INNOVATION IN CIRCULAR TEXTILES: RECYCLED, RECYCLABLE & BIODEGRADABLE POLYESTER

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Abstract

CiCLO® technology is a textile innovation that enables polyester made from recycled inputs to remain highly durable during its useful life, biodegrade when it inevitably pollutes the environment in the form of microplastics, and maintains recyclability.

Polyester is the preferred fiber for 57% of textiles, accounting for 71 million tonnes (MT) in 2023, up from 63 MT in 2022. Of the 71 MT, only about 8.9 MT were from recycled materials—98% from PET chips and 2% from textile waste (Textile Exchange, 2023). Volumes of recycled polyester are expected to grow, especially from textile waste, which our planet is abundant of today. EPR legislation requiring textiles to be recycled, combined with tremendous investment in collection and sorting infrastructures and recycling technologies, will exponentially increase the percentage of polyester produced from textile waste. These circular systems for textiles are beneficial for the planet, but polyester, a non-biodegradable plastic, persists in the environment indefinitely as pollution, regardless of the raw materials used.

Considering the extensive use of polyester and its non-biodegradable nature, it correlates that fiber fragmentation from synthetic textiles (referred to as "microfiber pollution") is the most prevalent form of microplastic pollution accumulating in all environments globally. Fiber fragments are so small that they unavoidably leak into the environment through many pathways, where they cannot feasibly be recaptured. The accumulation of this form of microplastic pollution is an environmental threat impacting biodiversity loss and climate change.

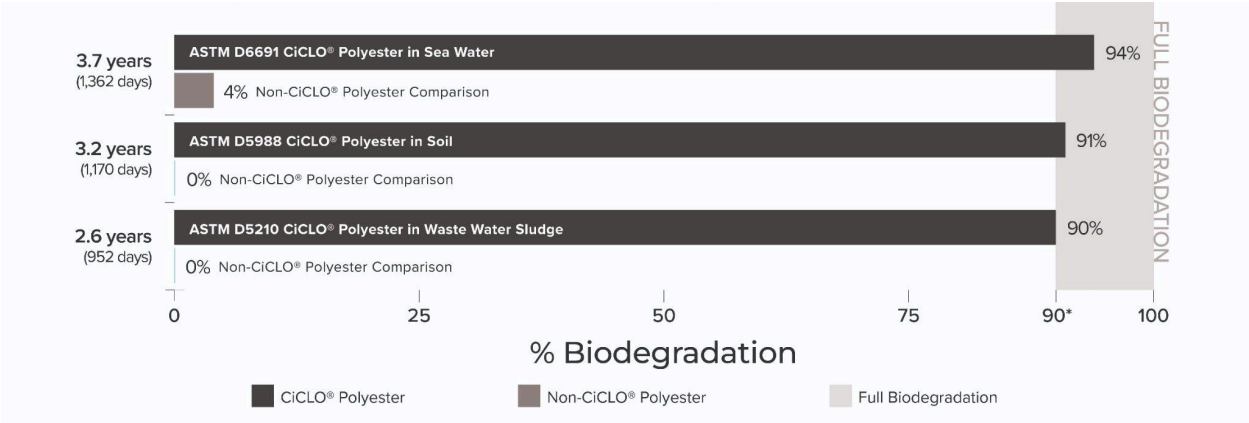
Source reduction, design for less shedding, and filtration are important primary mitigation measures, but only partial solutions and sometimes impossible or cost-prohibitive to implement. Polyester, largely from recycled textile inputs, will continue to be an important material for the textiles industry into the foreseeable future, and microplastics that shed from them will continue to pollute and accumulate in the environment at alarming rates.

For these reasons, textile veterans invented CiCLO® technology to enable polyester to remain durable and recyclable, yet inherently biodegradable. The inventors' approach, covered in this paper, proves:

- compatibility within existing batch and continuous polymerization manufacturing processes
- durability of fiber maintained
- complete mineralization of recycled polyester made with CiCLO® technology in aerobic and anaerobic conditions at a range of temperatures using internationally recognized ASTM and ISO respirometry test methods
- evidence of no microplastics left over
- non-toxicity to marine and plant life
- fiber traceability
- fabric recyclability

CiCLO® polyester is used by major brands and retailers across textile categories including apparel, home textiles, uniforms, cleaning supplies and more.

Biodegradation Rate Comparison:
CiCLO® Recycled Polyester Fabric Vs Non-CiCLO® Recycled Polyester Fabric



The chart above represents a summary of data from long term studies at third party labs comparing the biodegradation rate of a polyester fleece fabric made from recycled PET yarn that has been sold at retail for many years (identified as "Comparable Conventional Polyester") and the fabric recreated with the same specs except that the recycled PET yarn incorporated CiCLO®technology (identified as "CiCLO®Polyester"). The CiCLO®polyester fully biodegraded within 952 to 1,362 days depending on the environment, as compared to zero to 4% biodegradation of the polyester without CiCLO®technology. Rate of biodegradation in uncontrolled open environments will vary based on many factors.

Achieving ≥90% in respirometry is recognized as full biodegradation. The remaining percentage can be attributed to biomass. Further analysis has been conducted to confirm no microplastics leftover.

Introduction and Motivation

CiCLO® is the brand name for a patented textile technology that reduces the persistence of synthetic fiber pollution (commonly referred to as microfiber pollution), the most common form of microplastic pollution found in all environments around the world. When blended with polyester at a dose of 2% or less depending on the manufacturing process, CiCLO® technology imparts the inherent characteristic of biodegradability to the fiber and fabrics without impacting durability or recyclability. CiCLO® chemistry can be added to all types of polyester including virgin, recycled bottle flake or textile waste and is formulated for both batch and continuous polymerization manufacturing processes.

Inspired by the need for a more sustainable alternative to conventional polyester used in quick-serve uniforms, CiCLO® formulation development began in 2012. The lead inventors are textile industry veterans with expertise in workwear who recognized that the programs they managed required the high performance, durability and availability of polyester, a material that was unavoidably contributing to microplastic pollution. The polyester used in common textiles is the same grade PET (polyethylene terephthalate) used in plastic bottles and is non-biodegradable. Almost all yarns and fabrics shed small fibers during manufacturing, use and care. The fibers have many pathways into the environment and once fugitive are too miniscule to feasibly recapture.

Polyester is used in a wide range of applications, including apparel, home textiles, upholstery, carpeting, soft signage, geotextiles, filtration materials, cleaning fabrics, and flags, to name just a few. Consider the following statistics from reputable research organizations to put the ubiquitous issue of synthetic microfiber pollution from textiles in perspective:

- For every 500 shirts made, one is lost as microfiber pollution during the manufacturing process (The Nature Conservancy, 2020).
- An average household generates about 20 kg of dust a year, of which 6 kg consist of microplastics from synthetic clothing, carpets and furniture (Chua, J.M. 2021).

- Each load of laundry can emit up to 18 million microfibers (Ocean Conservancy, 2024).
- Annual estimates of plastic microfiber pollution entering the ocean is equivalent in weight to more than 50 billion plastic bottles (Ellen MacArthur Foundation, 2017).

Motivated by the desire to address the problem of microplastic pollution from textiles, the inventors spent four years researching and developing a safe chemistry that enables polyester to biodegrade in environments where textile fibers are prolific pollutants, while maintaining durability and recyclability. Two major design considerations were that 1) the solution must work within the existing massive and highly fragmented global supply network, and 2) it could be blended with virgin or recycled polyester.

Biodegradable plastics are not a silver bullet solution for the plastic pollution crisis but can be beneficial in cases like durable textile applications where plastic is unavoidably leaking into the environment and cannot feasibly be recovered. Textile Extended Producer Responsibility (EPR) legislation in Europe and California is requiring that the industry revolutionize and lessen its impact on the environment. Now is the time to consider implementing all incremental improvements during remanufacturing. As these EPR schemes take effect, industrial manufacturers, retailers and brands can easily and affordably integrate CiCLO® polyester fibers made from textile waste into their products. Recycled, recyclable, and biodegradable polyester is no longer just a vision for the future—it is a reality today, shaping the next generation of sustainable textiles.

Current State of the Technology Industry Uses

Having launched in 2017, CiCLO® technology is fully commercialized and scaled globally. Well over 100 Million pounds of CiCLO® polyester have been produced to date, with roughly half being made from recycled polyester.

CiCLO® chemistry is available in the form of pellets for batch fiber production and liquid formulations for use on continuous polymerization (CP) fiber manufacturing lines. Currently, polyester made from recycled raw materials (mostly bottle flake) is produced on batch lines. The majority of virgin polyester is run on CP lines, but as EPR schemes take effect and large volumes of textile waste are recycled through chemical processes, polyester made with recycled monomers will become more available from CP lines.

Formulations are manufactured in the USA and Asia, and sold exclusively to CiCLO® Certified Manufacturers (CMs) of polyester in all major textile fiber producing countries around the world. CMs protect the IP, certify the quality of the fiber they produce and participate in a traceability program to confirm that the CiCLO® chemistry has been properly dosed. There are currently about 50 CMs throughout the world who supply CiCLO® polyester staple fiber or filament yarn to any interested downstream yarn spinners or fabric mills, amounting to several hundreds of textile mills using CiCLO® polyester, and growing.

Consumer products made with CiCLO® have been in retail stores since 2020. Billabong was the first brand to market with boardshorts made from CiCLO® recycled polyester. Other notable retailers and brands using CiCLO® include McDonald's uniforms, Target, Costco, Macy's, Bloomingdales, Walmart, Champion, Hanesbrands, Nautica, Lucky Brand, Oakley, Landau and Barco.

Applications extend beyond apparel and consumer goods into things like flags and soft signage. For example, as part of a project themed "Only One Earth", a collaboration between UNEP and The Climate Museum, the 193 flags flying at Rockefeller Plaza were printed on CiCLO® polyester in honor of Earth Day in April 2022 (Phair, M. 2022). Some of the enormous banners that hang in front of the NY Stock Exchange when a company goes public have also been printed on CiCLO® polyester. Furthermore, multiple organizations are working on developing durable, recyclable and biodegradable netting for marine applications using CiCLO® technology.

Use cases for CiCLO® polyester are endless; Because the chemistry maintains durability and recyclability and can be combined with virgin polyester, recycled bottle flake or textile waste, it is a drop-in replacement for conventional polyester anywhere it is used today.

Technology Approach

General Approach

CiCLO® is a biomimetic technology that leverages the power of living microbial systems in their native environment to biocycle polyester fibers into their basic natural elements. Biodegradation studies were conducted using widely adopted ASTM Test Methods to determine the rate and extent of biodegradation in conditions that simulate environments where synthetic fibers are prolific pollutants including aerobic sea water and soil conditions, and anaerobic digesters where wastewater treatment plant sludge is treated. Data obtained from long-term third-party lab studies demonstrates that CiCLO® polyester fibers are fully metabolized by microbes within 2.6 to 3.7 years. In contrast, comparable non-CiCLO® polyester fibers tested in parallel under identical conditions remain refractory and relatively untouched by microbes.

Key to the overall approach was designing a biodegradable technology that also meets the stringent requirements of textile fibers sourced by major brands and manufacturers, which are discussed in the following sections.

Compatibility with Batch & CP Fiber Manufacturing with No Loss of Durability

As mentioned, CiCLO® chemistry is adapted for both batch and CP fiber manufacturing processes, making CiCLO® polyester accessible to spinners, fabric mills and brands from many fiber suppliers around the world. CiCLO® formulations use a biophilic polymer recipe consisting mainly of organic macromolecules that are somewhat similar in structure and properties to PET. Of note, the ingredients do not include enzymes, or metal salts like oxo-degradable technologies that are intended to make plastics oxidize quickly in the environment.

The presence of CiCLO® makes the molecular structure of the base material accessible for microbes to digest, or biodegrade, yet is intentionally designed in such a way that the technical performance characteristics of the polyester are not compromised. In addition to the active ingredients being similar to PET, desirable characteristics are maintained because CiCLO® is only embedded in the fiber at a low dosage of 1-2% by weight during fiber manufacturing. The low required dosage also makes CiCLO® polyester generally affordable.

As evidence of no loss of durability, the tables below compare CiCLO® polyester fiber to the exact fiber without CiCLO® that were manufactured on both batch and continuous polymerization lines. The fiber specification is a 1.2-1.3 denier x 38 mm length staple fiber, the most commonly used for spun yarn. We chose to illustrate this point with virgin polyester blended with CiCLO® instead of recycled polyester because the quality of recycled polyester can vary significantly and may skew the fiber comparison results.

Staple Fiber Characteristics Comparison for CiCLO® Polyester & Non- CiCLO® Polyester

Fiber Characteristic Measured	CiCLO® Staple Fiber Manufactured with Pellets In Batch Process	Comparative Non-CiCLO® Staple Fiber Manufactured by Same Supplier	CiCLO® Staple Fiber Manufactured with Liquid in CP Process	Comparative Non-CiCLO® Staple Fiber Manufactured by Same Supplier
Denier	1.36	1.37	1.24	1.22
Tenacity	5.77	5.84	6.38	6.41
Elongation	31.12	31.92	27.27	28.28
Crimp	12.62	11.80	14.46	13.71
Raw Fiber Color Values L*, a*, b*	91.76, 2.6, -17.7	91.64, 2.7, -17.31	93.29, 3.17, -16.55	93.68, 3.06, -16.28
Dyed Fiber Color Values L*, a*, b*	26.66, .72, -22.96	29.34, -.56, -28.9	25.14, 1.17, -26.06	26.89, .48, -27.33

The table above reflects characteristics of polyester staple fiber made with and without CiCLO® technology in both batch and continuous polymerization manufacturing processes. The inclusion of CiCLO® chemistry has no significant impact on the strength, fiber color or dyeability.

As further evidence, fabrics made with and without CiCLO® fibers have been subjected to The Microfibre Consortium (TMC) Test Method to determine the quantity of textile material losses from fabrics under standard

conditions which reflect those found in domestic laundering (TMC Test Method, 2021). The inclusion of CiCLO® has no impact on propensity for shedding (Figure 1). Additionally, studies have been conducted to confirm that the use of CiCLO® does not have any negative impact on fabrics when exposed to ultraviolet light for extended periods of time (Figure 2) (ASTM G154-16).

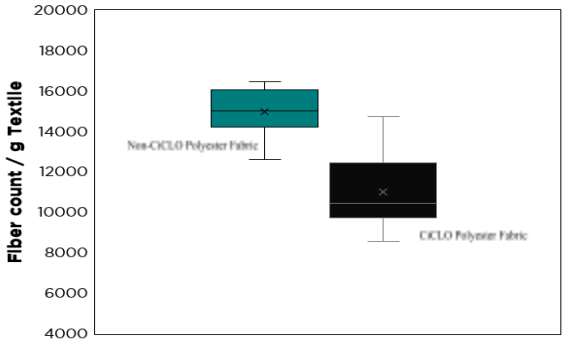


Fig [1] The Microfibre Consortium (TMC) Material Loss From Fabrics Test Method Results

100% polyester fabrics made with and without CiCLO® chemistry were compared using the TMC method to determine material loss under domestic laundering conditions. The fabric made with CiCLO® chemistry shed slightly less than the comparable fabric.

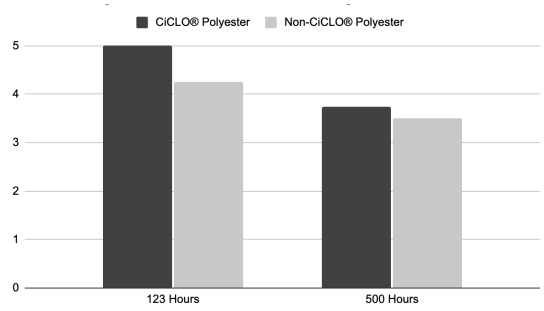


Fig [2] ASTM G154-16 Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure Test Results

Summary of study comparing CiCLO® polyester and non-CiCLO® polyester samples under UV light simulating outdoor exposure for 500 hours. On a scale of 1-5, the CiCLO® polyester performs slightly better than the comparison.

Complete Mineralization In Aerobic & Anaerobic Conditions At Varying Temperatures

Mineralization is synonymous with complete biodegradation. The biodegradation of polyester is a multistep process which, in a simplified explanation for the purpose of this paper, includes abiotic hydrolysis, chain scission, transformation of polymers to oligomers and simple chemicals through various mechanisms, and ultimately metabolic digestion by microorganisms. In the phase of metabolic digestion, the carbon content is utilized by microorganisms for energy, as measured by the respiration of carbon dioxide (CO^2) in aerobic environments and CO^2 plus methane (CH_4) in anaerobic environments. Therefore, assessing biodegradation of a given plastic first mandates quantitative measurements of the conversion of the plastic's carbon into CO^2 (or CO^2 and CH_4) (Zumstein, M.T. et al., 2019).

Standardized ASTM Test Methods that determine the rate and extent of biodegradation for plastics in various environments are conducted by third-party labs to prove that CiCLO® polyester biodegrades in comparison to the same material without CiCLO®. ASTM Test Methods are developed and adopted through consensus by volunteer technical committees representing academia and industry and are commonly used throughout industry and by labs including Bureau Veritas and Intertek.

Studies conducted in lab settings are well controlled and can be considered ideal and accelerated conditions to prove biodegradation is possible. In contrast, the natural environments where synthetic fibers end up as pollutants are uncontrolled and endlessly variably. The time it takes for *any* biodegradable material to fully biodegrade is largely dependent on the material characteristics including, but not limited to, surface area, morphology, crystallinity, and chemical finishes, and the actual environmental conditions. The value of lab testing is to demonstrate that microbial metabolism of polyester in aerobic and anaerobic conditions at various temperatures is made possible by CiCLO® technology, whereas polyester without CiCLO® remains refractory and persistent in the same conditions. Pollution is transient and it is impossible to know exactly how long it may take for microplastics to biodegrade without tracking the precise conditions. CiCLO® consumer marketing claims take this fact, as well as legal requirements for compliant marketing of biodegradable plastics, into account.

The tables below illustrate that per long-term ASTM Test Methods, CiCLO® polyester fully biodegrades (converts to CO^2 or CO^2 and CH_4) in waste water treatment plant sludge anaerobic digester conditions, aerobic ambient soil conditions, and aerobic sea water conditions (ASTM D5210 − 92) (ASTM D5988 − 18) (ASTM D6691 − 17). The material used in this case study was recycled PET blended with CiCLO® technology, further proving that the mechanism is effective on recycled polyester. Specifically, the samples are all 100% polyester microfleece fabrics made from recycled bottle PET with and without CiCLO® chemistry, dyed and then brushed into microplastics in the form of "microfibers" using a shedding tool to simulate how textiles pollute the environment.

CiCLO® Polyester & Non-CiCLO® Polyester in Waste Water Sludge — 2.6 years (952 days)

	Sludge Inoculum Blank	Cellulose Positive Control	CiCLO® Polyester	Non-CiCLO® Polyester
Cumulative Gas Volume (mL)	2190.3	10837.2	13815.6	866.8
Percent CH_4 (%)	41.2	44.5	53.7	49.4
Volume CH_4 (mL)	901.5	4818.0	7422.8	428.40
Mass CH_4 (g)	0.64	3.44	5.30	0.31
Percent CO^2 (%)	42.8	40.8	35.3	35.3
Volume CO^2 (mL)	937.6	4426.2	4874.4	306.3
Mass CO^2 (g)	1.84	8.69	9.57	0.60
Sample Mass (g)	10	10	10	10
Theoretical Sample Mass (g)	0.00	4.2	6.2	6.20
Biodegraded Mass (g)	0.99	4.95	6.59	0.390
Percent Biodegraded (%)	0.00	94.0	**89.9**	**-9.5 (0)**

Anaerobic municipal sewage sludge biodegradation study ASTM D5210 conducted at 35°C (95°F) for 952 days resulted in 89.9% (full) biodegradation for CiCLO® polyester and -9.5% (zero) biodegradation for Non-CiCLO®.

CiCLO® Polyester & Non-CiCLO® Polyester in Soil — 3.2 years (1,170 days)

	Soil Inoculum Blank	Cellulose Positive Control	CiCLO® Polyester	Non-CiCLO® Polyester
Sample Weight (mg)	300	1,000	400	400
Total Average C Recovered	2,700.3	3,052.6	2,925.5	2,689.4
Background Corrected		352.3	225.2	-10.9
Theoretical Carbon		442.0	247.2	247.6
Percent Biodegraded (%)		79.7	**91.1**	**-4.4 (0)**

Aerobic soil biodegradation study ASTM D5988 conducted at ambient temperatures for 1,170 days resulted in 91.1% (complete) biodegradation for CiCLO® polyester and -4.4% (zero) biodegradation for Non- CiCLO®.

CiCLO® Polyester & Non-CiCLO® Polyester in Sea Water — 3.7 years (1,362 days)

	Sea Water Inoculum Blank	Cellulose Positive Control	CiCLO® Polyester	Non-CiCLO® Polyester
Cumulative Gas Volume (mL)	14.00	90.61	130.78	18.76
Percent CO^2 (%)	91.81	91.34	94.84	92.64
Volume CO^2 (mL)	12.86	82.76	124.03	17.38
Mass CO^2 (g)	0.025	0.163	0.244	0.034
Sample Mass (g)		0.10	0.10	0.10
Theoretical Sample Mass (g)		0.04	0.06	0.06
Biodegraded Mass (g)	0.007	0.044	0.066	0.009
Percent Biodegraded (%)		88.74	**94.24**	**3.83**

Aerobic sea water biodegradation study ASTM D6691 conducted at 30 +/- 2°C (86 +/- 3.6°F) for 1,362 days resulted in 94.24% (complete) biodegradation for CiCLO® polyester and 3.83% biodegradation of Non-CiCLO®. See Figure 3.

Fig [3] Visual Inspection of ASTM D6691 Samples

In addition to CO^2 evolution data proving microbial digestion (biodegradation) of the CiCLO® polyester in sea water, the above image offers visual confirmation. Vessels labeled 1931 show the CiCLO® sample before and after 1,362 days in ASTM D6691. Sample 1930 is the comparative Non-CiCLO® polyester.

No Microplastics Leftover

Nanoplastics are a subset of microplastics typically characterized as one micrometer or smaller in size, which are not visible to the naked eye. To corroborate both respirometric and visual evidence of full biodegradation of the CiCLO® recycled polyester samples, further analysis using Pyrolysis Gas Chromatography Spectrometry (PYMS) was used to screen the leftover soil inoculum for the presence of residual microplastics. Some common soil contaminants were detected in both the soil blank and the soil that the CiCLO® samples biodegraded in. There was no evidence of microplastics observed in either sample.

Identification of thermal & pyrolysis degradation products in soil blank sample (never had plastic sample in it)

1st Heat (mins)	2nd Heat (mins)	Probable ID	CAS #	Comment
0.548		Benzene	71-43-2	Soil contaminants
	0.57	Toluene	108-88-3	Soil contaminants
0.676		Hexamethyl Cyclotrisiloxane	0541-05-09	Soil contaminants

PYMS identified only common soil contaminants in blank soil inoculum.

Identification of thermal & pyrolysis degradation products in soil that contained CiCLO® polyester for 1,170 days in ASTM D5988 and reported 91.1% (complete) biodegradation

1st Heat (mins)	2nd Heat (mins)	Probable ID	CAS #	Comment
0.578	0.468	Benzene	71-43-2	Soil contaminants
0.63	0.556	Toluene	108-88-3	Soil contaminants
0.684		Hexamethyl Cyclotrisiloxane	541-05-9	Soil contaminants

PYMS identified only common soil contaminants, which were also found in the sample of the soil blank. No evidence of the presence of PET was detected.

Non-Toxic to Marine & Plant Life

CiCLO® chemistry is certified safe for use by OEKO-TEX® ECO PASSPORT, an independent, multi-stage testing and certification system for chemicals, colourants and auxiliaries used to manufacture textiles. The process verifies that chemical products and their ingredients meet specific requirements for safety, sustainability and regulatory compliance (Hohenstein, 2025).

Additional independent tests have been conducted to confirm that the process of CiCLO® polyester biodegrading in seawater (Figure 4) and soil (Figure 5) are non-toxic to marine and plant life.

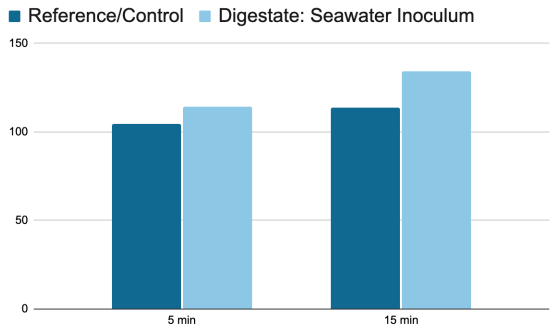


Fig [4] Microtox Bioluminescence Marine Toxicity Test Method

Test performed with ASTM D6691 seawater inoculum that contained CiCLO® polyester for 733 days, achieving 76.3% biodegradation. Measurement of the bioluminescence of the indicator Vibrio fischeri bacteria shows no drop compared to seawater alone, concluding no inhibitory effect as evidence of non-toxicity.

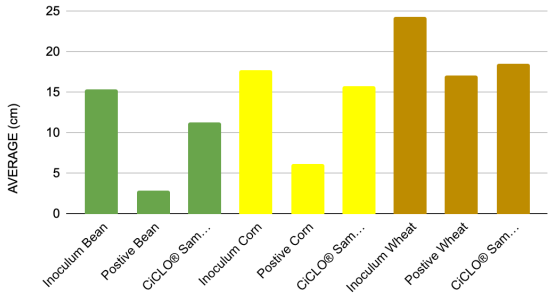


Fig [5] ASTM E1963 Terrestrial Plant Toxicity As Measured By Epicotyl Length

Test performed with residual soil inoculum that contained CiCLO® polyester for 1,170 days, achieving 91.1% biodegradation. Measurements of epicotyl length of bean, corn and wheat embryo plants after subjection to substance for 14 days indicate no retardation or mutations, concluding no inhibitory effect as evidence of non-toxicity.

Of importance, no plastics should be designed to be intentionally littered in nature and non-toxicity is not an indication of "good" for the environment. The purpose of these studies is to provide evidence that when polyesters containing CiCLO® chemistry inevitably end up polluting the environment, there is no additional risk of toxicity to marine or plant life. Independent of the use of CiCLO®, fibers and fabrics finished with toxic chemistries will present their own challenges when they pollute the environment and their use should always be avoided.

Fiber Traceability

Polyester fibers made with CiCLO® technology are fully traceable through an intentional business model of controlled distribution and end use applications. CiCLO® pellets and liquid formulations are only sold to CiCLO® Certified Manufacturers (CMs) of fiber and yarn. CMs are legally bound to protect the IP (ie, prohibited from reselling chemistry), ensure the quality of the fiber they produce, and participate in the CiCLO® traceability program. Samples of every lot of polyester made with CiCLO® are third-party validated for correct dosage rate, and CMs are issued a CiCLO® Certificate of Authenticity (CCOA) for every production lot. Infrastructure is also being set up in multiple locations around the world to quickly detect CiCLO® in finished fabrics. End product manufacturers must furnish CCOAs and execute a marketing agreement to use the CiCLO® brand and claims of "reduction of synthetic microfiber pollution" on consumer products. Of note, consumer products made with CiCLO® may not be labeled as "biodegradable" and all marketing must adhere to strict guidelines.

Fabric Recyclability

CiCLO® polyester fabrics are compatible with mechanical and chemical textile recycling processes. In a mechanical process where fabrics may be shred and/or melted to form new materials, the survival and further efficacy of the active ingredients that enable biodegradation need to be considered on a case-by-case basis depending on the specific recycling process, but in any case does not hinder recyclability.

In chemical processes like glycolysis that recycle materials back to monomers to be used in the creation of new materials, there are steps that separate the myriad of "contaminant" chemistries frequently used in polyester. Common functional additive chemistries that are considered contaminants are titanium dioxide, optical brighteners, fabric finishes and dye pigments. CiCLO® active ingredients will also be separated and removed during this step. New polyester produced with the recycled monomers needs to be dosed with CiCLO® for the new fiber to possess the inherent characteristic of biodegradability.

Discussion

The research covered here was conducted over many years to prove that CiCLO® chemistry safely and effectively enables both virgin and recycled polyester to biodegrade in environments where microplastics that shed from textiles (synthetic microfiber pollution) are known to be prolific pollutants. Using scientific test methods, CiCLO® polyester is proven to fully biodegrade in lab studies within 2.6 to 3.7 years under various environmental conditions, in comparison to conventional polyester which remains refractory.

Considering that the rate of biodegradation of any material is largely dependent on material characteristics and environmental conditions, lab results can generally be considered as accelerated. “Real life” conditions are endlessly variable and in the case of transient fugitive microplastic pollution, actual conditions are also unknown. Nonetheless, CiCLO® polyester can biodegrade completely and at greatly accelerated rates when it unavoidably leaks into the environment. Ultimately, CiCLO® polyester is non-persistent and contributes to the reduction of microplastic pollution, a growing global crisis.

Adoptions of this innovative technology are strong and growing. However, the topic of biodegradation is complex and progress can be slowed by misperceptions about “reasonable” timeframes for complete biodegradation and general misunderstandings about how true biodegradation (versus disintegration) is measured.

For example, there is a common misconception that a material must fully biodegrade within a specific timeframe for the characteristic of biodegradation to be beneficial. Legacy ideas about what designates a “reasonable” timeframe may come from confusion with commercial compostability requirements for biodegradable plastics (unrelated to textiles), as well as consumer protection efforts like the US Federal Trade Commission’s Green Guides for marketing claims. The Green Guides state that biodegradable claims “should have competent and reliable scientific evidence that the entire item will completely break down and return to nature within a reasonably short period of time after customary disposal”. The reasonably short period of time is defined as “within one year.” (eCFR, 2025) This threshold was erroneously based on results of a consumer perceptions survey where “60 percent of respondents expected that an item marketed as degradable will fully decompose in less than one year” (The Green Guide Statement of Bias & Purpose, 2012). This is an unrealistic expectation and not determined based on scientific evidence. Yet, it holds considerable weight because it is noted in an official government document and has consequences well beyond the intent of the marketing guidelines. Greater consideration should be given to materials that are safe and non-persistent in the environment, and biodegradation expectations should be based on science not uninformed perception.

Conclusions & Recommendations

Recent textiles EPR legislation is fast-tracking the development of the necessary infrastructure and technologies to make circular textiles a reality in the coming years. The entire industry will be going through a revolution and now is the time to thoughtfully and aggressively implement innovations that can help produce the most environmentally responsible recycled outputs. Manufacturers should not be satisfied with circular systems that make more of the same; remanufacturing is an opportunity to make things better. Recycled polyester textiles can and should include CiCLO® technology to reduce the persistence of fugitive microplastic pollution, while maintaining the durability and recyclability characteristics that largely drive the use of synthetics in the first place.

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