Unpacking non-conventional plastics
Introduction

As the debate on plastics heats up, non-conventional plastics including biodegradable, bio-based, compostable and oxo-degradable are sometimes promoted as sustainable alternatives as companies and policy-makers look to shift away from polymers derived from fossil fuels.

This briefing gives an overview of four commonly considered non-conventional plastics. Information is presented in a table providing background details and assessing how far they present a sustainable solution.

Given that no finished product has yet been proven to be marine biodegradable, all alternatives will continue to pose a risk to marine life if they leak into the natural environment. Furthermore, their widespread adoption could present additional problems such as putting undue pressure on natural resources; complicating waste collection and recycling systems, and causing microplastic pollution if the conditions required for full biodegradation are not met.

While there may be a limited role for some non-conventional plastics, they are not a silver bullet solution to the plastics crisis, which requires a more comprehensive strategy emphasising reduction, reuse, redesign and recycling.

Summary of non-conventional plastics

- **Bioplastics**: ‘Bioplastics’ is an ambiguous term used to describe materials and products which are bio-based, biodegradable or both. Bio-based plastics are those at least partially constituted of organic materials, while biodegradable plastics are those which break down into natural elements under certain conditions. Biodegradable plastics can be manufactured from both fossil fuels and biomass.

- **Biodegradable**: Biodegradable plastics break down under certain conditions through the actions of naturally occurring micro-organisms, within a timeframe specified by industry standards. Conditions required for rapid and full degradation are rarely met in the natural environment, thus the plastics will pose a hazard to marine life if they leak into the ocean or persist as micro- and nano-plastic fragments. If incorrectly sorted, they can contaminate recycling streams.

- **Bio-based**: These are derived, at least in part, from organic matter, predominantly from agro-based feedstock such as corn but they can also be produced from waste or by-products. To meet current plastics demand with bio-based feedstocks would divert land from agriculture or require conversion of natural habitats, neither of which are desirable. They do not necessarily break down any faster than conventional plastics and, like biodegradable plastics, will pose threats if they leak into the ocean. Given the interest in bio-based products, there is an urgent need to fully assess the potential impacts of growth in their use.

- **Compostable**: Compostable plastics break down through biological processes, yielding CO₂, water, inorganic compounds and biomass. Depending on the polymer, they are treatable through home or industrial composting systems. Conditions required for industrial composting are not be found in the natural environment, thus these plastics do not provide a solution to plastic pollution. If they are not separately collected and sorted, they could also contaminate recycling streams.

- **Oxo-degradable**: These are conventional polymers with chemicals added to speed up degradation. However, significant evidence suggests oxo-degradable plastics do not fully biodegrade but fragment into small pieces, contributing to microplastics pollution. They can contaminate conventional recycling streams. Experts have provided evidence that oxo-degradable plastics are not suited for effective long-term reuse, recycling at scale or composting.

- **Marine-biodegradability**: There is no international or European standard for biodegradability. A conformity mark has been developed for products described as biodegradable in seawater by Vinçotte, known as ‘OK Biodegradable MARINE’. The biodegradability component of this certificate is based on the now-withdrawn international standard ASTM D7081-05 and such products should therefore not be considered as safe for the marine environment. The test procedures involved do not address the impacts on multispecies communities and biogeochemical processes, and the toxicity assays required by the OK Biodegradable MARINE label do not account for the ability of microplastic particles to adversely affect aquatic organisms.
### Biodegradable plastics

- Break down through biodegradation.
- Actions of microorganisms.

### Bio-based plastics

- Derived from organic materials.
- Biodegradable (PHA, bio-PBS, bio-PVOH), biodegradable (PHA, bio-PBS, bio-PVOH), biodegradable (PHA, bio-PBS, bio-PVOH).

### Compostable plastics

- Break down through biological processes.
- Yielding CO₂, water, inorganic compounds and biomass.

### Oxo-degradable plastics

- Conventional polymers.
- Additives to accelerate fragmentation.

#### Definition and relevant standard

- Biodegradable plastics break down through biodegradation.

#### Conditions for degradation

- EN 13432 and EN 14995 require at least 90 per cent biodegradation after six months, with tests on ecotoxicity and heavy metal content.

#### Impact on marine species

- Even under the most optimistic biodegradation time horizons, biodegradable plastics could cause death and injury to marine life through entanglement and ingestion.

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<th>Example polymers</th>
<th>Conditions for degradation</th>
<th>Impact on marine species</th>
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<td>PBS, PCL, PBAT, PVOH, bio-PBS, PHA</td>
<td>EN 13432 and EN 14995 require at least 90 per cent biodegradation after six months, with tests on ecotoxicity and heavy metal content.</td>
<td>Even under the most optimistic biodegradation time horizons, biodegradable plastics could cause death and injury to marine life through entanglement and ingestion.</td>
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<td>Bio-PET, bio-PE, PEP, bio-PP, bio-PA, bio-PVOH, PHA</td>
<td>Some bio-based plastics are also biodegradable (PHA, bio-PBS, bio-PVOH), but biodegradability is not a necessary criterion. Many will take as long as conventional plastics to break down.</td>
<td>Given that the conditions required for industrial (and even home) composting are unlikely to be met in the marine environment, these plastics will pose a threat if they leak into the ocean.</td>
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<td>PLA, ecovio®, starch-based polymers, cellulose-based polymers</td>
<td>Composting is divided into two stages: active composting (minimum 21 days), followed by curing. Industrial composting facilities range between 50°C and 60°C. For hygiene purposes, temperatures need to remain above 60°C for a week. Many compostable plastics take around 60-90 days to compost industrially, but some facilities operate on shorter cycles (i.e. 30 days).</td>
<td>Oxidation enables faster fragmentation. In theory, this accelerates biodegradation. This process depends on multiple criteria that vary significantly in practice, including fragment size, quantity of additives, and environmental conditions (e.g. temperature, biotic factors). Studies show that the entire process varies and often takes (much) longer than claimed – with approximately 98 per cent of material remaining after 40 weeks under a test rig.</td>
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<td>Compostable plastic breaks down through biological processes, yielding CO₂, water, inorganic compounds and biomass. They are manufactured from either fossil-based or bio-based materials and, depending on the polymer, can be recovered through home or industrial composting systems. EU standard EN 13432 defines industrial compostability:</td>
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<td>Oxo-degradable plastics</td>
<td>Oxo-degradable plastics are conventional polymers with chemicals added to accelerate fragmentation under UV light and/or heat, and oxygen. Oxo-degradable plastics do not fulfil the requirements of relevant standards for composting, such as ISO 18606, EN 13432, ASTM D6400, AS 4736 or GreenPla, as their biodegradation takes too long, and plastic fragments can remain in the compost.</td>
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<td><strong>Recycling challenges</strong></td>
<td><strong>Other challenges</strong></td>
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<td><strong>Waste feedstock complications</strong> The economic viability of using waste feedstocks to produce bio-based plastics will depend on the volume, quality and cost of transportation of feedstocks to reprocessing facilities. Seasonal changes affect the availability of certain feedstocks. Many processes for converting waste feedstocks depend on enzymes that can be very resource intensive to produce.</td>
<td><strong>Disposal challenges</strong> Not all households have composting facilities or access to kerbside compostable waste collections; even when they do, it is possible that home-based composting will fail to achieve the heat or moisture levels required to trigger biodegradation. No data could be found on the nationwide availability of local authority collections of compostable waste or municipal industrial composting infrastructure in the UK.</td>
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<td>Under the anaerobic conditions likely to be found in landfills, anaerobic microbes decompose biodegradable polymers into methane and carbon dioxide. Methane is among the strongest greenhouse gases (GHGs) contributing to climate change.</td>
<td>Most bio-based plastics are produced from agro-based feedstock⁴⁷, requiring an estimated 600,000 hectares to produce 1.6 million tonnes of plastics in 2033 – a fraction of the total demand for plastics (&lt; 0.5 per cent of 2015 total). Increasing land-use could bring about competition with agriculture, cause biodiversity loss and raise land rights concerns. Emissions associated with land use change (i.e. deforestation) could release 9-170 times more CO₂ than the annual GHG savings bio-based plastics provide, and put pressure on other natural resources such as water. With growing interest in bio-based plastics, there is a need to fully assess the potential impacts.</td>
<td>If disposed to landfill with compostable plastics, they are likely to decompose anaerobically and produce methane, a strong greenhouse gas. While comprehensive research has not been undertaken, it seems likely that oxo-degradable plastics will have a similar carbon and resource footprint to conventional plastics.</td>
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<td>While biodegradable plastics can be recycled, they need separating from other polymers, requiring investment in sorting technologies. According to UNEP, their promotion as a greener alternative is unjustified in the absence of effective provision of industrial composting or anaerobic digestion facilities. There are also concerns that novel additives used to promote biodegradation may pose a challenge to the recycling sector.</td>
<td>Bio-based plastics generally require recycling in separate streams to fossil-based plastics and failure to separate them from other polymers could cause contamination. There are technological challenges associated with separation. If sorting and processing cannot be done economically because of low volumes, bio-based plastics will most likely be incinerated or sent to landfill. Use of compostable plastics in packaging formats that have established recycling systems (e.g. bottles) could result in contamination of recovered plastics, particularly if consumers cannot readily tell the difference between compostable and non-compostable plastics. Scientists report a “serve incompatibility” of PLA with PET recycling streams given the different behaviour of PLA at higher temperatures – with contamination occurring at levels of two per cent PLA.</td>
<td>While producers claim oxo-degradable plastics are recyclable, others in the plastic industry report that they negatively affect the quality and economic value of plastic recyclates. They reported that oxo-degradable plastic packaging cannot be detected by current technology at sufficient scale to be sorted from conventional plastics. Oxo-degradable plastics fragment over time, damaging medium- and long-life products such as those used in construction. Producers say stabilisers can be added to offset the oxo-degradable effect, but concerns then arise regarding the quantity of stabiliser required and how it affects recycling.</td>
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Non-conventional plastics are not a miracle solution to the plastic crisis, with all the proposed alternatives posing risks to biodiversity if they leak into the ocean or other natural environments. In line with the waste hierarchy, there may be a limited role for the adoption of certain non-conventional plastics for well-suited purposes (e.g. bags for compost collections) – particularly those produced from waste feedstocks that might otherwise be sent to landfill or incinerated - but the availability of suitable end-of-life collection and treatment infrastructure must be the foremost consideration.

While there remains a need for further analysis to fully understand the potential environmental, social, and economic impacts of increasing the production of non-conventional plastics, there is already enough evidence to suggest that a precautionary approach should be employed. Retailers can:

- support an holistic approach to addressing plastic pollution in line with the waste hierarchy, with an emphasis on reduction and re-use where possible;
- commit to eliminate all non-conventional plastics for single-use items and packaging, and engage with brand suppliers about setting similar targets;
- publish a policy stating their position and usage of different non-conventional plastics, engaging with policy-makers about sustainability concerns and promoting the precautionary principle;
- promote clear labelling of materials and discourage use of the term biodegradable without further clarification of the conditions under which biodegradation will occur;
- support research to better understand the social and environmental implications of increased consumption of non-conventional plastics, including full lifecycle analysis of different polymer types;
- ensure products are adequately labelled so that users and consumers are provided with clear, comprehensible information about use and disposal.

References
7. For example, see Yashchuk, O. et al. 2012. Degradation of Polyethylene Film Samples Containing Oxo-Degradable Additives, Proceda Materials Science, 1, pp:439-446. Available online.
19. European Standards Organisation, 2006. Guide for vocabulary in the field of Degradable and biodegradable polymers and plastic items: Oxo-degradation (or oxidative degradation) is defined as degradation identified as resulting from oxidative cleavage of macromolecules. ISO 17065-1.
27. Republis Services in Richmond, quoted in article available online
32. UNEP, 2018. Ibid.
34. UNEP, 2018. Ibid.
45. European Bioplastics, 2016. Ibid.
47. UNEP, 2019. Exploring the potential for adopting alternative materials to reduce marine plastic litter. Available online.
54. Such as the British Plastics Federation, Website/BPF Recycling group, in DEFRA response to OP A (2012)
56. European Bioplastics, 2016. Ibid.
60. Thomas, N.L. et al. 2012. Ibid.
ABOUT EIA

We investigate and campaign against environmental crime and abuse.

Our undercover investigations expose transnational wildlife crime, with a focus on elephants and tigers, and forest crimes such as illegal logging and deforestation for cash crops like palm oil. We work to safeguard global marine ecosystems by addressing the threats posed by plastic pollution, bycatch and commercial exploitation of whales, dolphins and porpoises. Finally, we reduce the impact of climate change by campaigning to eliminate powerful refrigerant greenhouse gases, exposing related illicit trade and improving energy efficiency in the cooling sector.

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