Material Testing Protocols

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TOM FORD Plastic Innovation Prize

INTRODUCTION

The following document outlines the laboratory and field tests conducted as part of the TOM FORD Plastic Innovation Prize (TFPIP). Designed as a straightforward guide for external stakeholders, the information included is intended to provide an overview of the testing methods utilized in TFPIP material testing to evaluate the environmental and service life performance of the materials submitted by TFPIP Finalists. Through the TFPIP, one of our aims is to catalyze further discussion about how to identify and evaluate alternative materials that may help address the issues caused by traditional, fossil fuel-based thin-film plastic.

Although the regulatory landscape for single-use plastics has evolved rapidly, how alternative materials fit within these frameworks lacks clarity in some cases. Similarly, there has been rapid growth in the universe of companies working to develop these alternatives to traditional fossil fuel-based plastics, but it is hard for the non-scientist to understand and evaluate their environmental credibility based solely on marketing claims. Even the scientific community is challenged in their ability to do so, in part because the majority of existing testing standards are narrowly focused on singular factors (e.g. toxicity) versus a holistic understanding of the material's end of life.

We believe that biologically degradable, marine-safe alternatives to traditional plastic are a critical tool to help turn the tide of plastic pollution. But we also recognize they are one solution among many, and their appropriateness depends on context, data, and an honest assessment of the dynamics of different use cases and systems. We hope that the work conducted as part of the TFPIP can help advance that dialogue and understanding. To facilitate that process, the Lonely Whale team is collaborating with the Prize testing partners on one or more methods papers that will document the evaluation methods utilized for the Prize, specifically the novel methods designed to help create a holistic picture of the environmental impact of alternative materials.

PRIZE OVERVIEW & CRITERIA

The TOM FORD Plastic Innovation Prize, a two-year competition followed by an accelerator support phase, is focused on the advancement of ***scalable and truly biologically degradable*** plastic alternatives that are capable of replacing thin-film plastic at scale in current supply chains. A $1.2 million Prize Purse was awarded in March 2023 towards three winning solutions that best achieved the Judging Criteria.

The TOM FORD Plastic Innovation Prize embodies three core strategic components as it seeks to catalyze the adoption of these desperately needed innovations:

Focus: Material Innovation Solutions for Thin-Film Plastic
The Prize specifically focuses on upstream replacements (new materials or packaging redesigns). While recycling technology, reusable solutions, and new business models are also critical, we believe the most impactful approach for solving the thin-film plastic crisis is through material innovation.

Validating Performance via Third-Party Testing
Competition Finalists submitted samples of their materials for rigorous third-party analysis against a set of testing protocols developed in conjunction with the Prizes' Scientific & Technical Advisory Board.

Facilitating Scale, Not Just Innovation
The Prize is designed to accelerate the trajectory of companies already working on new innovations that provide an alternative to traditional thin-film plastic, bringing visibility to the issue, vetting solutions, and facilitating scale.

The TOM FORD Plastic Innovation Prize was structured into two rounds occurring over approximately two years.

TECHNICAL SUBMISSION ROUND: Entrants first completed an initial Technical Submission, which was reviewed by the Scientific & Technical Advisory Board and the Judging Panel, who then selected a set of competition Finalists.

FINAL TESTING ROUND: Finalists submitted samples of their innovations for lab and field testing. The Scientific & Technical Advisory Board and Judging Panel used the results of these analyses, together with an 'Updated Submission' provided by each Finalist detailing additional information relevant to the three other judging criteria not assessed during the lab and field testing, to choose the Prize Winners.

Given the focus on scalable innovation and the use of lab testing to validate the performance of the materials submitted by competing teams, the innovations submitted to the competition were required to be beyond the idea stage at the time the initial submission was made. Innovations were required to at a minimum have a working prototype (TRL 4 and above).[1]

Outlined below are detailed descriptions of the judging criteria used to evaluate competition submissions. For the Final Testing Round, Lonely Whale collaborated with the Prize's testing partners (discussed below) and Scientific & Technical Advisory Board to define the detailed testing protocols, outlined later in this document, used to evaluate the product submissions provided by Finalists.

[1] https://www.nasa.gov/directorates/heo/scan/engineering/technology/technology_readiness_level

Prize Judging Criteria

JUDGING CRITERIA	DESCRIPTION
BIOLOGICAL DEGRADATION AT END-OF-LIFE	Materials must be capable of demonstrating soil and marine biological degradation under conditions that closely approximate natural environments. Biological degradation was evaluated under controlled soil and marine conditions, as well as in a field ocean environment. Analyses were conducted to examine the presence of toxicity and microplastics among the remaining mass. Note that materials that are designed to break down solely under idealized controlled conditions, such as industrial or home composting, will not meet this criteria.
ENVIRONMENTAL & SOCIAL IMPACTS OF PRODUCTION	Materials must minimize negative social & environmental impacts arising from their production. Materials were assessed against a set of environmental & social metrics to measure the impacts of production. Such measures included: ● Projected carbon cycle impacts ● Input feedstocks (e.g. biobased vs. non-biobased) ● Supply chain / raw material sourcing practices
PRODUCT PERFORMANCE	Products must align with industry standard performance specifications to ensure solutions are capable of meeting the technical requirements for packaging system integration and for consumer end-use. Performance criteria included: ● Strength ● Flexibility ● Water vapor transmission
SCALABILITY	Solutions must be scalable to meet the massive scope of the thin-film plastic pollution challenge. Factors affecting scalability include, but are not limited to: ● Raw material / feedstock input constraints ● Barriers to integrating materials within existing manufacturing operations ● Marketability and appeal to both brands and end consumers ● Minimization of unintended consequences for existing waste management systems
COST	Solutions must have a clear pathway to becoming reasonably cost competitive with traditional thin-film plastics.

The lab and field testing conducted during the final testing round focused on providing objective information regarding the attributes of Finalist materials in two areas of the judging criteria: Biological Degradation at End-of-Life and Product Performance. The tests conducted within each category are detailed below.

Towards the end of the testing period, Finalists were asked to submit an Updated Submission that provides additional information relevant to the three other judging criteria not assessed during the lab and field testing (Environmental & Social Impacts of Production, Scalability, and Cost). This document also provided an opportunity to provide additional contextual details relevant to the two criteria assessed during lab and field testing.

The results of the lab and field testing, together with the details contained in this Updated Submission, helped develop a comprehensive picture of each Finalist and their material and how it aligns with the holistic evaluation criteria of the Prize, forming the basis for the Prize Winner selection process.

Prize Timeline

Below is a high-level timeline for the Prize.

PHASE	DATES
SUBMISSION PORTAL OPENS	MAY 18, 2021
INITIAL SUBMISSIONS DUE	OCTOBER 24, 2021
SUBMISSION REVIEW	NOVEMBER 2021 - FEBRUARY 2022
ANNOUNCEMENT OF FINALISTS	MARCH 29 2022
DEADLINE FOR FINALISTS TO SUBMIT MATERIAL SAMPLES	MARCH 31 2022
TESTING OFFICIALLY COMMENCES	APRIL 14 2022
UPDATED SUBMISSIONS DUE FROM FINALISTS	DECEMBER 2022
REVIEW OF UPDATED SUBMISSIONS - SCIENTIFIC & TECHNICAL ADVISORY BOARD	DECEMBER 2022 - JANUARY 2023
TESTING CONCLUDES	JANUARY 16 2023
ALL TESTING RESULTS RECEIVED AND SHARED WITH SCIENTIFIC & TECHNICAL ADVISORY BOARD	FEBRUARY 8 2023
REVIEW OF TESTING RESULTS COMPLETED - SCIENTIFIC & TECHNICAL ADVISORY BOARD	FEBRUARY 15 2023
MATERIAL TESTING REVIEW SUMMIT - SCIENTIFIC & TECHNICAL ADVISORY BOARD & LONELY WHALE	FEBRUARY 17 2023
FINAL REVIEW MATERIALS SHARED WITH JUDGING PANEL	FEBRUARY 20 2023
REVIEWS COMPLETED & JUDGING SUMMIT - PRIZE JUDGES	FEBRUARY 28 2023
WINNERS ANNOUNCED	MARCH 9 2023
ACCELERATOR SUPPORT & SCALING INNOVATIONS	Q2 2023 - Q1 2024

OVERVIEW OF TEST METHODS

The testing component of the TOM FORD Plastic Innovation Prize encompassed experiments conducted in both the laboratory and in various field settings. Tests were conducted in partnership with two organizations: The New Materials Institute at the University of Georgia (NMI), and the Seattle Aquarium.

These Prize's evaluation methods were designed by NMI and the Seattle Aquarium in consultation with Lonely Whale to provide objective information regarding the attributes of Finalist materials in two areas of the judging criteria: Biological Degradation at End-of-Life and Product Performance. The Lonely Whale team worked closely with both testing partners throughout the testing process to monitor the testing process, including weekly and biweekly meetings during the final three months of the testing process.

The tests conducted within each category were as follows:

BIOLOGICAL DEGRADATION AT END-OF-LIFE

TEST METHOD	PURPOSE	TIMEFRAME
Respirometry - Soil inoculum	Degradation of materials over time under controlled conditions	April - December 2022
Respirometry - Seawater inoculum	Degradation of materials over time under controlled conditions	April - December 2022
Disintegration Photography	Visual analysis of degradation over the course of ocean exposure	April - December 2022
Raman Microscopy & Spectral Analysis - Field testing	Analysis of degradation of microscopic particles during ocean exposure	April - December 2022
Raman Microscopy & Spectral Analysis - Laboratory testing	Analysis of microparticles remaining after respirometry	January 2023
Germination	Testing for soil toxicity after respirometry	January 2023
Gray Whale Gut Simulation	Evaluating impacts on marine life from simulated material ingestion	April - December 2022

PRODUCT PERFORMANCE

TEST METHOD	PURPOSE	TIMEFRAME
Tensile Properties	Evaluation of strength and flexibility	Fall 2022
Water Vapor Transmission Rate	Analysis of water barrier properties of materials	Fall 2022

NMI led sample preparation, providing necessary samples to the Seattle Aquarium for testing and subsequent analysis. For tests conducted at both sites (e.g. disintegration photography), all efforts were made to ensure that measurement protocols were identical between the two sites. NMI cleaned samples provided by Finalists at the time they were received prior to conducting the lab-based tests, and each site cleaned samples to remove biofouling and other contaminants as part of the field testing conducted.

Finalists were provided with a detailed overview of each test to be conducted, and parameters for submitting their samples (weight, area, width, thickness, format). All samples were stripped of identifying information and assigned a unique identifier to ensure that testing partners are not aware of which material was submitted by which Finalist.

Taken as a whole, the Prize testing methods represent a rigorous and comprehensive set of assessments for alternative materials, particularly in regards to evaluating their potential impact on the environment. Many of the specific tests reflect brand new or emerging methods that are part of a broader push in the scientific community to develop better ways to understand and measure these impacts. To facilitate dialogue and understanding around these approaches, the Lonely Whale team is collaborating with the Prize testing partners on one or more methods papers that will document the evaluation methods utilized for the Prize.

DETAILED OVERVIEW OF TEST METHODS

BIOLOGICAL DEGRADATION AT END-OF-LIFE - TESTING METHODS
RESPIROMETRY - SOIL INOCULUM

PURPOSE	To understand the rate of degradation of materials over time in soil under laboratory conditions.
DESCRIPTION	This test method covers determination under laboratory conditions of the degree and rate of aerobic biodegradation of plastic materials, including formulation additives, in contact with soil. Carbon dioxide evolved by the microorganisms present in the soil is measured over time.
TESTING PARTNER(S)	New Materials Institute, University of Georgia
TESTING TIME FRAME	8 months, conducted April - December 2022
KEY DEPENDENT VARIABLE(S)	Conversion of organic C to CO_2 measured as a function of time
ALIGNMENT WITH EXISTING STANDARDS / TEST METHODS	• Modified ASTM D5988-18. This ASTM test method is equivalent to ISO 17556. • ASTM D6400
TEST MEDIUM / LOCATION	Fertile soil was collected from the surface layers of a field, forest, and meadow. Soil particles were sieved to < 2mm, and the resulting soil was mixed with 5mm sieved mature compost at a ratio of 1 g compost to 25 g soil. A total of 500 grams of prepared inoculum (C:N of between 10:1 and 20:1) was utilized in each respirometry chamber. A detailed analysis was conducted to determine the composition of the soil inoculum prior to beginning respirometry, measuring total solids, volatile solids, C%, N%, pH, and density. Total acid digestion and combustion method was used to determine trace metal content.
TEMPERATURE	25°C
FREQUENCY OF MEASUREMENT	Every 2-3 hours for 8 months
SAMPLE PREPARATION	Each respirometry chamber held a single square of film. Each sample material was tested in triplicate.
CONTROLS	• Control inoculum (empty chamber) • Type A cellulose powder (positive control) • LDPE film (negative control)
FURTHER DETAILS	The respirometer apparatus was set to about 200 mL/min air flow for each bioreactor and samples were incubated at 25°C for the duration of the test. Methane emissions were monitored to ensure aerobic conditions. Each soil inoculum was monitored weekly for moisture content and maintained at 40 +/- 10% moisture. Each soil inoculum was stirred weekly. At the end of the test, an aliquot of each triplicate inoculum was combined and saved for microparticle analysis.

RESPIROMETRY - SEAWATER INOCULUM

PURPOSE	To understand the rate of degradation of materials over time in seawater under laboratory conditions.
DESCRIPTION	This test method covers determination under laboratory conditions of the degree and rate of aerobic biodegradation of plastic materials, including formulation additives, exposed to an indigenous population of aerobic marine microorganisms in natural seawater. Carbon dioxide evolved by the microorganisms present in the seawater is measured over time.
TESTING PARTNER(S)	New Materials Institute, University of Georgia
TESTING TIME FRAME	8 months, conducted April - December 2022
KEY DEPENDENT VARIABLE(S)	Conversion of organic C to CO_2 measured as a function of time
ALIGNMENT WITH EXISTING STANDARDS / TEST METHODS	• Modified ASTM D6691-17 • ASTM D6400
TEST MEDIUM / LOCATION	Seawater was collected from the Atlantic coast of Georgia, off of St. Simons Island, sourced right after the apex of low tide. The seawater was aerated and temperature controlled during transport to the laboratory. Sterile, inorganic nutrients were added to each reactor at a concentration of 0.5 g/L of NH_4Cl and 0.1g/L $KH_2(PO_4)$. All bioreactor components were sterilized by autoclave prior to introduction to the inoculum. Samples were sterilized by either ethylene oxide or ethanol vapor. A total of 1.5L of prepared inoculum was utilized in each respirometry chamber. A detailed analysis was conducted to determine the composition of the seawater inoculum prior to beginning respirometry, measuring total solids, volatile solids, C%, N%, pH, and density. Total acid digestion and combustion method was used to determine trace metal content.
TEMPERATURE	30°C
FREQUENCY OF MEASUREMENT	Every 2-3 hours for 8 months
SAMPLE PREPARATION	Each respirometry chamber held a single square of film. Each sample material was tested in triplicate.
CONTROLS	• Control inoculum (empty chamber) • Type A cellulose powder (positive control) • LDPE film (negative control)
FURTHER DETAILS	The respirometer apparatus was set to about 400 mL/min air flow for each bioreactor and samples were incubated at 30°C for the duration of the test. Stirring and agitation of the water was accomplished by air displacement using custom reactor base assemblies to ensure aerobic conditions. Methane emissions were monitored to ensure aerobic conditions. At the end of the test, an aliquot of each triplicate inoculum was combined and saved for microparticle analysis.

DISINTEGRATION PHOTOGRAPHY

PURPOSE	To understand the process of degradation and fragmentation of materials over time in a field ocean environment.
DESCRIPTION	This test method uses high resolution photography to examine sample disintegration over time. Samples were suspended vertically in ocean water in nylon mesh bags. Any residual sample residues were documented at the end of testing.
TESTING PARTNER(S)	• New Materials Institute, University of Georgia • Seattle Aquarium
TESTING TIME FRAME	8 months, conducted April - December 2022
KEY DEPENDENT VARIABLE(S)	Samples must fully visually disintegrate by the end of testing or sooner.
ALIGNMENT WITH EXISTING STANDARDS / TEST METHODS	This method has been utilized in other published and unpublished studies conducted by the New Materials Institute.
TEST MEDIUM / LOCATION	Testing was conducted in coastal seawater in both the Atlantic and Pacific oceans. The Atlantic testing site is located in the Caribbean, while the Pacific testing site is located in the Pacific Northwest of the United States. Atlantic testing was conducted using a flow tank containing tidal surface water drawn from a depth of 3-4 meters. Pacific testing was conducted with samples suspended at depths of both 0.3 meters and 10 meters.
TEMPERATURE	To be determined via ongoing field temperature measurements
FREQUENCY OF MEASUREMENT	Weekly for months 0-2, biweekly for months 2-8, with the exception of the sheets of film samples (described below) tested at the Seattle Aquarium, which were sampled after 2, 4, and 8 months of exposure. This was due to concerns that the action of removing the film sheets from the 10 meter depth would artificially induce degradation, due to the force required to remove the sample apparatus.
SAMPLE PREPARATION	• Sheets of film samples (approximately 25x25 cm in size) were cut and suspended individually in nylon mesh sample bags. Samples were tested in triplicate for this method. • Sheets of film samples were cut into 5 cm squares and mounted in photographic film slides and suspended in nylon mesh sample bags. Samples were tested in singlet for this method.
CONTROLS	• Kraft paper (positive control) • LDPE film (negative control)
FURTHER DETAILS	Photography illumination conditions were controlled by the use of a photographic light box and gridded backgrounds. Lighting conditions were standardized across the two sites.

FIELD TESTING

RAMAN MICROSCOPY & SPECTRAL ANALYSIS

PURPOSE	To understand the process of degradation of materials at a microscopic level over time in a field ocean environment
DESCRIPTION	This test method evaluates the disappearance of samples in ocean waters using Raman microscopy and spectroscopy. Sample slides were withdrawn during testing and at the end of testing in field studies and sent to the laboratory for analysis.
TESTING PARTNER(S)	• New Materials Institute, University of Georgia • Seattle Aquarium
TESTING TIME FRAME	8 months, conducted April - December 2022
KEY DEPENDENT VARIABLE(S)	The disappearance of sample particles were monitored by Raman microscopy, assessing whether the microparticles surveyed by Raman microscopy return spectra that confirm the presence of the original sample spectrum (controlling for any precision errors in the measurement). The confirmation of positive Raman spectra for samples was at the discretion of the scientists (i.e. S/N > 5 for significant peaks).
ALIGNMENT WITH EXISTING STANDARDS / TEST METHODS	This methodology is based on analytical methods described in Environ. Sci. Technol. 2021, 55, 17, 11646–11656
TEST MEDIUM / LOCATION	Testing was conducted in coastal seawater in both the Atlantic and Pacific oceans. The Atlantic testing site was located in the Caribbean, while the Pacific testing site was located in the Pacific Northwest of the United States. Atlantic testing was conducted at a tidal surface location. Pacific testing was conducted at depths of both 0.3 meters and 10 meters. Due to equipment issues at the Pacific site, the slides were exposed and collected, however the slides were not analyzed. The slides from the Pacific site were provided to the New Materials Institute with the hope that they can be analyzed in the future.
TEMPERATURE	To be determined via ongoing field temperature measurements
FREQUENCY OF MEASUREMENT	Analyzed at 2 months, 4 months, and 8 months of exposure
SAMPLE PREPARATION	Film samples were cyroground, filtered with a 250µm sieve, and microparticles below 250µm were then affixed to glass microscope slides using a polyether epoxy. Samples were tested in duplicate for this method, at each time point.
CONTROLS	Polystyrene negative control microbeads were incorporated on the slides to account for the action of ocean physics
FURTHER DETAILS	Images of slides were taken on day 0 to calibrate future analyses. When sample slides were withdrawn from the field site, they were first immersed in a 70% ethanol solution.

LABORATORY TESTING

RAMAN MICROSCOPY & SPECTRAL ANALYSIS

PURPOSE	To analyze the presence of microparticles after controlled laboratory degradation (respirometry) from both soil and seawater.
DESCRIPTION	This test method evaluated sample residues from the end of both soil respirometry and ocean water respirometry for the presence of microparticle residues using Raman microscopy.
TESTING PARTNER(S)	New Materials Institute, University of Georgia
TESTING TIME FRAME	Conducted after respirometry concluded
KEY DEPENDENT VARIABLE(S)	The absence of remaining microplastic residues will suggest total sample disintegration below the detection limit of the method (approximately 20 microns).
ALIGNMENT WITH EXISTING STANDARDS / TEST METHODS	The New Materials Institute has developed a method to look for microplastics in compost that was adapted for use in the current study and is detailed in part here.
TEST MEDIUM / LOCATION	Testing was conducted on both soil and seawater inocula used as part of respirometry testing. The test media, etc. for those analyses are described above.
TEMPERATURE	Not applicable
FREQUENCY OF MEASUREMENT	Conducted after respirometry concluded
SAMPLE PREPARATION	Inoculum residues of the three replicate respirometry reactors were first combined and mixed well. Obvious large undegraded microparticles, if any, were manually sorted with tweezers and cleaned using the optimal cleaning methods (i.e. washing and sonication cycles in 8.25% NaClO). A small aliquot of the inoculum residue (of known mass) was digested (in NaClO, then H_2O_2 when needed). The digested material was centrifuged with the appropriate density separation solution (i.e. NaCl, NaI, $ZnCl_2$, corn starch, etc.) for the density of the test material. Particles of the appropriate density were collected by siphon and washed with copious water on a 3 micron nitrocellulose filter.
CONTROLS	LDPE film (negative control)
FURTHER DETAILS	Samples were analyzed with Raman microscopy directly on the nitrocellulose or desorbed using a compressed gas sample dispersion unit equipped on the instrument. A fixed number of external control particles of polystyrene (approximately 200-500 microns) were added to samples to ensure Raman spectroscopy targeting fidelity.

GERMINATION

PURPOSE	To determine if the sample material produces toxic residues as it degrades after controlled laboratory degradation in soil.
DESCRIPTION	The test assesses effects on corn seedling emergence and early plant growth following exposure to the test substance in the soil. Seeds were placed in contact with soil exposed to the sample material and evaluated for effects following 50% emergence of the seedlings in the control group.
TESTING PARTNER(S)	New Materials Institute, University of Georgia
TESTING TIME FRAME	Conducted after soil respirometry concluded
KEY DEPENDENT VARIABLE(S)	Emergence of >/= 70% of corn seedlings is required for a test material to be regarded as non-toxic to germination
ALIGNMENT WITH EXISTING STANDARDS / TEST METHODS	OECD 208
TEST MEDIUM / LOCATION	Testing was conducted on soil inocula used as part of respirometry testing. The test media, etc. for those analyses are described above. Approximately 2 kg of low carbon soil was used.
TEMPERATURE	22°C
FREQUENCY OF MEASUREMENT	Effects were examined 14 days after 50% seedling emergence in the control samples was reached.
SAMPLE PREPARATION	Soil residues from respirometry were utilized. Each material was assessed in triplicate.
CONTROLS	• Control inoculum (empty chamber) • Type A cellulose powder (positive control) • LDPE film (negative control)
FURTHER DETAILS	Humidity was set at 70%, up to a maximum of 95%. The photoperiod provided a minimum 16 hours of light. Light intensity was 350 + 50 $\mu E/m^2/s$, 20-50k lux, per Pallett et al. Seedlings were watered with 200mL of deionized water thrice weekly.

GRAY WHALE GUT SIMULATION

PURPOSE	This test was designed to answer the following questions: If sample materials were consumed by a marine mammal, would they be digested? Would they cause any harm to the animal?
DESCRIPTION	This analysis sought to model in a laboratory environment the performance of the sample materials if they were to be ingested by a marine mammal, in this case a gray whale. Materials were tested after multiple intervals of exposure to seawater as well as in an unexposed state.
TESTING PARTNER(S)	Seattle Aquarium
TESTING TIME FRAME	8 months, conducted April - December 2022
KEY DEPENDENT VARIABLE(S)	• Tensile strength • Mass loss • Electrical conductivity • Estrogenicity
ALIGNMENT WITH EXISTING STANDARDS / TEST METHODS	Not applicable - this test method has been developed by the Seattle Aquarium in conjunction with the prize.
TEST MEDIUM / LOCATION	Seawater exposure of films used in this test was conducted in coastal seawater in the Pacific Northwest of the United States at depths of both 0.3 meters and 10 meters.
TEMPERATURE	The temperature of seawater exposure ranged from approximately 8°C to approximately 14°C during the test period, with the 10 meter depth having a slightly lower peak temperature achieved. The laboratory portion of the analysis was conducted at 38°C.
FREQUENCY OF MEASUREMENT	Materials were tested at time zero (i.e. no exposure to seawater) and then after both 4 months and 8 months of exposure to seawater.
SAMPLE PREPARATION	Sheets of film samples were cut and suspended individually within porous metal mesh containers and then suspended in seawater using nylon mesh sample bags. Samples were tested in triplicate for this method at each depth and time.
CONTROLS	• Kraft paper (positive control) • LDPE film (negative control)
FURTHER DETAILS	A combination of low pH (acidic) conditions, physical mixing, elevated temperature and digestion enzymes created conditions similar to a gray whale stomach. Materials were tested under the following conditions: An aqueous solution of reverse osmosis water with pH of 5.25 (1N Hydrochloric acid) and 1% pepsin A was created, heated to 38°C and agitated using magnetic stir bars for 24 hours on heated magnetic stir plates. After 24 hours samples were tested for degradation.

PRODUCT PERFORMANCE - TESTING METHODS

TENSILE PROPERTIES

PURPOSE	To determine the strength and flexibility of sample materials and how they align with industry requirements for service-life performance.
DESCRIPTION	This test method covers the determination of tensile properties of plastics in the form of thin sheeting and films (less than 1.0 mm (0.04 in.) in thickness). Samples were tested on a universal tensile tester (Shimadzu, 1kN load cell) equipped with 1-inch rubber grips for thin plastic films. An initial grip separation of 4 inches (100 mm) was used.
TESTING PARTNER(S)	New Materials Institute, University of Georgia
TESTING TIME FRAME	Point-in-time; conducted in Fall 2022
KEY DEPENDENT VARIABLE(S)	• Tensile Strength at Yield • Tensile Strength at Break • Elongation at Yield • Elongation at Break • Tensile Modulus
ALIGNMENT WITH EXISTING STANDARDS / TEST METHODS	ASTM D882-18
TEST MEDIUM / LOCATION	Not applicable
TEMPERATURE	Room temperature, approximately 22°C
FREQUENCY OF MEASUREMENT	Point-in-time evaluation
SAMPLE PREPARATION	Testing was conducted on films without any environmental exposure. Films were cut into a “dogbone” for use on the testing machine. Films were tested in triplicate.
CONTROLS	LDPE film (negative control)
FURTHER DETAILS	The test specimens consisted of strips of uniform width and thickness at least 50 mm (2 in.) longer than the grip separation used. The nominal width of the specimens was not less than 5.0 mm (0.20 in.) or greater than 25.4 mm (1.0 in.). The rate of separation was calculated from the required initial strain rate.

PRODUCT PERFORMANCE - TESTING METHODS

WATER VAPOR TRANSMISSION RATE

PURPOSE	To determine the water barrier properties of sample materials and how they align with industry requirements for service-life performance.
DESCRIPTION	This test method covered a procedure for determining the rate of water vapor transmission through flexible barrier materials. The method is applicable to sheets and films up to 3 mm (0.1 in.) in thickness.
TESTING PARTNER(S)	New Materials Institute, University of Georgia
TESTING TIME FRAME	Point-in-time; conducted in Fall 2022
KEY DEPENDENT VARIABLE(S)	Measures the water vapor transmission rate through film samples. Reports water transmission rate in grams/m^2/day.
ALIGNMENT WITH EXISTING STANDARDS / TEST METHODS	ASTM F1249-20
TEST MEDIUM / LOCATION	Not applicable
TEMPERATURE	Tests were conducted at 37.8°C $^{+}$/- 1°C and 95% $^{+}$/- 5% relative humidity.
FREQUENCY OF MEASUREMENT	Point-in-time evaluation
SAMPLE PREPARATION	Testing was conducted on films without any environmental exposure. Films were tested in triplicate.
CONTROLS	LDPE film (negative control)
FURTHER DETAILS	The desiccant drying carrier gas was nitrogen (0.0001% relative humidity or lower) operating at 5-100 mL/min. Permeance was calculated as grams/(m2·day·mmHg) or an equivalent value.

Further Reading & Next Steps

The Prize's Competition Guidelines provide additional details about the structure and purpose of the competition. Please note that in a few cases, elements of the timeline and prize operations have evolved from this initial document, which was released at the time that the competition opened for submissions in May 2021. If any inconsistencies exist, the current document should be considered the most accurate representation of the activities conducted during the prize. The Competition Guidelines also includes details about the prize purse and the various stakeholders involved in the competition.

We recognize that a prize is not sufficient, in and of itself, to create a dramatic shift in the utilization of traditional, problematic plastics. To that end, our team will conduct an accelerator phase with Prize Winners to help bring visibility to their work, provide advice and mentorship to their leadership team, support engagement with manufacturers within the plastics value chain, and continue to engage with forward-thinking brands, including those from among the Prize Early Adopter Coalition, who are seeking to displace fossil fuel-based thin-film plastics from within their supply chains. Through these efforts, and by elevating companies with innovations that have the potential to replace these plastics at scale, our hope is to play a role in changing the troubling trajectory of traditional single-use plastics and to advance the dialogue and awareness around biologically degradable alternatives.

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