consumed each year, with applications ranging from paint to shampoo (Royal Society of Chemistry, 2021). As highlighted by the Royal Society of Chemistry, WSPs and their breakdown products represent a key sustainability risk since they will be highly mobile in soil and water, resulting in widespread environmental fates.

Finally, incoming chemical regulations will continue to intersect with the regulatory landscape for single-use plastics and microplastics in the UK and Europe. For example, Denmark, Germany, the Netherlands, Norway and Sweden submitted a proposed market restriction on around 10,000 per- and polyfluoroalkyl substances (PFAS) to the ECHA on 13 January 2023. Often collectively referred to as "forever chemicals", the persistence and bioaccumulation of PFAS in the environment and the human body is a significant concern, with exposure to certain PFAS thought to cause adverse health outcomes. PFAS have been widely used as a functional and barrier coating for single-use paperboard packaging, providing grease, oil, and water resistance properties; however, there is now a concerted industry drive to eliminate PFAS from single-use paperboard packaging applications.

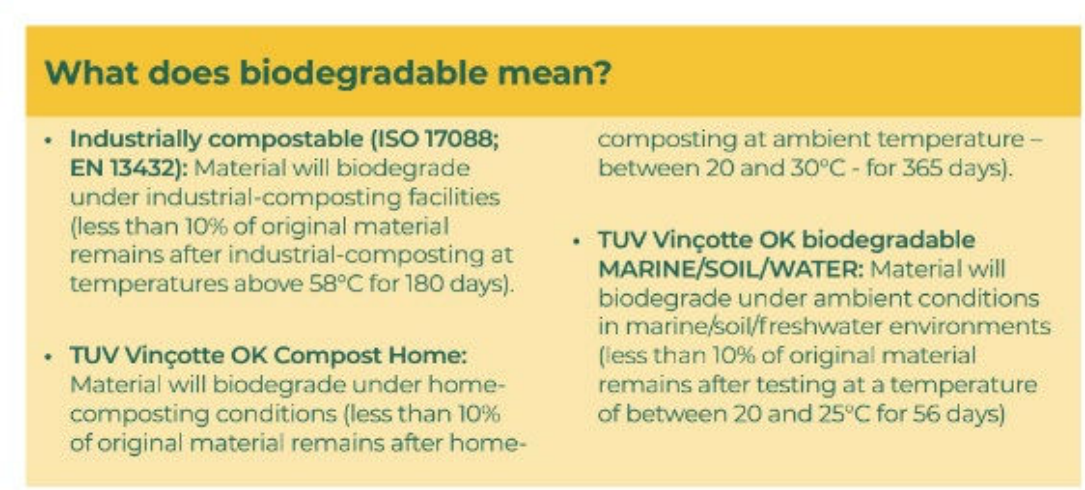
3. Alternative Materials

(i) Ideal Materials Properties

According to the Single-Use Plastics Directive and the Plastic Packaging Tax, plastic is defined as both traditional petroleum-derived plastics and natural polymers that have been chemically modified, and also includes polymers that are biodegradable or compostable. Thus, an ideal plastic-free material would need to be 100% manufactured from natural, non-chemically modified polymers, yet deliver performance in use, while providing a drop-in solution for plastics manufacturers and converters, with no risk of harm in case of release into the environment (i.e., fully biodegradable across home-compost, soil, water, and marine environments). In certain applications, the material must also be compatible with existing recycling processes (i.e., removed within conventional packaging recycling process steps). Finally, an ideal material would be produced from abundant, and renewable feedstock, which does not compete with food production at scale.

(ii) Certification Landscape for Biodegradable and Compostable Materials

For “biodegradable” materials, there are ongoing concerns regarding their real-world environmental fate, since there are well-recognised issues with the current biodegradability standards and test methods (UK Government, 2021). These include ISO standards such as ISO 17088 for industrially compostable materials as well as TÜV AUSTRIA standards for home-composting and biodegradability in soil, freshwater, and marine environments (OK Compost HOME, OK biodegradable MARINE, SOIL, WATER).



Firstly, materials are frequently described as biodegradable, without any reference to the conditions and timeframe required for biodegradation. Secondly, the test conditions are not sufficiently representative of real-world environmental conditions. Thirdly, standards solely focused on measuring biodegradability in terms of carbon dioxide release do not consider ecotoxicity or the release of potentially harmful fragments during partial or complete biodegradation. Thus, even a material termed “biodegradable” may in fact risk damaging the environment. In a recent UK-wide study, researchers found that the majority (60%) of commercially available packaging labelled home-compostable did not fully disintegrate in home-compost bins, with fragments instead persisting and contaminating soils (Purkiss et al., 2022).

It is noted also that the UK's Waste and Resources Action Programme (WRAP) recommends the use of the term "compostable" rather than biodegradable, unless a material has been proven to biodegrade in any environment it could potentially pollute (i.e., spanning soil, freshwater, and marine environments; WRAP, 2020). Yet, even the term compostable is confusing since materials may be home-compostable or only compost in industrial-composting conditions.

The confusion around the definition of biodegradable and compostable materials contributes to greenwashing, since biodegradable and compostable materials are often marketed as sustainable alternatives, yet do not necessarily provide a solution to plastic waste or marine litter since very few materials offer proven biodegradability across all environments. As has been shown, even natural polymers that are biodegradable or compostable sit within the scope of single-use plastics regulations, if they have been chemically modified, reflecting their uncertain fate and potential impact on the environment.

(iii) Certification Landscape for Plastic-Free Materials

New certification schemes are being developed to identify and label materials as "plastic-free". However, these are currently at an early stage and facing implementation challenges. For example, flustix is an EU-registered certification mark introduced in early 2022 by DIN CERTCO (DIN CERTCO, 2022). It provides the independent certification mark 'flustix - NO PLASTICS' to eligible products. The certification is divided into four different categories: plastic-free total product; content free from microplastics; plastic-free product; and plastic-free packaging. Plastic-free means in the case of the product and/or packaging that it is at least 99.24% plastic-free. In the case of microplastics, plastic-free means at least 99.79% is free from microplastics >6 µm.

In general, "plastic-free" labelling and certification marks such as flustix work best for monomaterials and are more challenging to apply to multimaterials. For example, plastic-coated paperboard packaging could be considered and labelled "plastic-free" according to the 99.24% threshold defined by flustix, while according to the single-use plastics regulations, there is no de minimis threshold for the plastic content. Indeed, plastic-coated paperboard packaging creates a significant waste challenge, since the plastic coating is challenging to separate from the paperboard; thus, plastic-coated paperboard packaging contaminates conventional paperboard recycling facilities and instead faces incineration, landfill, or environmental release.

(iv) Alternative Materials

A variety of alternative materials based on natural polymers have been developed with a view to replacing petroleum-derived plastics; however, significant confusion remains around how they intersect with the existing regulatory landscape. Current category-leading materials include polylactic acid (PLA) and polyhydroxyalkanoates (PHA). The European Commission has made it clear that both PLA and PHA sit within the scope of the single-use plastics regulations since although they are produced from bio-based feedstocks, they are considered to be chemically modified; thus, neither PLA or PHA provide a "plastic-free" alternative.

- PLA is manufactured from lactic acid, typically produced by bacterial fermentation of carbohydrates extracted from corn starch or sugar cane (Jem and Tam, 2020). Global

annual PLA production capacity reached 460,000 tonnes/year in 2022 (European Bioplastics, 2022). PLA is a rigid thermoplastic, providing a natural alternative to plastics such as polyethylene terephthalate (PET) and polystyrene (Jem and Tam, 2020). Although PLA is a natural polymer and is often marketed as a biodegradable alternative to traditional plastic packaging, it will only biodegrade under industrial-composting conditions (temperatures of > 58°C for 180 days; ISO 17088; Narancic et al., 2018), and risks releasing potentially harmful microplastics in the environment. PLA sits within the scope of the single-use plastics regulations because it is considered to be chemically modified.

- PHAs are polymers manufactured by genetically modified bacteria. With widely tuneable properties, PHAs can be used as a natural alternative to many traditional plastics (Muneer et al., 2020). Global PHA production has reached a capacity of nearly 90,000 tonnes/year but is constrained by scale-up and performance issues (European Bioplastics, 2022). Polyhydroxybutyrate (PHB, a short-chain PHA) is biodegradable in soil, freshwater, and marine environments (Narancic et al., 2018), but it is brittle and has poor thermal stability, restricting its commercial application. Other longer chain PHAs such as polyhydroxyoctanoate (PHO) have improved mechanical properties, but will only biodegrade under industrial-composting conditions (Narancic et al., 2018). Similarly to PLA, PHAs sit within the scope of the single-use plastics regulations since although they are natural, they are considered to be chemically modified.

(v) Morro: Xampla's High-Performance Plant-based Materials

With Deep Tech expertise in the engineering of natural polymers, Xampla has developed a natural, non-chemically modified, biodegradable polymer-based alternative to plastic that has been designed to sit outside the scope of single-use plastics regulations and should not be liable for plastic packaging taxes in the EU or the UK. Xampla has developed Morro as a solution to some forms of single-use plastics. Morro materials are natural, fully biodegradable, and 100% plastic free.

Xampla is on a mission to eliminate the world's most polluting plastics for good, with a core focus on developing natural solutions for plastic use cases where reducing, reusing, and recycling are not viable alternatives. These applications include replacing single-use plastics, intentionally added microplastics, WSPs, and PLFs with natural, non-chemically modified, biodegradable polymer-based alternatives.

Rather than relying on chemical modification, Xampla leverages biomimetic processes such as self-assembly to create Morro materials, high-performance materials that are suitable for replacing plastic in multiple applications. These biomimetic processes are low energy, low cost, and inherently scalable since they have already been optimised by evolution. Crucially, since Morro materials rely on self-assembly rather than chemical cross-linking to deliver material performance, Xampla's all-natural, plant-based Morro materials will biodegrade at end-of-life, whether in home-compost, soil, freshwater, or marine environments, with no risk of harm. To deliver performance at scale, Xampla has developed natural, non-chemically modified polymer-based resins that provide drop-in solutions to existing plastics manufacturing supply chains. Morro materials can also be manufactured from a range of feedstocks, including non-food-grade raw materials in the case of non-food-grade material applications.

To demonstrate the commercial potential of the natural, non-chemically modified polymer-based alternatives, Xampla has developed four differentiated launch products all under the Morro banner comprising:

- Water-soluble film (Morro Soluble Film)
- Paperboard coatings (Morro Coating)
- Microcapsules (Morro Micro)
- Edible film (Morro Edible Film)

A detailed overview of each of these launch products can be found in the case studies that accompany this regulatory landscape overview. In each application, Morro materials have been designed to support manufacturers and brands to meet existing regulations, while supporting companies to future-proof themselves against anticipated regulatory changes.

4. Conclusion

Galvanised by escalating awareness of the harm caused by plastics to the environment and to human health, the UK and the EU are imposing increasingly strict restrictions on the supply, use, manufacture, and importation of different kinds of plastic, from bans on specific single-use plastics and microplastics to wider taxes and Extended Producer Responsibility schemes for plastic packaging.

Businesses need to comply with existing legislation and future-proof themselves by preparing for incoming and anticipated regulatory changes, while responding to increasing pressure from consumers to phase out single-use plastics and microplastics.

With Deep Tech expertise in the engineering of natural polymers, Xampla's Morro materials are poised to replace plastic and microplastics across multiple commercial use cases, and have been designed to support businesses to comply with existing regulations and future-proof their products against anticipated regulatory changes. Crucially, unlike alternative biodegradable materials such as PLA, which are chemically modified, Morro materials are 100% manufactured from natural, non-chemically modified polymers, leveraging nature's self-assembly techniques; thus, Morro materials provide a uniquely high-performance yet affordable plastic-free solution.

To find out more about Xampla's range of high-performance, plant-based Morro materials, request commercial samples, and discuss specific development requirements in relation to current and incoming regulations, please contact Head of Business Development Stanley Mitchell at stanley.mitchell@xampla.com. You can also find out more on the website xampla.com and follow Xampla on LinkedIn linkedin.com/company/xampla/ and Twitter@XamplaUK.

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