Activate AG LABS

Seeding Sustainability: Embracing Microplastic-Free Seed Coatings

Utilising fresh regulations as a launchpad to a Greener Future

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Executive Summary

Utilising seed-coating polymers to treat seeds directly has always been an environmentally sound practise. The recent regulations implemented by ECHA regarding microplastic-free products serve as a timely reminder of the continual need for advancement. As society globally transitions towards a more sustainable future, it is imperative that those who play a significant role within the agricultural sector evolve to keep pace with such changes.

> Banning intentionally added microplastics addresses a serious concern for the environment and people's health. Microplastics are found in the seas, rivers and on land, as well as in food and drinking water. Today's restriction concerns very small particles, but it is a big step towards reducing human-made pollution. Virginijus Sinkevičius, Commissioner for Environment, Oceans and Fisheries - 25/09/2023[1]

By prioritizing long-term objectives while maintaining a balanced approach to addressing immediate needs, we can collectively steer toward progress. Making decisions rooted in comprehensive knowledge and ethical motives enables us to navigate effectively, avoiding the pitfalls associated with ambiguity and undefined parameters.

> Embracing and leveraging the latest regulatory frameworks as a foundational platform for propelling society towards a more sustainable and environmentally conscious path. These regulations serve not only as guidelines but as catalysts for transformative action, encouraging industries, communities, and individuals to adopt practices that prioritize ecological integrity and long-term stewardship of our planet. By embracing the spirit of these regulations, we embark on a journey of innovation, collaboration, and responsibility, paving the way for a brighter, greener future for generations to come.

We shouldn't see this as a threat, or just another opportunity, it is a chance to make a pivotal change. The decisions we make today will shape the world of tomorrow, defining a legacy we leave for generations to come. Let's act now to ensure that this change happens as intended.

03

Introduction

Welcome to Activate Ag Labs insights on the newly founded microplastic regulations in Europe. As an independent company specializing in the development of seed coating formulations, we aim to provide a comprehensive view for those who may not have an extensive background in chemistry or regulatory matters. This information will be particularly valuable for decision-makers who are tasked with navigating the complexities of these regulations. Starting from the basics, our goal is to present the necessary concepts in a clear and accessible manner, enabling a deeper understanding without assuming prior expertise.

What is a seed coating?

If you go way back into antiquity you will find sources that describe rolling seed in clay, ash, and manure materials, which are your earliest examples of seed pellets. The process became more industrialised during the 1960's and the three main types of coating emerged being filmcoat (thin -film coatings), encrustment and pellets.

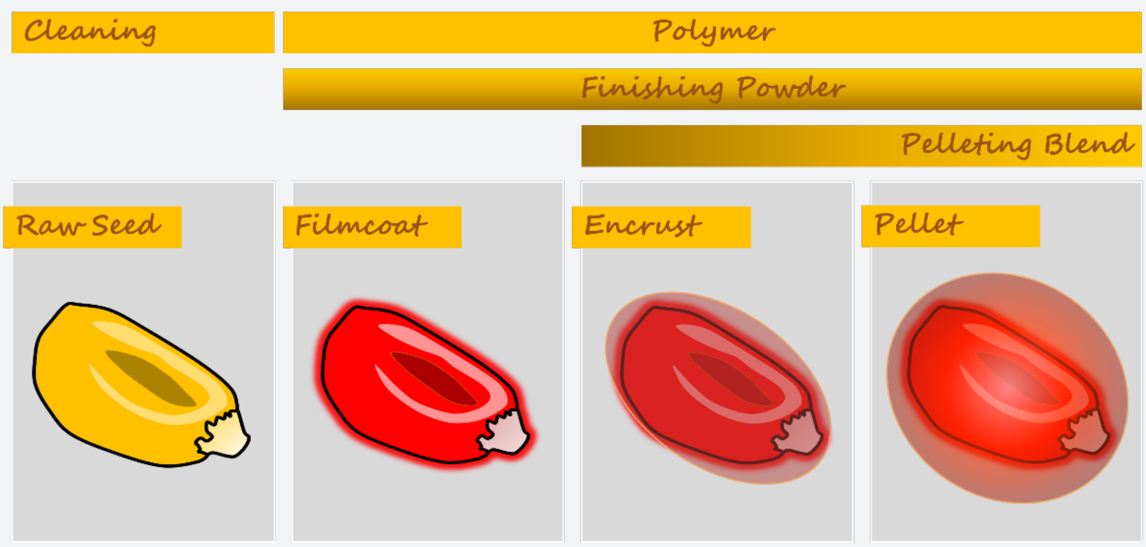


Fig 1. Different types of seed coating and application materials.

The materials used for building weight, or size are typically powders such as lime, talc or clay which are not amiss as part of the makeup of any soil. Filmcoats, and binders, which are used to hold pellets together, generally contain polymers that act, in layman's terms, as glue, or paint, these can be synthetic polymers, some of which may be classified as plastic.

The reasons for applying a seed coating are usually highly beneficial from an environmental standpoint. They can reduce the application of plant protection products by as much as 90% by replacing the requirement to spray an entire field.

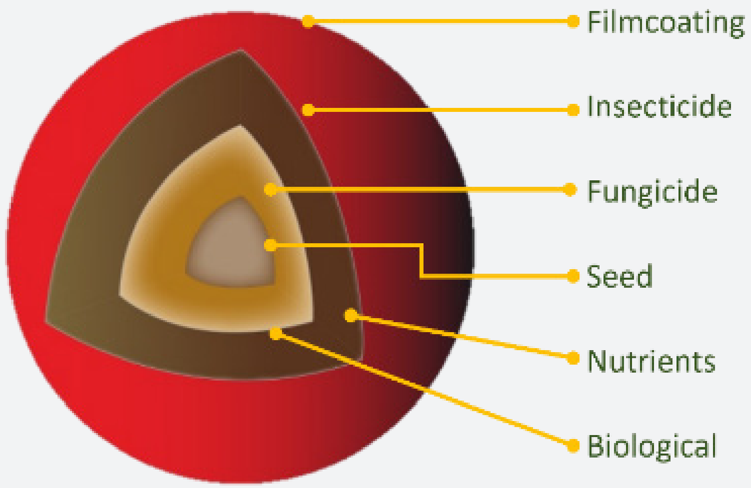


Fig 2. Pelleted seed showing ways in which additives can be added in discrete layers.

Pelleted products can aid with the planting of difficult-shaped, or sized seeds, these techniques when suitably employed increase the yields of many crops. Today we see biological and microbiological additives being incorporated into these coats Fig 2, these types of products have the potential to improve the soils within which they are used as well as to promote higher yields.

So when we are discussing a filmcoat or a seed-coating polymer, and when we throw in the terms of intentionally added microplastic, what is it we are saying?

What is a microplastic?

Plastic Definition

Plastic is an artificial material crafted from a diverse array of organic polymers, including but not limited to polyethylene (PE), PVC, nylon, polystyrene (PS), polymethyl methacrylate (PMMA), polyamide, polypropylene (PP), polycarbonates, etc. These polymers are generally pliable and can be shaped into various forms.

The intricacy arises from the fact that there is no singular, unequivocal definition of plastic due to the term being applied to various materials. Additionally, the origin of the raw materials used in plastic production is a significant factor. While the majority of plastics are derived from petrochemicals, there are now nearly identical alternatives utilizing plant-based oils. It's noteworthy, however, that this discussion extends beyond the microplastic discourse from the perspective of the European Chemicals Agency (ECHA), and is discussed later in this text with biobased materials.

Microplastics Scale

For discussion in this paper, we will use the ECHA specifications, the size range of microplastics is set between 0.1 μm and 5 mm. To give some idea of scale the graphic below demonstrates how this looks against common objects.

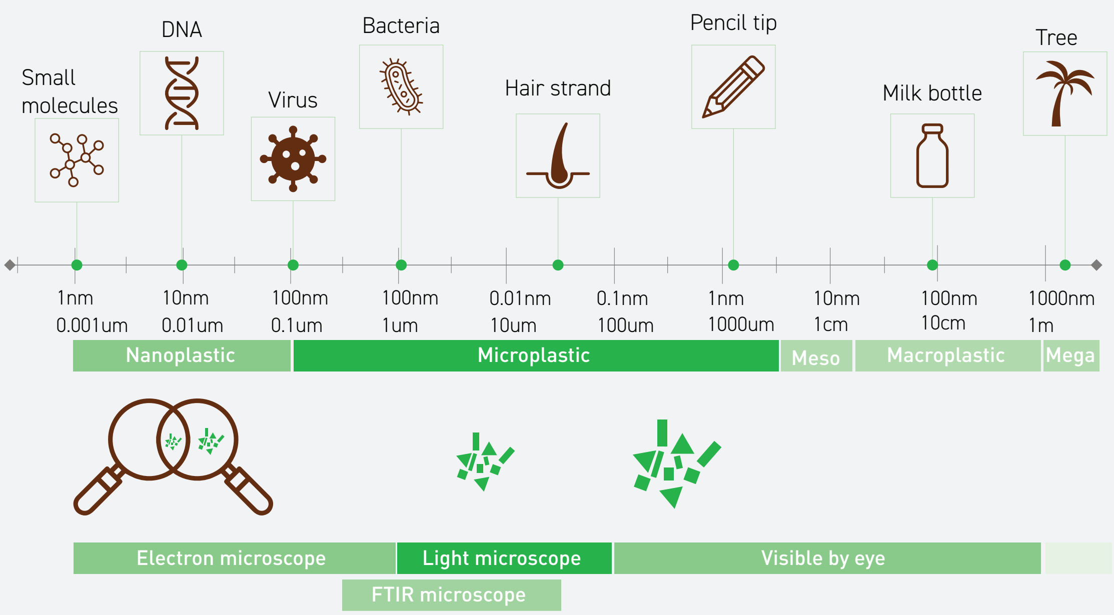


Fig. 3. Where microplastics fit in relation to their size (0.1μm to 5mm)

There was a desire to not set a lower limit as the nano-plastics also have consequences within the environment, however, analytical techniques in this range become more complex and costly. As can be seen in the figure 3 transmission electron microscopy, scanning electron microscopy and scanning probe microscopy are the current techniques employed at this scale. These are all relatively expensive techniques when compared with light microscopy, FTIR microscopy, and some Dynamic Light Scattering (DLS) analytics.

04

General Background

Microplastics, and how it all started

The production of plastic began in the mid-20th century, synthetic polymers, such as nylon and polyester became industrialised in the 1930's, increasing significantly during the 1950's and 1960's. As a versatile and inexpensive material, it found uses in many applications. Due to its ubiquitous use in all facets of our lives, and its inherent properties, there is now so much plastic in the world that the problems of its over-use, without proper, considered end-of-life solutions have been making themselves felt. The issues surrounding microplastics have only gained attention relatively recently the first use of the term microplastics was in a paper from 2004[2], since then awareness of the matter has been growing, research intensified during the 2010's as scientists began to evaluate their prevalence in oceans, rivers, air, and soil. The potential consequences of microplastic pollution have become a significant concern leading to building efforts to understand and mitigate possible harms.

UN SDG and sustainability

Way back in 2012 at a conference in Rio de Janeiro, the United Nations (UN) began a process that would bring about in 2015 a meeting of world leaders who adopted the 2030 Agenda for Sustainable Development and with it its 17 Sustainable Development Goals, the SDG's Fig 4, these have been taken up by industry as part of the ESG, as well as helping to shape governmental policy.

Fig.4 The 17 Sustainable Development Goals set by the United Nations

FAO Reports

The Food and Agriculture Organization of the United Nations (FAO) produced a report in 2021 (FAO. 2021. Assessment of agricultural plastics and their sustainability. A call for action.)[3]

This report focuses on the use of plastic in the agricultural sector and makes comment on the pervasive use of plastic, particularly single-use plastic. Further, it goes on to add that soil may contain more microplastic than the oceans, which prompts the need to reduce environmental harm from plastic pollution. Later aligning with the UN SDG 12 – Responsible Consumption and Production.

For most of the report it focuses on the packaging, films for mulching, silage and greenhouses, irrigation tape and coated fertiliser. Seed coatings are though mentioned in Annex 1 on value chains it displays graphically how the plastic in seed coatings is viewed when compared to the other uses of plastics in Horticulture shown in Fig 5&6.

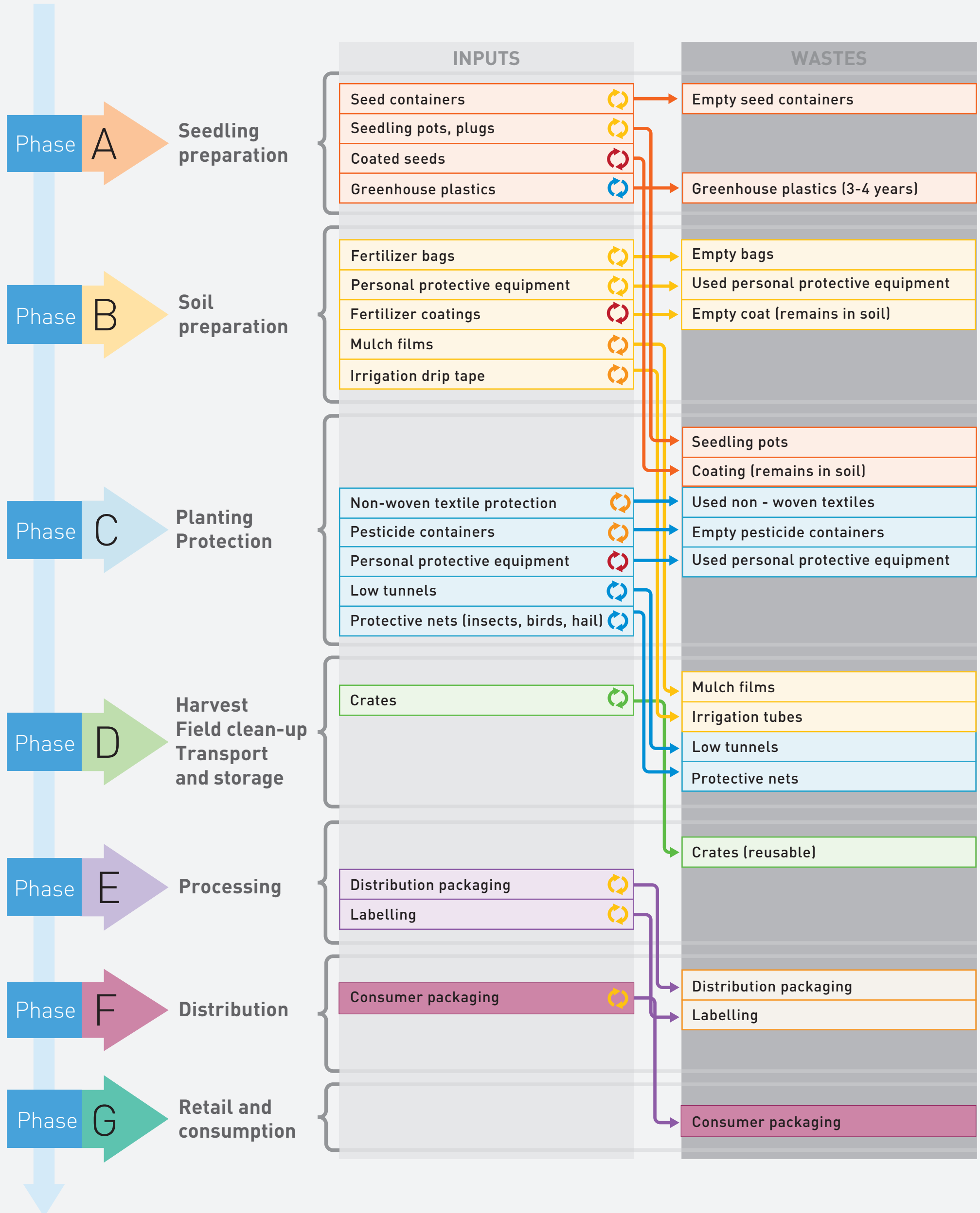


Fig 5. Table from FAO 2021 report

The graphic below indicates the potential of each to cause harm to the environment.

Increasing potential for harm to the environment

Increasing potential for circularity

Symbol	Description	Examples
	Products where the plastics become completely dispersed in the environment	• Polymer coatings of fertilizers, seeds and pesticides • Elastration bands for livestock • Dolly rope on trawl nets in capture
	Products with a high risk of dispersal into the environment or contamination that limits options for recycling	• Mulching films and irrigation tape • Plant support twines and nets • Pesticide containers and impregnated plastics • Veterinary consumables • Tree guards
	Single use products with short period of use (<6 months) but with potential for collection and some recycling	• Packaging for fertilizers and seeds • Personal protective equipment • Distribution and consumer packaging
	Single use durable products (useful life >3 years) and with potential for collection and some recycling	• Greenhouse films • Pond liners and irrigation mains • Ear tags for marking livestock • Fishing nets and cages
	Reusable products that only become waste after several use cycles and with potential for collection and recycling	• Crates for harvesting crops • Crates for small livestock • Hermetically sealed crop storage bags • Sanitizable insulated boxes for distribution of fish

Fig 6. FAO 2021 Gradients

EU Green Deal

The European Union (EU) set out a European Green Deal, this deal set out in Figure 7, is a part of the European Commission's strategy to implement the UN 2030 Agenda and the sustainable development goals.

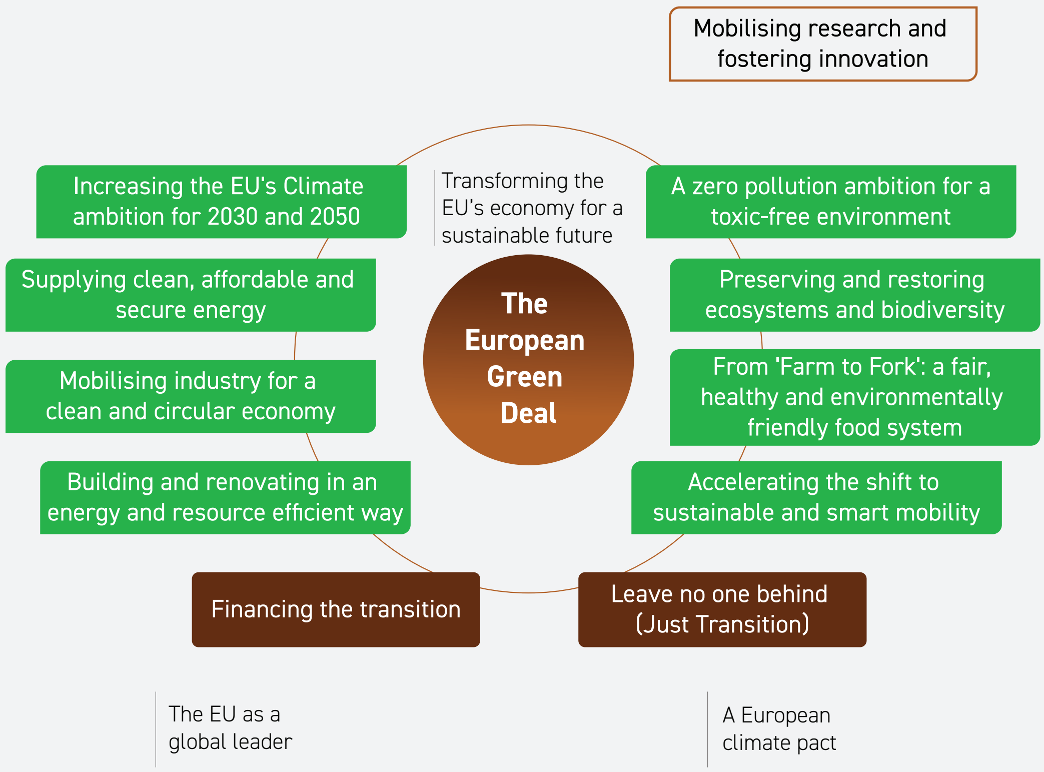


Fig 7. European Union Green Deal

The Green Deal is a comprehensive set of objectives introduced by the EU to address climate neutrality[4], redress environmental degradation, and promote sustainable development and systems, with a goal to achieve this by 2050. To help make this work economic growth is to be decoupled from resource use. Although there are additional interests around renewable energy and investments, of relevance and included within this package are the initiatives on biodiversity protection, to ensure a healthy environment, and sustainable agriculture, creating a food system for people and the planet. The Farm to Fork Strategy initiative aims to make food systems more sustainable, ensuring fair income to farmers, reducing pesticide use, and promoting organic farming.

Zero Pollution

The zero-pollution effort is a cross-cutting objective that also intersects with the UN SDGs, the key targets identified for 2030 are as follows:

The zero pollution targets for 2030[5]

Under EU law, Green Deal ambitions and in synergy with other initiatives, by 2030 the EU should reduce:

by more than **55%** the health impacts (premature deaths) of air pollution;

by **30%** the share of people chronically disturbed by transport noise;

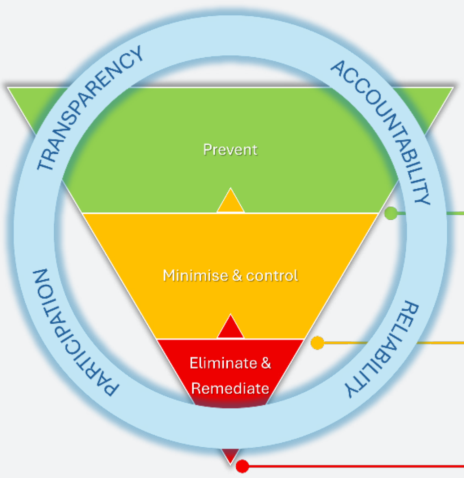
by **25%** the EU ecosystems where air pollution threatens biodiversity;

by **50%** nutrient losses, the use and risk of chemical pesticides, the use of the more hazardous ones, and the sale of antimicrobials for farmed animals and in aquaculture;

by **50%** plastic litter at sea and by **30% microplastics released into the environment;**

significantly total waste generation and by **50%** residual municipal waste.

Union policy on the environment shall be based on the **precautionary principle** and on the principles that **preventative action** should be taken, that environmental damage should as a priority be **rectified at source** and on the **polluter pays principle.**



PROTECT HEALTH AND THE ENVIRONMENT	ENCOURAGE INNOVATION
Prevent pollution in all stages of a clean and circular economy from extraction of natural resources, to production, service provision and consumption at end-of-life.	Promote clean 'zero pollution' production processes, safe and sustainable products and services by design as well as innovative tools, technologies, and behavioral change.
Minimise releases and exposure of humans and the environment to pollution through management, technological measures and information about releases.	Promote modern and smart production processes, safe and sustainable product uses, services and business models, and digital solutions for tracking and reducing pollution.
Eliminate and remediate, as far as possible, existing pollution of water and soils and apply measures to return to a 'good state'.	Promote zero pollution recycling, waste management, decontamination and remediation.

Fig 8. Zero pollution

05

Background for Agriculture

Microplastic pollution has emerged as a global concern due to its potential adverse effects on ecosystems and human health[6,7]. In the realm of agriculture, seed coatings play a crucial role in improving germination rates, plant health, and overall crop productivity. However, traditional seed coatings may often contain microplastics that pose environmental risks. This whitepaper explores the concept of microplastic-free seed coatings as an eco-friendly alternative, discussing their benefits, development processes, application methods, and potential impact on sustainable agriculture and environmental preservation.

Size of the Problem

By now you might be asking the question, how much of an issue is seed coating in all of this? The estimates from the ECHA background document[8,9] are encapsulated in the Figure 9 below.

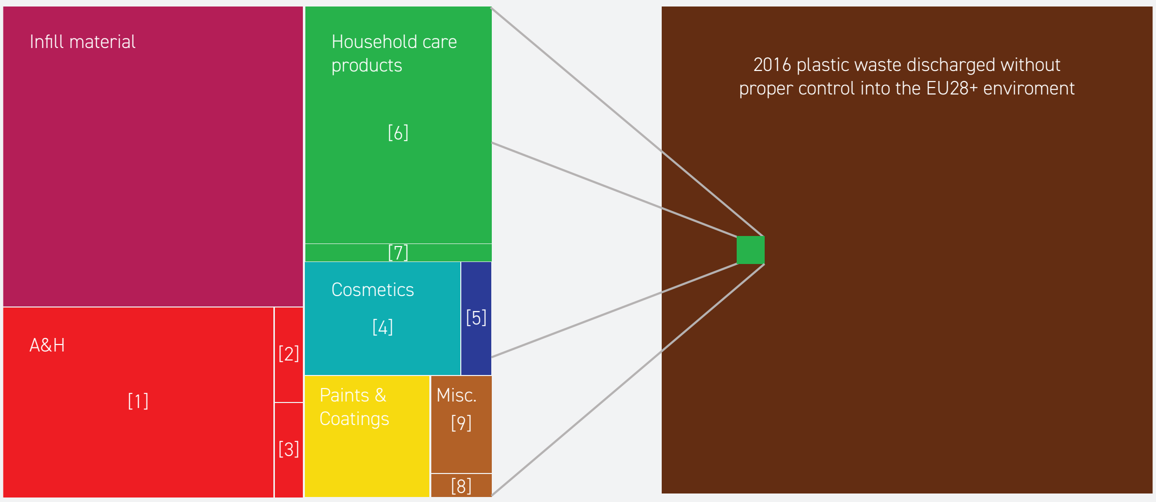


Fig 9. Weight-based comparison of microplastic to overall plastic waste; [1]Fertilising products, [2] Plant Protection products, [3] Coated seeds, [4] Rinse-off cosmetics, [5] Leave-on cosmetics, [6] Detergents, [7] Waxes, [8] Oil & Gas, [9] Medicinal uses.8,9

This has been further extrapolated for just the Agriculture & Horticulture sectors. Given the small volumes of seed coating, how has it that it has drawn so much scrutiny from regulators? The answer to this lies in the fact that these are intentionally added products that go directly into the soil and are not expected to be recovered.

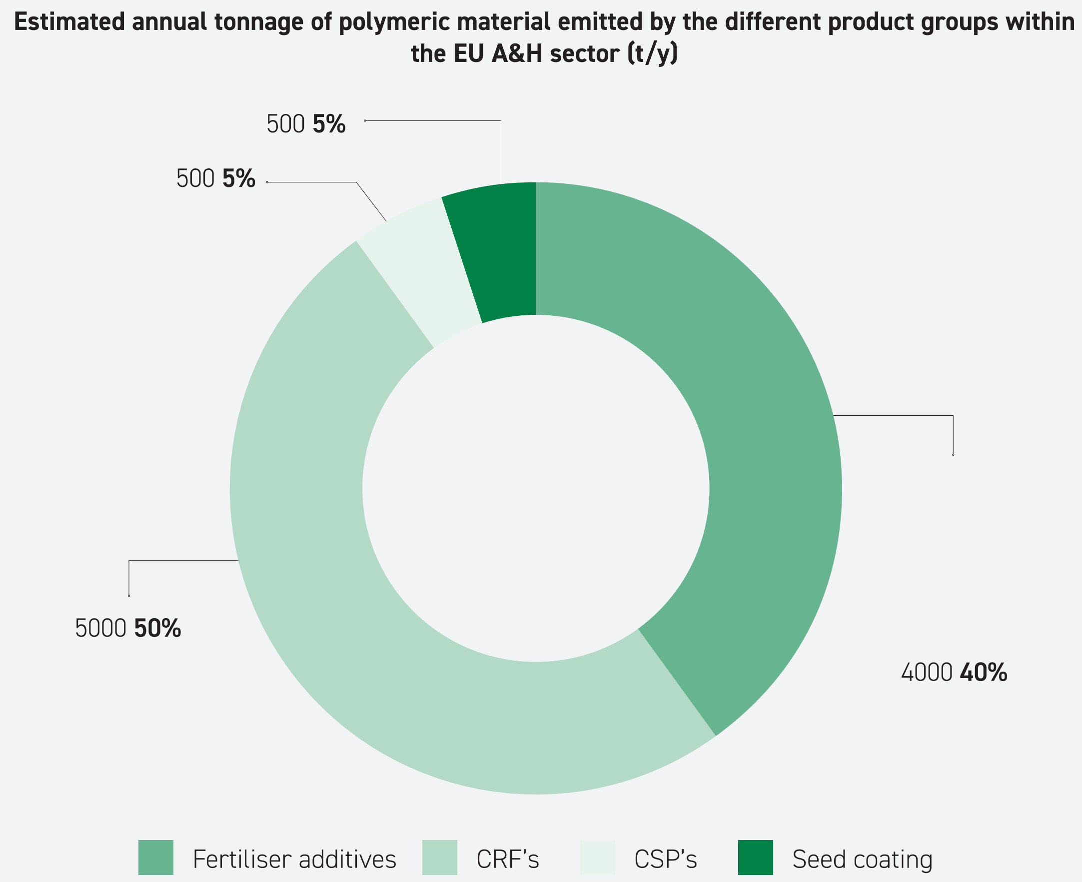


Fig 10. Estimate in tonnes per year derived from the ECHA background document.

Concerns

Soils

The initial concerns for microplastic, when it began to garner interest, were centred around the aquatic environment[10], the focus is now shifting to include the land and more specifically our soils. The size of the particles of interest is also beginning to shift far from the macro plastic, past the microplastic, and towards the nanoscale. The route of these microplastics includes the use of wastewater on agricultural land, mulching in agricultural systems, and landfill sites[11], and although at much smaller volumes, of course including synthetic seed coating polymers. Just what the effects microplastics will have within the soil is still the subject of ongoing research but it is becoming clear that there will be several effect[12,13]. Just one example of these effects, which may also depend on the type of plastic, shows that Arbuscular Mycorrhizal Fungi (AMF), which can be highly beneficial to some crops, can be both positively and negatively affected by the presence of microplastics[14,15]. What will be of growing concern is the build-up of the amount in our soils while the rate of addition continues to far outrun the rate of degradation.

Taken up in Food Chain

The uptake of microplastics in plants is going to be low because of their size but as these particles break down into more mobile, smaller, nano-plastics., then uptake can occur and has been observed in several studies on different plants[11,12]. The effect on chlorophyll content and other properties will become better understood as this work progresses. The next obvious question then becomes if this happens in crops, what will happen when these go into the food chain and are consumed by humans[16,17], will our health be affected?

This is a question that will take time to answer, it is thought that right now the levels in the environment are too low to affect human health[18], but levels are expected to rise, this is a good demonstration of why the precautionary principle has been enacted by the EU, and why they have pursued and enacted the implementation of regulations around products with intentionally added microplastics.

Based on the influx of similar information from a growing number of studies this became the driver for the European Commission to request that the European Chemicals Agency (ECHA) assess the risks posed by microplastics that are intentionally added to products, based on evidence and analysis new REACH restrictions were proposed and have been adopted.

06

Timelines

ECHA Timelines

Intention to prepare restriction dossier
17 January 2018

Call for evidence
1 March - 1 May 2018

Stakeholder workshop
30 - 31 May 2018

Submission of the Annex XV restriction dossier
11 January 2019

Consultation of the Annex XV dossier
20 March 2019 – 20 September 2019

RAC opinion
June 2020

Draft SEAC opinion
June 2020

Consultation on draft SEAC opinion
1 July - 1 September 2020

Combined opinion submitted to the Commission
February 2021

Draft amendment to Annex XVII by Commission
30 August 2022

Discussions with Member States and vote
2022-2023, voted on 27 April 2023

Scrutiny by Council and European Parliament
Before adoption (3 months)

Restriction adopted
25 September 2023

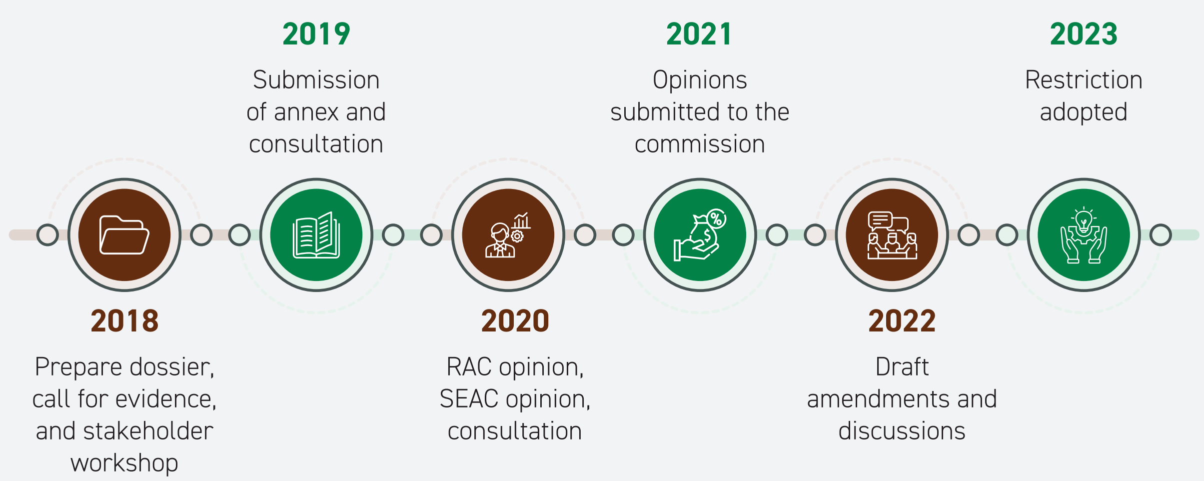


Fig. 11 ECHA Timeline for intentionally added microplastics

07

New Regulations

On the 27th of September 2023 the European Commission published Commission Regulation (EU) 2023/2055 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards synthetic polymer microparticles. The regulation entered into force in October 2023. The timeline for Entry into Force (EiF) was stipulated for different items, those of interest here are:

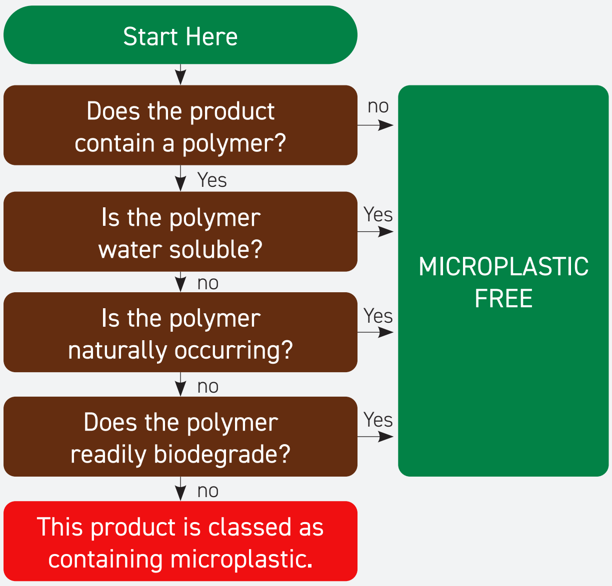
- **EiF+ 5 years for seed coatings** **October 2028** and,
- EiF +8 years for agrochemicals October 2031

This additional time for transition was to enable the development of biodegradable polymers suitable for this function, and the additional time for agrochemicals (plant protection products) the additional requirement of regulatory reapproval.

The definition that ECHA proposed for microplastics is:

> 'microplastic' means particles containing solid polymer, to which additives or other substances may have been added, and where ⩾ 1% w/w of particles have (i) all dimensions 0.1µm ⩽ x ⩽ 5mm, or (ii) a length of 0.3µm ⩽ x ⩽ 15mm and length to diameter ratio of >3.

The pathway to determine a microplastic-free seed coating is summarised in the diagram Fig 12 below:



There are now included definitions of what each of these derogations encapsulates, however upon close inspection, there seem to remain areas where the distinctions may not be as so clear.

Figure 12 microplastic-free flowchart based on ECHA / REACH regulations.

08

Grey Areas

Biodegradation

The concept of biodegradability may appear straightforward at first glance, but determining the rate at which a material breaks down after use presents a more nuanced challenge. The complexity arises when we're tasked with providing empirical evidence of a product's biodegradability. This necessitates careful consideration of the conditions under which such tests are conducted. The choice of testing conditions depends largely on the intended lifespan of the product and its ultimate disposal method.

Take, for example, the case of a seed coating. Ideally, once the seed is planted, we anticipate that the coating will naturally degrade shortly after the germination process. Consequently, the most relevant testing environment becomes soil. It's important to distinguish between testing in compost, where temperatures are elevated due to the decomposition process, and soil, where conditions are more varied and typically remain below 20 degrees Celsius. While testing in water could be indicative of how seed-coating polymers behave under certain circumstances, such as exposure to rainfall or accidental spillage, it may not fully capture the complexities of degradation in soil environments. As such, additional investigation may be warranted to comprehensively assess the biodegradability of seed coatings across different environmental scenarios.

In essence, verifying the biodegradability of products demands meticulous consideration of appropriate testing conditions, with a focus on replicating real-world disposal environments. We should expect more nuanced methods to arise in the future.[19]

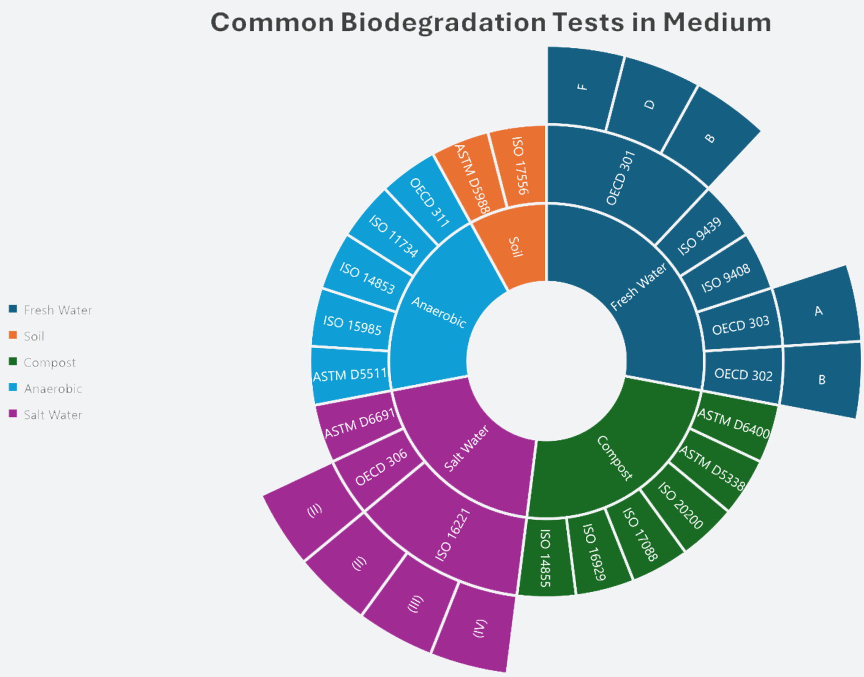


Fig 13 Options commonly available for biodegradation testing to various standards.

Contained in Appendix 15 is Entry 78 which contains instructions on relevant tests including but not limited to OECD TG 301 B, C, D, F, TG 306, TG 310, and other ISO methods. The breakdown over time and to a relevant percentage is usually specified, and the different levels of biodegradation are given, such as readily biodegradable, inherent biodegradable, etc.

Petrochemical, Biobased and Biodegradable

To enhance understanding, let's explore some definitions that can often intertwine and contribute to confusion regarding the appropriate courses of action.

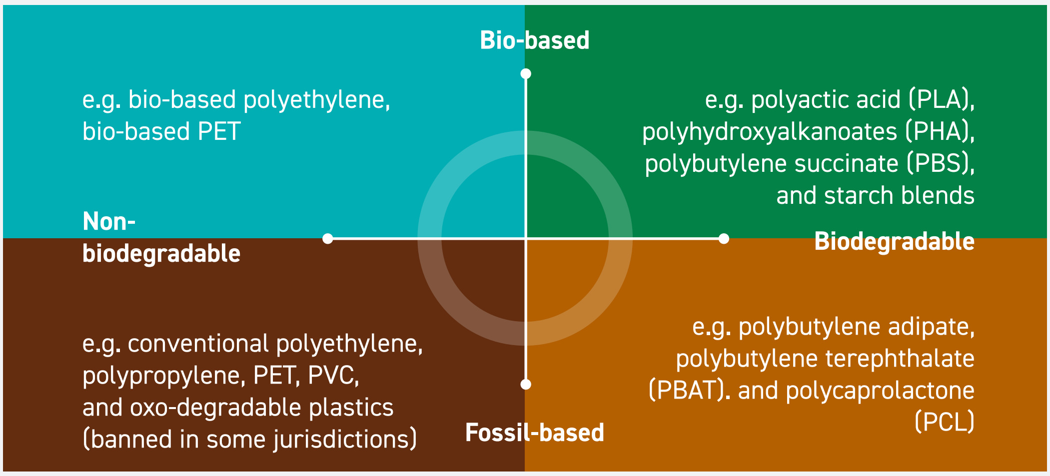
Petrochemicals derive their source materials from fossil fuels. The majority of polyethylene (PE) and polypropylene (PP) manufactured today originate from petrochemicals, although there are now options for biobased PE and biobased PP materials. It's important to note that regardless of the raw material source, PE and PP remain plastic. Even if derived from renewable sources, such as plants, biobased PE or PP that still fall within the size range of 0.1 micron to 5mm and are considered microplastics.

Bio-based materials utilize renewable resources, such as plant oils. However, the distinction isn't always clear-cut. In some instances, materials may be labelled as biobased despite being a blend of renewable biological and petrochemical sources.[19, 20]

The term "biodegradable" presents its own complexities both in definition and in determining appropriate testing methodologies. In the context of seed coatings, it's crucial to recognize that these products will ultimately be introduced into the soil.

In summary, navigating the nuances of these terms requires careful consideration, particularly in industries like ours where environmental impact is a significant concern. By clarifying these definitions and understanding their implications, we can make more informed decisions regarding the materials we use and their environmental consequences.

Figure 1: Classification of plastics by precursors and biodegradability



Source: Based on European Bioplastics fact sheet, European Bioplastics, 2019.

Fig 14. Biobased and Biodegradable distinctions[3]

While some coffee cup lids made from Polylactic acid (PLA) are generally perceived as biodegradable, it's important to note that they do not degrade effectively in soil. Similarly, Polyvinyl alcohol (PVA) is considered biodegradable in water, but its biodegradability in soil is questionable, particularly due to certain factors (ref).

Biodegradability must be assessed based on the specific environment it encounters at the End of Life (EoL). This is why there are tests designed for compostable, freshwater, seawater, soil, and anaerobic conditions.

The process of biodegradation is a microbial process, the microbial consortia of soil is wide and varied, indeed in some cases the pollutants if they are common enough will develop a consortia that is bias towards breaking down of the pollutants, this is useful in the case of sewage treatment, however when selecting microbes poses significant challenges. In the case of soil microbes, there can be tens of thousands, most of which have not been identified, they will vary with soil type and location, therefore producing a standardized test for soil poses significant challenges.

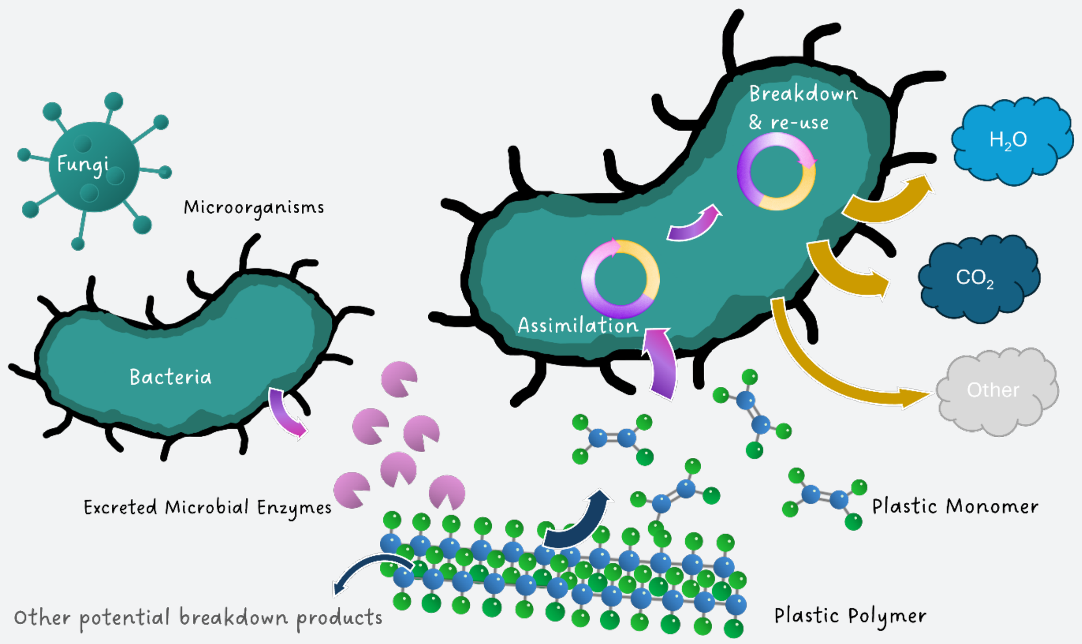


Fig 15 Biodegradation of plastic

What we hope for, or expect, from biodegradable materials is that they break down into non-toxic by-products, which for the most part they do, however, there are routes beyond the scope of this paper in which this is not always the case.

Solubility

This is another grey space, although the earlier question over what solubility was being considered has now been set by the permitted test methods:

1. OECD Guideline 120
2. OECD Guideline 105

Which may well rule out some materials, that are either water-dispersible or soluble only at high temperature.

These tests are to be conducted at 20°C, with a neutral pH and a test time of 24 hours.

PVOH as an example

Using Poly Vinyl Alcohol (PVOH, commonly known as PVA) as an example, some argue that despite being a synthetic polymer derived from polyvinyl acetate, its water solubility exempts it from being classified as a microplastic according to the definition set forth by the European Chemicals Agency (ECHA).

However, it's important to note that there are various grades of PVOH, and their solubility characteristics can vary. Some grades may be insoluble or only soluble under specific conditions.

Furthermore, biodegradation of PVOH in soil and water is unlikely to occur without the presence of suitable acclimated inoculum[21,22].

The biodegradation of PVOH has been more extensively researched in wastewater environments than in soil. However, the prevailing understanding suggests that biodegradation in soil, if it occurs at all, will likely take significantly longer than in water.

Another factor to consider is the utilization of wastewater in agriculture, especially during periods of water scarcity such as drought conditions. While this falls beyond the immediate scope of this paper, it's important to acknowledge the unintentional introduction of microplastics into agricultural systems. This overlap underscores the potential for additional impacts on soil health and ecosystems.

Furthermore, the use of wastewater in agriculture may have a more pronounced cumulative effect on soils compared to water waste treated in sewage plants. This is because sewage plants may harbor acclimated bacteria due to the continuous presence of polyvinyl alcohol from washing water, with PVOH commonly used in capsules for washing machines and dishwashers[23].

09

Regulatory Approval and Certification

REACH

The diligent work carried out by the European Chemicals Agency (ECHA) has prompted the introduction of stringent reporting mandates within the framework of REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals).

These updated requirements have shifted the accountability onto suppliers and manufacturers, compelling them to undertake thorough assessments to ensure that their products are devoid of intentionally added microplastics[24]. This necessitates meticulous scrutiny of manufacturing processes, material sourcing, and formulation compositions to safeguard against the inadvertent inclusion of microplastic components.

Who is policing?

The responsibility for ensuring compliance now falls upon manufacturers and producers, who are required to provide detailed information about their products. Suppliers must maintain comprehensive documentation to verify whether a substance or mixture falls within the scope of the restriction, and they must be prepared to present this documentation to enforcement authorities upon request.

Moreover, it is emphasized that employing inadequate analytical methods that fail to confirm the presence of microplastics in a product does not exempt manufacturers from their restriction obligations. The transition periods outlined in the restriction afford stakeholders and enforcement agencies the opportunity to adjust and adopt more suitable methods for compliance.

Certification (flustix)

Independent third-party certifications, such as the flustix certifications, play a crucial role in verifying whether newly introduced products adhere to regulatory standards.

flustix collaborates with its internationally accredited certification partner, DIN CERTCO (TÜV Rheinland), and laboratories accredited according to ISO 17025, such as Intertek (Switzerland) AG. The flustix Microplastic-free Certification is based on the latest international standards - currently on the definitions and guidelines of ECHA and will soon incorporate the latest requirements of the amended REACH regulation [Commission Regulation (EU) 2023/2055 of 25 September 2023] in the certification scheme. The certification process involves the requirement to disclose protected information under confidentiality agreements and the conducting of laboratory testing of product samples using defined and appropriate techniques, such as RAMAN spectroscopy. The resulting test report undergoes an independent conformity assessment at the accredited certification body, DIN CERTCO (TÜV Rheinland), based on which, if conformity with certification requirements is confirmed, the certificate and the “flustix PLASTICFREE - Product Content Free from Microplastic” seal are awarded.

Fig 16 Flustix Microplastic-free Seal

The seal graphic displays the unique license number Fig 16 of the certified product and includes a link to the public database of DIN CERTCO (TÜV Rheinland). All interested parties, for example within the supply chain and end consumers, can access further information about the certified product by entering the license number in the search field of the database.

This approach enables safe green claiming by providing full transparency at all levels while relying on independent testing and certification, all in accordance with international standards.

Biodegradation

The incorporation of regulations concerning the demonstration of biodegradability was a process that unfolded over time, reflecting the complexity inherent in biodegradation testing. Although ECHA/REACH has chosen to adopt OECD or EN ISO methods, alternative methodologies are also being proposed by various groups. This ongoing evolution presents an opportunity for continued refinement and clarity, particularly in sectors like seed coatings.

Furthermore, the implementation of certifications and reporting requirements mandated by REACH serves as a vital safeguard against greenwashing—a deceptive practice in which companies make exaggerated or false claims about the environmental benefits of their products. By promoting transparency, accountability, and adherence to rigorous standards, these regulatory measures help consumers make informed choices and foster trust in environmentally responsible practices within the industry.

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Greenwashing

Referencing the Green Claims Directive[25], which addresses the issue of false environmental claims, underscores the ongoing efforts to combat deceptive marketing practices. This initiative aligns with broader objectives outlined in the Green Deal, the New Circular Economy Action Plan, and the New Consumer Agenda, reflecting a comprehensive approach to sustainability across various sectors. While delving into extensive detail may not be necessary at this juncture, it is evident that stakeholders within the industry who skirt regulatory requirements rather than embracing transformative changes and prioritizing transparency may face significant challenges in the future.

The overarching goal is to eradicate misleading environmental messaging by establishing a more transparent and credible framework. This may entail requiring claims to be substantiated through life cycle assessments and external verification processes. Implementation of these measures could potentially commence as early as 2026,[25] as shown in Fig 17, contingent upon negotiations within the EU.

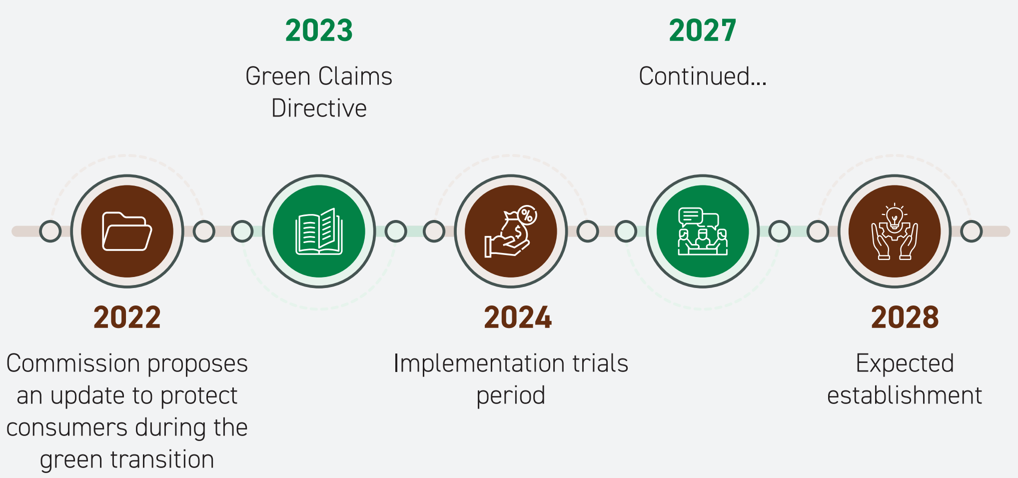

Fig 17 A Potential EU Green Claims Directive Timeline

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Developing new seed coating formulations

When examining the constituents of seed-coating polymers that could potentially contain microplastics, it becomes apparent that the binder, responsible for forming a film and adhering other materials to the seed surface, is the main character. Among the diverse range of binders utilized in seed coatings, these would commonly include, but not be limited to, polyvinyl alcohol, polyvinylpyrrolidone, polymethyl acrylate, carboxymethyl cellulose, chitin, hydroxypropyl cellulose, polyvinyl acetate, polyurethane, modified starch, pectin, lignosulphonate, gum arabic, and locust bean gum, among others.

Beyond binders, seed coating formulations may incorporate a variety of additives to enhance performance and functionality. Traditional polymers such as polyethylene (PE) and polypropylene (PP) may be included, alongside specialized polymers like dendritic polymers and core-shell polymers. These additives serve diverse purposes, ranging from improving adhesion and durability to facilitating controlled release of active ingredients.

For professionals within the formulation sector, the presence of these polymers is unsurprising, given their integral role in optimizing seed coating formulations. However, for external observers, particularly those who may underestimate the complexity of formulation science, the extensive variety and precise selection of polymers may come as a revelation.

It's essential to recognize that each polymer component is carefully chosen and meticulously incorporated into seed coating formulations to achieve specific performance objectives. As such, the notion of simply substituting one polymer for another without thorough consideration of its functional properties and compatibility with the formulation may prove overly simplistic and impractical.

For some additional context, let's look at just some of the benchmark's polymers are put up against when selecting the best product.

Seed Coating Polymer Benchmark Results

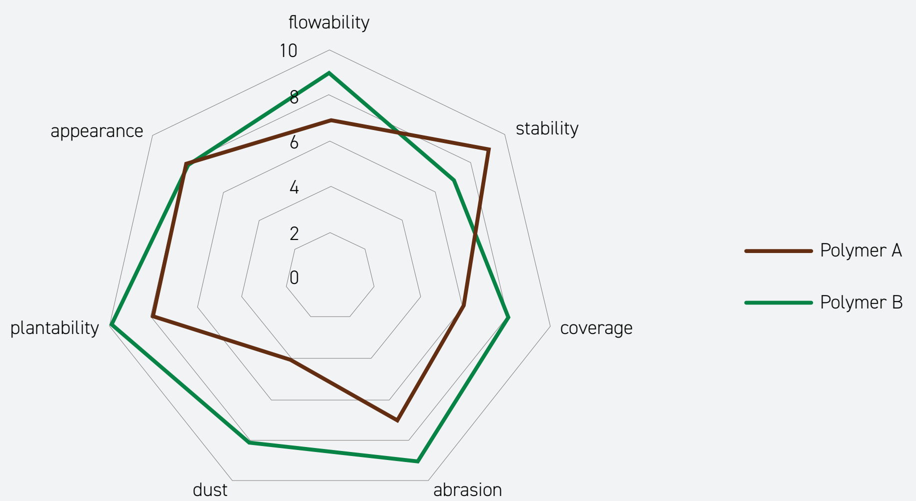

Fig 18 Typical web diagram comparing some seed coating polymer features.

Future of seed treatments – seed coating polymers

As the list of requirements for seed coating polymers continues to expand and the market becomes increasingly competitive, operating in this space poses significant challenges. The true value of seed coating innovations is not always fully appreciated throughout the industry chain, with stakeholders often focusing more on immediate costs rather than considering the comprehensive benefits offered.

The question arises: How far should we push our efforts in developing new seed coating formulations?

It's worth noting that some existing seed coating products may have inadvertently complied with microplastic-free regulations but may lack essential physical properties such as dust-off reduction and abrasion resistance. Conversely, certain products rushed to market to meet microplastic regulations may offer little in terms of additional benefits.

The development of new seed coating products not only entails substantial investment in research and development (R&D) but also necessitates sourcing new ingredients from raw material suppliers to ensure microplastic-free and sustainable options. The European Commission's approach, spanning various industries including personal care, paints, and pharmaceuticals, has played a crucial role in facilitating the availability of these new ingredients.

For manufacturers producing new formulations, achieving a return on investment (ROI) can be a prolonged process. It typically takes around six years or longer to recoup investments, factoring in field trials and the stringent requirements for high-end products. Field trials alone may require 1-2 years of data collection, followed by additional field trials conducted by seed producers.
When considering the time spent developing formulations in the laboratory and assessing product stability both in-can and on seed, the complexity of the process starts to become apparent.

At this point, it is easier to understand the timeline outlined by the European Chemicals Agency (ECHA) with an EiF of 5 years which acknowledges the meticulous nature of this process and the commitment required to bring innovative and environmentally sustainable seed coating products to market.

Sustainability of all products

To effectively evaluate the sustainability of a new formulation, it's imperative to understand the production processes involved in manufacturing all the raw ingredients. Historically, much of this information has been proprietary to manufacturers, making it challenging to obtain a comprehensive understanding. However, this landscape is evolving, with companies committed to robust Environmental, Social, and Governance (ESG) practices increasingly embracing transparency and providing certifications to substantiate their claims.

As with any emerging advancements, progress will unfold incrementally. Expectations include gaining greater clarity on the sources of raw materials, refining processing techniques, and reducing the carbon footprint associated with production. This involves considerations such as energy intensity, energy sources, and overall sustainability practices within the supply chain.

Furthermore, as research progresses both in industrial and academic settings, understanding the intricate systems governing the environmental impact of products within relevant ecosystems will continue to expand. This ongoing exploration will contribute to enhanced comprehension and the adoption of more sustainable practices throughout the product lifecycle.

Futureproof

Sustainability is key to providing a solution for seed coating materials, the removal of microplastics is just the beginning, with an emphasis on circular economies, and improving environmental stewardship, there will continue to be ongoing improvements. The pace of change will be affected by the availability of suitable raw materials, as well as physical, biological, and chemical restraints, but these are welcome challenges to do better.

Just meeting the regulations, is it enough?

It is the minimum, why not do a little better? When interpreting new regulations, it is easy to say what is the minimum amount of work we can do, or changes we can make in order to meet the requirements of the regulations. Further consideration of the spirit in which these regulations have been introduced gives a better source of reflection so that instead we ask questions like, how can we fully embrace the changes that have been deemed necessary to improve our environment and food safety and go beyond what is currently required to aid in greater advancement of our industry.

Towards more positive outcomes

Utilise materials/additives that rather than degrading our soils will build them up and repair them from damage done during the green revolution. Or allow utilisation of otherwise marginal soils.

Traditional methods of seed coating involve applying chemical pesticides to safeguard seedlings and plants against pathogenic fungi and insect pests. As the industry evolves, there is a growing comprehension of the mode of action employed by various biostimulant products. This understanding, coupled with an enhanced awareness of the seed's surrounding microbiota and the advantages of fostering a more symbiotic rhizosphere for plant growth, marks a maturation in the field.

Through the strategic selection of materials to be incorporated into seed-coating polymers and the use of biostimulants that promote soil health, we can embark on the restoration of land that has suffered degradation due to excessive fertigation and other suboptimal management practices. This approach signifies a shift towards more sustainable and ecologically mindful methods in seed protection and soil management.

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Discussion & Conclusion

Is there a simple fix?

The notion of the precautionary principle suggests halting the use of plastics altogether, yet the reality proves it's far from straightforward. Focusing on seed coatings, if we were to remove plastics from seed-coating polymers, what consequences might arise?

For example, the performance of the coating could mean that the co-applied products like pesticides would no longer be as well adhered to the seed surface and the flow through farm equipment could be affected so much that it would potentially lead to reduced plantability, which means health hazards for the operators and the environment as well as significant losses in yields. Many other examples of this type could be given.

So, no there is no simple fix. It will require in most cases great efforts to bring suitable products to the market, and additional efforts of those who utilise the products to ensure their needs continue to be met.

When do seed companies need to have this done by, what does the timeline look like?

Fig 19 Example timeline for a new microplastic-free seed coating polymer to reach market

Given the average time to get a new seed coating polymer out into the market is around 4 years, if you started today, you would be ready just in time for the October 2028 deadline.

Will there be further alterations following this?

Likely, albeit not immediately. It's understood that seed treatment chemicals, insecticides, fungicides, and herbicides have an eight-year period for full implementation to accomplish their intended tasks. Moreover, there's awareness of proposed legislation aimed at addressing unsubstantiated green chemistry claims, yet the exact trajectory remains uncertain. Our actions need to be grounded in present knowledge, driving us towards increasingly sustainable and environmentally conscious solutions.

Environmental advocates are pushing for additional regulatory measures[26], delineating key provisions they hope to see implemented. Foremost among these is the elimination of the minimum size threshold for microplastics, encompassing particles under 5 mm, as well as the removal of exemptions for water-soluble polymers. These adjustments essentially transition towards a 'no plastic' paradigm rather than simply targeting microplastics.

Ongoing research and development efforts are crucial for refining coating formulations, improving compatibility between seeds and crops, and comprehending the long-term impacts on soil health and biodiversity. Embracing microplastic-free seed coatings offers a sustainable avenue for advancing agriculture while addressing microplastic pollution. The application methods, advantages, and potential for collaboration herald a transformative approach to modern farming. By embracing this innovation, we not only secure our agricultural future but also contribute to environmental preservation for future generations.

Balancing the costs - Economics

Over the past several decades, the market for seed coating polymers has witnessed a substantial expansion, marked by a consistent upward trajectory, with compound annual growth rates (CAGR) typically ranging between 5% and 11%.

The global market for seed coating polymers is valued at approximately $2-3.5 billion USD currently, with projections indicating continued growth. This growth can be attributed to several factors contributing to the proliferation of seed coating applications and the widening adoption of this technology across diverse agricultural sectors.

Advancements in seed coating formulations and technologies have led to the development of a greater variety of coatings tailored to address specific agricultural needs. These formulations offer enhanced protection against pests, diseases, and environmental stresses, while also promoting seed germination, seedling vigor, and crop establishment. As a result, farmers and growers have increasingly turned to seed coatings as a means to optimize crop performance and maximize yields.

North America and Europe are traditionally significant markets for seed-coating polymers, accounting for a substantial share of global consumption. However, emerging economies especially in the Asia-Pacific and Latin America, are witnessing rapid growth in seed coating adoption due to expanding agricultural sectors and increasing demand for enhanced crop productivity.

Moreover, the growing awareness of the benefits associated with seed coatings has spurred their adoption across a broader spectrum of crops. Initially utilized predominantly in major commodity crops such as corn, and soybeans, seed coatings are now being employed in a wider range of crops including vegetables, fruits, and specialty crops. This expansion is driven by the recognition of the potential for seed coatings to improve seed quality, uniformity, and overall crop productivity across diverse agricultural contexts.

Furthermore, advancements in seed coating application technologies, such as precision coating equipment and automated application systems, have facilitated the widespread adoption of seed coatings. These innovations have enhanced efficiency, accuracy, and scalability in seed coating operations, making the process more accessible and cost-effective for growers of all scales.

The seed coating market is characterized by intense competition among key players, including seed companies, agrochemical manufacturers, and specialized coating companies. Differentiation strategies based on product quality, performance, and sustainability credentials play a crucial role in gaining market share and maintaining competitiveness.

As new regulatory procedures are introduced, the gap between compliance requirements and product development may widen, posing challenges for formulation teams. Navigating through regulatory hurdles demands meticulous attention to detail, extensive testing, and adherence to evolving standards. Despite these complexities, regulatory changes also serve as a catalyst for innovation and improvement within the industry.

For formulation experts, this presents a unique opportunity to refine their processes and develop products that not only meet regulatory standards but also exceed market expectations. By embracing these challenges, formulation teams can leverage regulatory compliance as a competitive advantage, positioning their products as trusted, reliable solutions within the market. Moreover, products that successfully navigate the regulatory landscape are likely to enjoy greater acceptance and longevity in the market. With consumers and stakeholders increasingly prioritizing sustainability, safety, and compliance, products that meet these criteria stand to gain a competitive edge and foster long-term relationships with customers.

In essence, while regulatory procedures may pose initial hurdles, they ultimately incentivize innovation, elevate product quality, and strengthen market positioning. By embracing these changes and proactively addressing regulatory requirements, formulation teams can drive continuous improvement and deliver value-driven solutions that resonate with consumers and industry stakeholders alike.

By pivoting effectively, businesses can demonstrate their commitment to regulatory compliance and showcase their ability to meet evolving standards. This not only enhances their reputation as responsible and trustworthy entities but also instils confidence among customers and stakeholders. Moreover, by staying ahead of regulatory changes, businesses can capitalize on emerging market trends and consumer preferences. By aligning their offerings with regulatory requirements from the outset, companies can establish themselves as leaders in compliance and innovation, gaining a distinct advantage over competitors who may lag behind in adapting to new regulations. Furthermore, by embracing regulatory changes as opportunities for growth and differentiation, businesses can foster a culture of continuous improvement and innovation. This mindset encourages proactive problem-solving and encourages teams to seek out new opportunities for value creation and market expansion.

In essence, by pivoting effectively in response to new regulations, businesses can position themselves for long-term success by staying ahead of the curve, meeting customer needs, and capitalizing on emerging market opportunities.

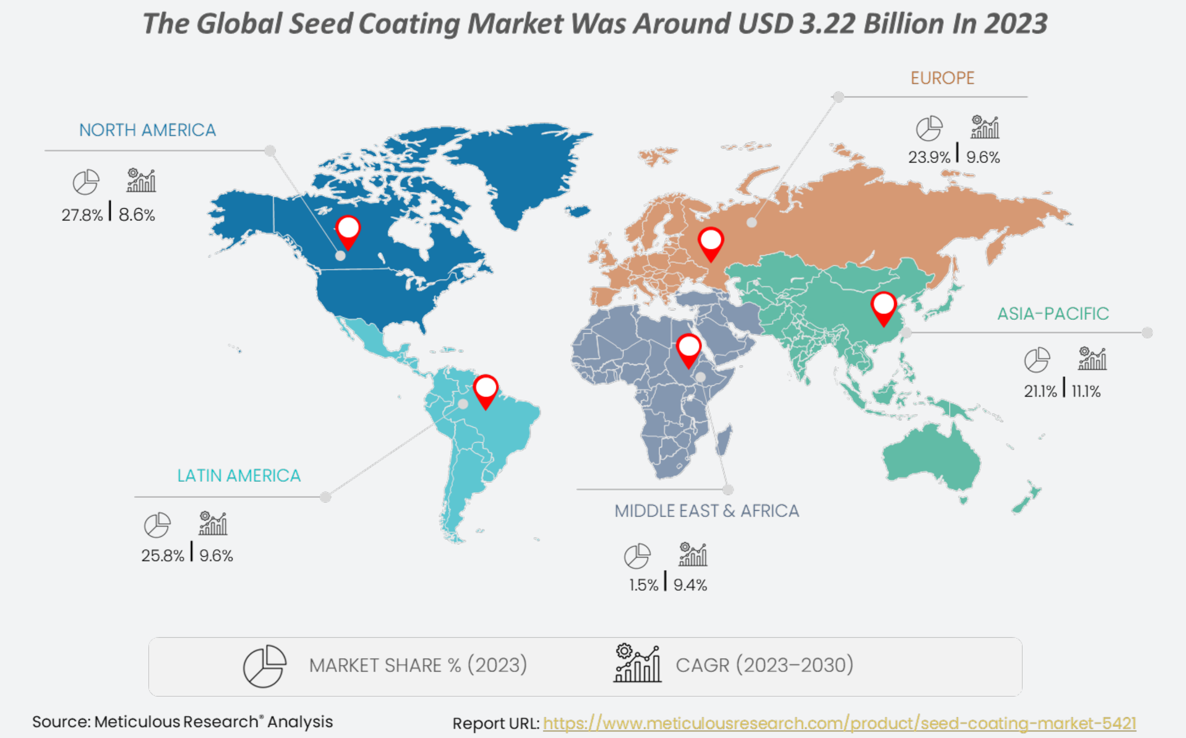

Fig 20 Global Seed Coating Market[27]

The potential costs of not staying abreast of these developments are significant. While suppliers are tasked with providing information on microplastic-free products, the situation becomes murkier for seed companies that lack appropriate seed coating formulations or have mistakenly used incorrectly identified products. The pivotal question arises: will they be able to effectively position their products competitively in the market amidst growing consumer demands for environmentally sustainable solutions?

Addressing this issue goes beyond the confines of the European Union (EU). While the development of microplastic-free products initially impacts seed producers operating within the EU and those treating seeds within its borders, the implications extend globally. As environmental stewardship becomes a paramount concern worldwide, it's foreseeable that many countries will adopt similar regulations and standards.[28] This reflects a broader global movement towards sustainability and regulatory alignment across various industries and regions.

Failing to align with these evolving standards can result in missed opportunities and potential reputational damage. Companies that lag behind in adopting sustainable practices risk losing market share to competitors who proactively embrace eco-friendly solutions. Additionally, as consumers become increasingly discerning about the environmental footprint of the products they purchase, brands that fail to meet regulatory expectations may face consumer backlash and diminished trust.

Staying ahead of regulatory changes and aligning with global sustainability initiatives is not only a regulatory necessity but also a strategic imperative for businesses operating in the seed industry. Embracing sustainability not only ensures compliance with regulations but also enhances brand reputation, fosters consumer trust, and drives long-term business success in an increasingly eco-conscious marketplace.

Conclusion

To be clear these regulations from ECHA have not come about because we are seeking innovation, these regulations have been put into place because of unforeseen consequences of prior actions.

> The most exciting breakthroughs of the 21st century will not occur because of technology but because of an expanding concept of what it means to be human.
>
> **- John Naisbitt**

We will all be adapting to the ever-changing needs because as humans we fundamentally understand the protection of our planet requires that we act.

At Activate Ag Labs, we've dedicated years to developing microplastic-free seed-coating products that match the efficacy of synthetics, all while ensuring compliance with new regulations. Our journey doesn't end here; we're committed to exploring further enhancements and adapting to evolving coating technologies. In addressing the formidable challenge posed by the reformulation of seed coatings, it is imperative for both seed companies and growers to undertake resolute and decisive measures, ensuring not only environmental sustainability but also economic viability.

Actions by seed companies:

Seed companies can lead the charge in conducting rigorous research and development endeavors aimed at identifying and implementing alternative materials for seed coatings devoid of microplastics. Through a steadfast commitment to sustainable innovation, seed companies can help diminish their ecological footprint while simultaneously enhancing their economic resilience. By embracing environmentally responsible practices, seed companies can unlock new market opportunities and foster long-term profitability.

Actions by growers:

Growers, as stewards of the land, wield considerable influence in shaping agricultural practices. It is imperative for them to endorse seed companies that prioritize environmentally responsible seed coatings and to adopt practices that curtail the dissemination of microplastics into the environment. By embracing sustainable agricultural practices, growers can mitigate operational risks, enrich the soils, and bolster long-term profitability. Additionally, investment in eco-friendly initiatives can improve market access and consumer perception, further bolstering economic viability.

Call to collaborate in a timely fashion:

The exigency of addressing the pervasive issue of microplastics in seed coatings necessitates a concerted and expeditious collaborative effort among stakeholders. By fostering synergistic partnerships encompassing seed companies, growers, formulators, researchers, and policymakers, we can expedite the development and deployment of economically justified sustainable solutions. Prompt and collective action is imperative to safeguard our planet's ecological integrity and ensure the prosperity of future generations.

Let us unite resolutely and collaborate, thereby forging a pathway towards a more sustainable, economically viable, and resilient agricultural paradigm.

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Appendix 1 Legislation

The EU has issued legislation to regulate microplastics under Annex XVII of REACH. The provisions in the new law will be implemented in phases, starting October 17, 2023.

On September 27, 2023, the European Union (EU) issued Commission Regulation (EU) 2023/2055 to regulate synthetic polymer microparticles (‘microplastics’) as substances on their own and in mixtures (the Regulation).