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Contents

EMERGING TECH RESEARCH

Unwrapping Sustainable Packaging

Novel materials aim to replace plastic

PitchBook is a Morningstar company providing the most comprehensive, most accurate, and hard-to-find data for professionals doing business in the private markets.

Key takeaways

- An estimated 82.2 million tons of containers and packaging are generated annually in the US, much of it made from plastic that ends up in landfills or as pollution.
- Novel materials and circular economy schemes are emerging to offer sustainable alternatives to plastic packaging. Sustainable packaging products are biodegradable, compostable, returnable, and even edible depending on the material.
- VC investment in sustainable packaging providers has grown steadily over the past decade, peaking at $834.4 million across 87 deals in 2021, with deal count up 58.2% YoY.
- We identify and explain 10 different categories of sustainable packaging and segment 120 startups across these various product types.

Overview

Plastic packaging is an essential component of the food system, providing an affordable and convenient vehicle to store, transport, and consume food. While usage has ballooned since its introduction in the 1940s, plastic packaging has harmful environmental, health, and economic impacts. These negative outcomes are prompting more demand among various stakeholders from consumers to governments to shareholder groups to reduce plastics use. At the same time, new tech-driven processes are opening the door to a wide range of alternative packaging products that offer similar benefits to plastic, though current offerings do not reach price parity. As a result, several packaging companies have emerged in recent years in pursuit of the potentially lucrative opportunity to develop technologies and materials that address the most significant problems associated with plastic. While consumer preference for sustainable packaging is likely to help drive market growth, we believe further regulatory actions will be necessary to create the tipping point that reduces plastics consumption.

Customers of packaging and packaging inputs can be grouped into three categories based on use case:

- Major packaging companies that source plastic resins and other inputs to manufacture packaging
- Consumer packaged goods (CPG) companies that source finished packaging to package food and beverages for retail
- Restaurants and cafes that source finished packaging for takeaway

It is estimated that $348.1 billion is spent annually in the provision of plastic-based products,[1] representing a significant market opportunity for companies that can introduce environmentally friendly alternatives at competitive prices. Year to date, we have tracked 47 companies that have raised $566.0 million in VC funding to develop sustainable packaging products. These startups focus on several different market opportunities, with a primary differentiator being the material inputs used in the production process—such as bioplastics, seaweed, mycelium, and fibers. While we expect that venture investment will continue to flow into this space, we have not recorded significant exit activity among sustainable packaging startups. The key exits we have recorded include Origin Materials and Danimer Scientific, both of which went public via SPAC merger.

1: "Plastic Packaging Market Size, Share, Trends, Growth, Forecast 2021-2030," Vision Research Reports, March 2021.

Sustainable packaging VC ecosystem

Click to view the interactive market map on the PitchBook Platform.

Market map is a representative overview of venture-backed or growth-stage providers in each segment. Companies listed have received venture capital or other notable private investments.

Additives & enzymes

SAMSARA · Radical Plastics · INTROPIC materials

Circular economy

TBM · PATH · innerbottle · boomerang · Vytal · Boox · Algramo · (re)zip · Loop · GreenSpense · CLUBZERO

Edible materials

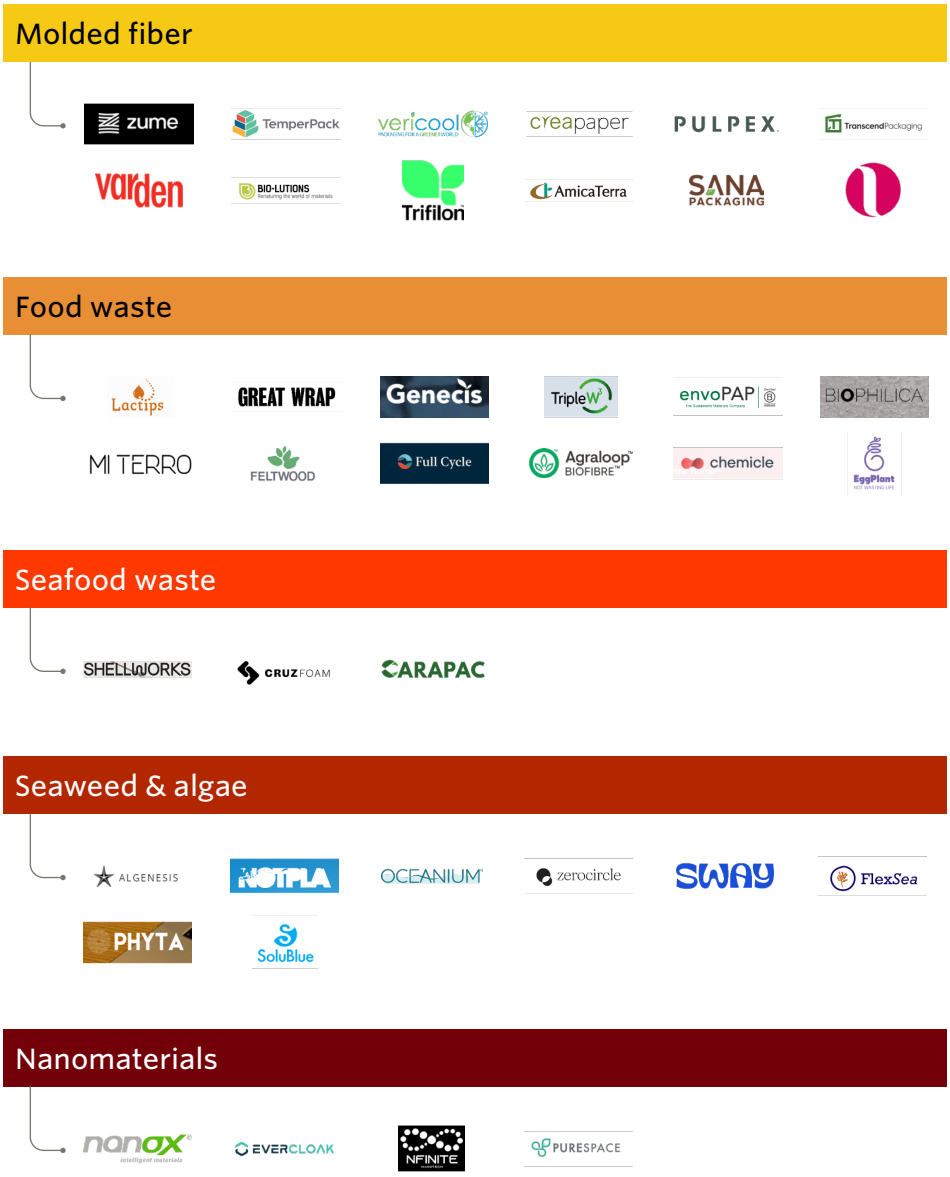
NATURE Bio · DECOMER TECHNOLOGY · incredible EATS · CUPFFEE · SAVEGGY

Mycelium

MYCOWORKS · ecovative · MAGICAL MUSHROOM COMPANY · MUSHROOM MATERIAL

Bioplastics

TIPA Compostable Packaging · NATRIFY A Sustainable Future · Xampla · ERT EARTH RENEWABLE TECHNOLOGIES · EVANESCE · SULAPAC · one • five · 숨쉬는 G구 · Repurpose. · WOODLY · SOLUTUM

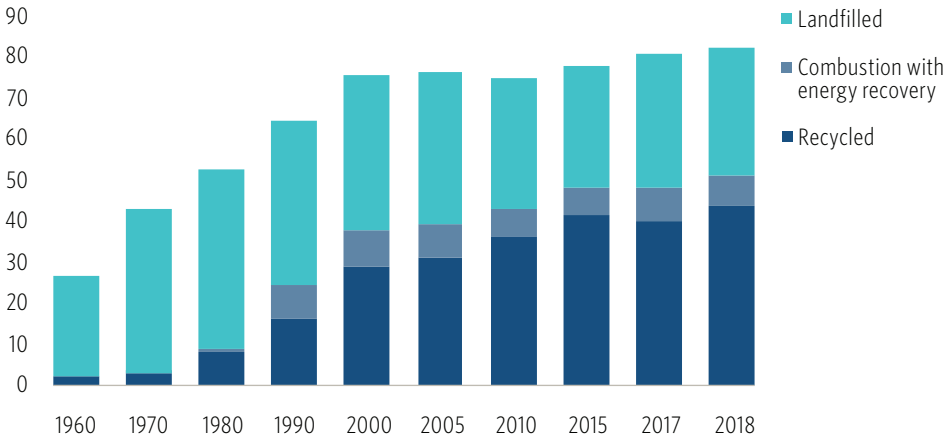


The costs of plastic

An estimated 82.2 million tons of containers and packaging are generated annually in the US. This includes packaging made from paper, glass, plastics, and other materials, and much of it is single-use plastics like soda bottles and plastic grocery bags. The Environmental Protection Agency (EPA) estimates that 37.9 million tons, or 46.1%, of packaging are either incinerated or sent to a landfill, although other sources cite much higher percentages.[2] The EPA does not provide statistics, but a substantial amount of packaging waste—much of it plastic—eventually makes its way into waterways; an estimated 8 million tons of plastic enter the ocean every year.[3] Although some types of plastic can break down into microplastics, plastics are not naturally biodegradable.

2: "Advancing Sustainable Materials Management: 2018 Fact Sheet," EPA, December 2020.
3: "Plastic Waste Inputs From Land into the Ocean," Science, Jenna R. Jambeck, et al., February 13, 2015.

Container and packaging weight (millions of tons) by disposal method



Source: EPA | Geography: US
*As of March 8, 2022

Plastic pollution contributes to the following social and environmental issues:

- **Entanglement & ingestion** – Marine life can get caught in or choke on plastic debris.

- **Economy** – Dirty beaches and coastlines can negatively impact tourism and recreation, spoiling the natural resources and aesthetics of environments that rely on natural beauty for tourism dollars.[4]

- **Human health** – Although research is ongoing, studies suggest that plastics have a negative impact on human health. Industrial chemicals, like BPA used to make plastics, negatively affect the brain and prostate gland.[5] Some plastics break down into microplastics or smaller pieces. These plastics have been found globally, from the highest mountain peaks to the bottom of the ocean floor.[6] Fish and other mammals inadvertently consume microplastics and are then eaten by humans. Likewise, microplastics are unconsciously consumed by humans through drinking water and even inhaled as dust. Early research indicates that microplastic exposure causes cell death, damage to cell walls, and allergic response.[7]

- **Climate change** – 94% of plastic is made from virgin plastic derived from fossil feedstock, including petroleum, natural gas, and coal. Plastic production contributes a sixth of global carbon dioxide emissions and 14% of oil demand.[8] Rising temperatures accelerate the breakdown of plastics into microplastics, and extreme weather events spread microplastics throughout the environment.

- **Consumer confusion** – In most countries, the onus of recycling is on the consumer. Although plastic packaging often includes recycling information, there are

4: "Why is Marine Debris a Problem?" NOAA, n.d., accessed September 27, 2022.
5: "What is BPA, and What are the Concerns about BPA?" Mayo Clinic, Brent A. Bauer, March 8, 2022.
6: "Reaching New Heights in Plastic Pollution—Preliminary Findings of Microplastics on Mount Everest," ScienceDirect, Imogen E. Napper, et al., November 20, 2020.
7: "A Rapid Review and Meta-regression Analyses of the Toxicological Impacts of Microplastic Exposure in Human Cells," National Library of Medicine, Evangelos Danopoulos, et al., April 5, 2022.
8: "Plastics and Climate Change—Breaking Carbon Lock-ins Through Three Mitigation Pathways," ScienceDirect, Fredric Bauer, et al., April 15, 2022.

different types of plastic formulations, and recycling facilities differ in processing ability, meaning some facilities cannot process packaging even though it appears to be recyclable. Additionally, some packaging contains multiple layers of differing materials—such as an aluminum can with a plastic liner—making recycling very difficult.

The benefits of plastic

To understand what it will take to successfully transition away from plastics, it is necessary to understand why plastics are so popular with customers like CPGs and retailers. Plastic offers key benefits that help explain its attractiveness as a packaging material:

- **Convenience** – Plastic packaging is lightweight, disposable, and transparent.

- **Protects and preserves foods** – Rigid plastic packaging can protect fragile foods through the supply chain or from the grocery store to the home. "Active packaging"—a term used to describe packaging with additional functionality beyond containment—can have antimicrobial or antifungal properties and control the amount of oxygen and carbon dioxide. Together, these attributes enable plastic packaging to extend shelf life and reduce food waste.

- **Low cost** – Plastic packaging is typically less expensive to produce than comparable products made from glass, paper, or other materials. For example, plastic straws typically cost $0.02 per item, compared with $0.05 to $0.12 for a paper equivalent.[9] Likewise, plastic packaging can be very lightweight compared to glass, metal, or paper, leading to lower transportation costs.

- **Attractive and versatile** – Plastic can be molded into any shape imaginable and is an ideal canvas for branding.

- **Durable and resistant to trauma** – Plastic is resistant to cracking and shattering. It performs well under hot and cold temperatures and maintains strength when wet.

Market size

The global plastic packaging market was estimated to be valued at $348.1 billion in 2020, growing at a 4.8% CAGR to reach $586.2 billion by 2030.[10] This estimate includes all packing applications; however, food & beverage applications are expected to exceed 51.0% of revenue share. Single-serve consumer packaging is cited as a major growth driver.

The majority of food & beverage plastic packaging can be attributed to a handful of household names. Coca-Cola is the largest user of plastic packing, producing 2.9 million metric tons (MMT) of plastic each year.[11] The company is also the largest polluter based on a global audit where branded packaging waste is collected and

9: "Paper or Plastic? Why the Answer Should be Neither," ReThink Disposable, Allie Molinaro, March 24, 2021.
10: "Plastic Packaging Market Size, Share, Trends, Growth, Forecast 2021-2030," Vision Research Reports, March 2021.
11: "Global Commitment Progress Report: Organization Report for 2020 Reporting Cycle - The Coca-Cola Company," Ellen MacArthur Foundation, 2020.

recorded.[12] Although 99% of its packaging is recyclable, much of it appears to make its way to city streets, rivers, beaches, and elsewhere. There is a clear breakdown of how packaging is processed after use. The following table provides an assessment of how leading CPG providers are designing packaging:

Key producers of plastic packaging and packaging design assessment

Company	New plastic packaging weight (MMT)	Plastic waste collected (pieces)	Reusable packaging	Recyclable	Compostable
Coca-Cola	2.9	19,826	1.7%	99.0%	0.0%
PepsiCo	2.4	8,231	0.0%	77.0%	0.0%
Nestlé	1.3	4,149	1.0%	60.0%	0.0%
Danone	0.7	3,223	4.8%	62.2%	0.0%
Unilever	0.7	6,079	0.0%	52.0%	0.0%
Colgate-Palmolive	0.3	941	0.0%	60.8%	0.0%
Keurig Dr Pepper	0.2	1,939	1.0%	50.0%	0.0%
Mondelez	0.2	2,065	0.0%	5.0%	0.0%
Mars	0.2	961	0.0%	21.7%	0.0%
Diageo	N/A	Unknown	0.0%	66.8%	0.0%

Source: Ellen MacArthur Foundation and Break Free From Plastic | Geography: Global

Sustainable packaging

There are a variety of types of packaging materials, including paper, glass, and aluminum, although plastic is the most prevalent. These materials are shaped into end forms including beverage bottles, cups and lids, cling wrap and films, liners that provide liquid or thermal barriers, and takeout containers.[13] Some sustainable packaging providers develop raw materials to replace plastic, while others manufacture the end packaging.

Plastic packaging is created from a variety of materials. Polyethylene Terephthalate (PET) is the most used base material, although there are many others, including Polyvinyl Chloride (PVC), Polypropylene (PP), and Polystyrene (PS), which is more commonly known by the popular brand name Styrofoam. Roughly 96% of plastic bottles and containers are made from PET.

Plastic packaging typically begins in the form of thermoplastic polymer resin, which are essentially plastic pellets. These pellets are melted down and injected into molds in the shape of the end packaging in a process called injection molding.

12: "Branded: Brand Audit Report 2021, Vol IV," Break Free From Plastic Movement, September 24, 2021.
13: "Sustainable Packaging Materials," FTW Ventures, Brian Frank, et al., n.d., accessed September 28, 2022.

Another process, extrusion molding, involves extruding the melted plastic into long tubes. Molds are clamped around the plastic tubing and air is inserted, expanding the plastic into the shape of the molds. Many food & beverage companies source finished packaging from third-party packaging companies. The largest injection molding providers by revenue in the US include Plastek Industries ($369.4 million), LexaMar ($106.9 million), and Jones Plastic ($313.4 million).[14] However, large CPG companies like Coca-Cola have dedicated bottling partners to manufacture their own bottles and packaging.

Sustainable packaging includes physical materials, as well as supply chain strategies that replace or reduce the use of virgin and single-use plastic. Biodegradable bioplastics,[15] natural materials, and upcycled materials offer a replacement for virgin plastics. Durable materials such as glass, metal, or even plastic can be returned, washed, and reused. Public policy and improved infrastructure will likely be essential to enable more materials to be recycled or returned for reuse.

The leading types of sustainable packaging include bioplastics, seaweed and algae, plastic additives, mycelium, molded fiber, and reusable materials.

Key sustainable packaging inputs

Input	Cost to produce	Manufacturing method	Scalability (Easy/Hard)	Benefit	Main use cases
Bioplastics	$2 to $7 per kilo. Expected to reach price parity with plastic	Procured from plants or other natural sources	Easy	End output (e.g. resin) similar to plastic. Easy to integrate into existing production streams	Industrial, consumer
Food waste	Varies based on waste stream	Varies	Hard	Compostable, low input cost	Cling film, foam plastic, bioplastic inputs
Molded fiber	Molded paper cups estimated to cost $2,333.0/ton	New or recycled fiber pulp is prepared, pressed into molds, and trimmed	Easy	Biodegradable, reduced labor and storage requirements	Cups, plates, cutlery, bottles
Mycelium	Expected to be cost comparable to PS	Grown using agricultural waste as a feedstock	Hard	Compostable, upcycles agricultural waste	Replaces PS packaging
Seaweed and algae	Likely costlier than plastic	Chemical and heat treated seaweed to extract polysaccharides	Hard	Edible, compostable	Cling film, bags, straws, cups

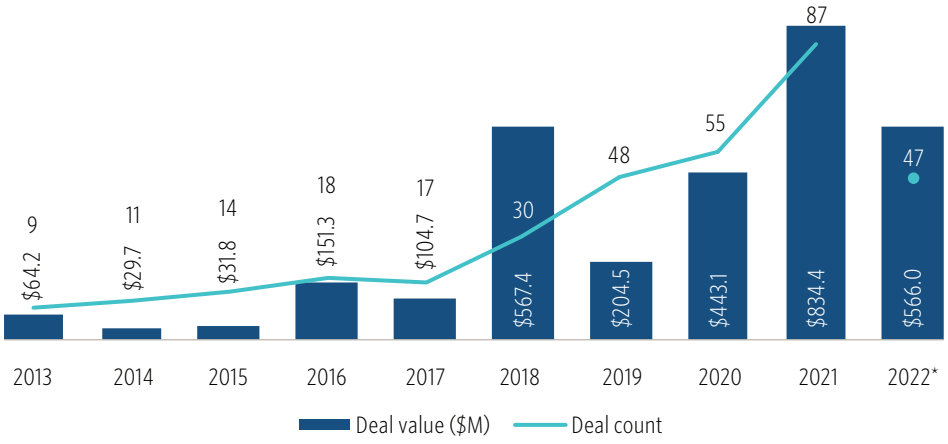
Source: Sparkoncept, FutureBridge, Matmatch, and Matter | Geography: Global

14: "Top 10 Plastic Injection Molding Companies in United States," *PlasticRanger*, Ashish Mittal, September 10, 2022.
15: Note: Not all bioplastics are biodegradable.

VC funding

VC investment in sustainable packaging providers has grown steadily over the past decade, peaking at $834.4 million across 87 deals in 2021, with deal count up 58.2% YoY. Sustainable packaging deal activity has waned in the first three quarters of 2022. At the end of Q3, deal activity totaled $566.0 million YTD across 47 deals, pacing for a significant decline from 2021 totals. We believe that investors may be exercising caution around a capital-intensive model with a long sales cycle. Scaling up sustainable materials production to meet global demand will require significant investment in infrastructure and supply chain optimization. A potential recession on the horizon is adding uncertainty to the market and would significantly diminish overall packaging demand and willingness to pay for premium-priced sustainable goods. Market volatility aside, we expect a continued increase in investment support for sustainable packaging companies over the long term. Regulatory support and corporate commitments will accelerate investment in the sector.

Global VC deal activity in sustainable packaging



Source: PitchBook | Geography: Global
*As of September 28, 2022

Bioplastics

Most plastic packaging is made from petroleum-based resin pellets or powders that are melted down and shaped. These resins can be modified or replaced with sustainable plant-based alternatives. Bio-resins that can replace petroleum-based resins without significant adjustments to production hardware and processes have a greater chance of successful adoption by packaging companies.

The generic name for plant-based plastics is "bioplastics," a term describing a broad spectrum of organic raw materials, some of which are combined with chemicals or petroleum to enhance performance. A key feature of bioplastics is its potential to eliminate or reduce petroleum-based plastic. Some food & beverage companies are shifting entirely to bioplastics and other sustainable packaging alternatives, while others are pursuing a combination of plastic and bio-based fibers or polymers. Bioplastics may have different performance characteristics than petroleum-based plastics; a hybrid approach allows companies to achieve desired functional traits while reducing overall plastic use.

Although bioplastics reduce reliance on fossil fuels, there are notable considerations at end of life. Bioplastics may not be any more biodegradable or compostable than petroleum-based plastic. And the addition of new bioplastic materials into the waste stream may complicate an already complex recycling process. Key VC-backed providers include TIPA Sustainable Packaging, Natrify, and Earth Renewable Technologies. These startups are facing off against packaging incumbents ramping up bioplastics offerings, including Danimer Scientific and NatureWorks, a joint venture between Cargill and PPT Global Chemical.

Key VC-backed bioplastic packaging companies

Company	Key products	VC raised to date ($M)	Most recent deal type
TIPA Sustainable Packaging	Hybrid fossil fuel and bio-based biodegradable films and packaging	$118.8	Series C
Natrify	Plant-based polymers and natural textiles	$50.0	Seed round
Earth Renewable Technologies	Sugarcane fiber-based packaging, trays, and cutlery	$22.7	Series C
Sulapac	Jars, straws, cuttlery, and resins	$17.6	Series A
GreenBio	Biodegradable resins used to replace plastics such as films, disposable containers, beverage cups, plates, and straws	$8.5	Series A
Solutum	Novel plastic material which completely dissolves and degrades in water	$4.5	Early-stage VC
erthos	Undisclosed	$4.3	Seed round
Smart Planet Technologies	Cups, cartons, trays, takeaway boxes, labels, and bags	$4.0	Late-stage VC
Humble Bee Bio	Sustainable textile coating	$3.4	Series A

Source: PitchBook | Geography: Global
*As of September 28, 2022

Seaweed and algae

Providers are developing bioplastics from seaweed and algae. Both are attractive as a sustainable material because they grow rapidly, sequester atmospheric carbon, and require no fertilizer. At its end of life, seaweed and algae-based packaging are often able to biodegrade in a matter of weeks. The most common packaging using these materials include cling film, bags, straws, and cups. This material is very early stage and not yet widely available. Key providers include Notpla, Loliware, and Oceanium.

Key VC-backed seaweed and algae-based packaging companies

Company	Key products	VC raised to date ($M)	Most recent deal type
Notpla	Sachets, coatings, takeaway boxes, and films	$20.5	Series A
Loliware	Seaweed pellets, three straw types, utensils, and films	$14.2	Series 2
Oceanium	Undisclosed	$3.9	Seed round
Algenesis	Bioplastics and foams	$3.2	Late-stage VC
Zerocircle	Flexible packaging and transparent films	$3.0	Seed round
Sway	Flexible packaging	$2.5	Early-stage VC
Flexsea	Biopolymer material used to make bioplastics	$0.3	Early-stage VC

Source: PitchBook | Geography: Global
*As of September 28, 2022

Plastic additives

Instead of replacing plastics with sustainable materials, plastics can be modified to biodegrade. Although the science is nascent, companies and research institutions are developing enzymes that "eat" or break down plastic. The startup Intropic Materials has developed an enzyme that can be embedded into the plastic. When the plastic is exposed to water and heat above 104 degrees Fahrenheit, the enzyme activates, triggering the plastic to self-degrade. Other companies working on similar concepts include Samsara Eco and Radical Plastics.

Mycelium

Mycelium is another organic material that some providers use to replace PS. This material traditionally serves as cushioning in packages. Mycelium can be thought of as the rootstock of fungi and mushrooms. It can be molded, grown rapidly and inexpensively, and is lightweight, making it a close substitute to PS. Additionally, mycelium is hydrophobic—meaning it repels water—and unlike PS, it's biodegradable and flame resistant. Key providers include Magical Mushroom Company, Ecovative Design, and Mushroom Material.

Key VC-backed mycelium-based packaging companies

Company	Key products	VC raised to date ($M)	Most recent deal type
MycoWorks	Leather-alternative	$187.0	Series C
Ecovative	Alternative to PS	$97.4	Series D
Magical Mushroom Company	Alternative to PS	$4.1	Seed round
Mushroom Material	Alternative to PS	$0.2	Seed round

Source: PitchBook | Geography: Global
*As of September 28, 2022

Molded fiber

Packing materials are full of tradeoffs, including environmental. Consumers are offered the choice between plastic and paper bags at the grocery store. Many believe that paper is an environmentally superior choice, but it is not so clear-cut. Trees sequester atmospheric carbon, helping to counter carbon emissions. Tree harvesting eliminates this benefit, taking about 15 to 20 years to regrow trees to maturity. Producing paper bags requires 10% more energy and 4 times as much water as plastic, and heavier weight means greater fuel usage and transportation costs.[16] At the same time, paper packing is often much easier to recycle than plastic. Although wood-based packaging is the most common form of paper, new plant fiber alternatives are gaining popularity.

Startup creapaper manufactures hay pellets to produce grass paper. These pellets can be substituted for wood pulp as input to paper mills, minimizing new infrastructure requirements. Grass grows much quicker than trees and continues to grow after it is harvested. Pulpex, a joint venture between Diageo and Pilot Lite Ventures, is developing PET-free paper bottles to replace plastic and glass. The company says its products are fully recyclable and have a lower carbon footprint than plastic and glass.[17] Other VC-backed providers include Transcend Packaging, Varden, and Bio-Lutions.

Key VC-backed molded fiber packaging companies

Company	Key products	VC raised to date ($M)	Most recent deal type
Zume	Trays, can holders, and cups	$445.7	Early-stage VC
TemperPack	Thermal liners	$219.9	Series D
Vericool	Thermal liners	$28.8	Series A
creapaper	Trays and paper products	$27.6	Series B
Pulpex	Bottles	$26.3	Series B
Transcend Packaging	Straws, cups, and cutlery	$20.5	Early-stage VC
Varden	Undisclosed	$13.9	Series A
Bio-Lutions	Single-use packaging such as trays, cutlery, and lids	$13.1	Series B
Amica Terra	Cups, trays, straws, bottles, and cutlery	$5.5	Seed round
Sana Packaging	Packaging for the cannabis market	$2.8	Seed round

Source: PitchBook | Geography: Global
*As of September 28, 2022

16: "Paper or Plastic? Why the Answer Should be Neither," ReThink Disposable, Allie Molinaro, March 24, 2021.
17: "Diageo Announces Creation of World's First Ever 100% Plastic Free Paper-based Spirits Bottle," Diageo, July 12, 2020.

Food and seafood waste

One of the most sustainable types of packaging involves diverting waste from the landfill and repurposing it into packaging. Food waste packaging startups identify agricultural, food, and seafood waste streams with desirable attributes and develop sustainable packaging solutions. Startup Great Wrap is developing a compostable cling wrap made from the starch of potato waste. Startup Shellworks produces compostable biopolymers and natural dyes from shellfish waste and microbes. Other providers include TripleW, Cruz Foam, and EnvoPAP. A notable risk of these packaging companies is that they rely on stable waste streams. It may be challenging to scale if demand exceeds waste stream supply, and supply shocks and handling could create major headaches for producers.

Key VC-backed food waste-based packaging companies

Company	Key products	VC raised to date ($M)	Most recent deal type
Lactips	Biodegradable thermoplastic pellets from milk protein	$21.0	Series B
Great Wrap	Compostable stretch wrap made from potato waste	$16.4	Series A
Genecis	Biodegradable PHA plastic from food waste	$12.4	Series A
Shellworks	Plastic alternative upcycled from lobster shells	$7.1	Seed round
Cruz Foam	Shell-based plastic foam	$3.7	Series 1
Biophilica	Leather-like material from green waste	$1.9	Seed round
EnvoPAP	Paper packaging from discarded agricultural fibers	$1.9	Seed round
CuanTec	Films from shell waste	$1.9	Early-stage VC
Mi Terro	Hydrophilic biopolymers made from dairy waste	$1.5	Early-stage VC
Feltwood	Industrial materials and packaging made from upcycled vegetable fibers	$0.1	Angel (individual)

Source: PitchBook | Geography: Global
*As of September 28, 2022

Edible materials

If consumers are dead set on avoiding the landfill, some packaging companies are working on an even more sustainable option: edible packaging. Like an ice cream cone, Cupffee produces edible cups for coffee, yogurt, and other foods and beverages. The cups stay crunchy when wet and maintain form when filled with hot or cold beverages. Startup incrEDIBLE eats makes edible cutlery. The products are flavored and made from a variety of grains. Companies in this category have raised minimal venture funding and it is unclear if the model can gain widespread acceptance or will be resigned to fringe use cases.

Key VC-backed edible packaging companies

Company	Key products	VC raised to date ($M)	Most recent deal type
incrEDIBLE eats	Spoons and sporks	$0.5	Early-stage VC
Saveggy	Coatings	N/A	Early-stage VC
Nat4Bio	Coatings	N/A	Seed round
Cupffee	Cups	N/A	Angel (individual)

Source: PitchBook | Geography: Global
*As of September 28, 2022

Nanomaterials

Typical plastic packaging is made of multiple layers of plastic. More layers add strength but also add weight and can make recycling more challenging. Common paper, foil, and aluminum packaging like soda cans, chip bags, and milk cartons appear to be metal or paper, but almost always contain plastic liners to maintain freshness, prevent corrosion, and avoid imparting off-flavors to the food or beverage. Aluminum can coatings can sometimes be incinerated during the recycling process depending on the capability of the facility. However, many packages are too complex to separate and end up at landfills. Nanotech startups like Nfinite Nanotech are developing thin, sustainable coatings that provide the same performance benefits as plastic coatings but are biodegradable and enable packaging to be recycled or composted. Other VC-backed providers include Valentis Nanotech and Nanox.

Key VC-backed nanomaterial companies

Company	Key products	VC raised to date ($M)	Most recent deal type
Nanox	Antimicrobial coatings	$2.5	Seed round
Evercloak	Coatings	$0.8	Seed round
Valentis Nanotech	Polymeric films that replace aluminum foil	$0.7	Seed round
Nfinite Nanotech	Coatings	N/A	Seed round

Source: PitchBook | Geography: Global
*As of September 28, 2022

Circular economy

The ultimate sustainable solution to packaging waste is to stop creating and disposing of the waste entirely. Although not a new idea, reusable packaging relies on durable materials and sophisticated reverse logistics to return and clean packaging. Some companies are taking a half-step approach by packing food and beverages in higher-quality containers meant to be reused. Startup PATH is a bottled water company that uses sturdy aluminum water bottles that are recyclable and intended to be refilled and reused by consumers. A comprehensive circular economy approach involves educating consumers and investing in durable materials made to be reused and the infrastructure to return it for reuse. ClubZero is disrupting disposable restaurant packaging with reusable materials and logistics. Participating restaurants and cafes package food and beverages in proprietary containers. Consumers return the packaging to the point of purchase where they are cleaned and reused. On the retail side, startup Loop coordinates global circular supply chain efforts in partnership with major consumer brands such as Unilever, Kraft Heinz, and Danone. These companies sell products in reusable, durable containers. In some markets, these products are delivered to consumers. Empty containers are picked up and returned for cleaning and reuse. In other markets, consumers can buy Loop products at retail and return empty containers at the same point of purchase. Other key providers include Innerbottle, TBM, and Boomerang.

Key VC-backed circular economy companies

Company	Key products	VC raised to date ($M)	Most recent deal type
VYTAL	Reusable takeaway packaging and rental platform	$12.4	Series A
Innerbottle	Lined bottle and reuse platform	$11.3	Early-stage VC
Boox	Reusable shipping boxes and bags	$11.2	Series A
Algramo	Returnable packaging system	$10.3	Series A
Boomerang	Returnable water bottle system	$9.7	Seed round
Pyxo	Reusable takeaway packaging and rental platform	$8.0	Early-stage VC
Loop	Returnable packaging system	$6.7	Series A1
GreenSpense	Propellant-free continuous dispensing	$1.4	Late-stage VC
Olyns	Returnable packaging system	$1.0	Seed round
Reath	Returnable packaging system	$0.6	Seed round

Source: PitchBook | Geography: Global
*As of September 28, 2022

Top global VC-backed sustainable packaging companies

Company	VC raised to date ($M)	Post value ($M)	Most recent deal type	Country
Zume	$445.7	N/A	Early-stage VC	US
Genomatica	$401.5	$436.0	Series C	US
RWDC Industries	$263.1	N/A	Series B2	Singapore
TemperPack	$219.9	$600.0	Series D	US
UBQ Materials	$216.0	N/A	Series B	Israel
TBM	$208.5	$908.8	Late-stage VC	Japan
MycoWorks	$187.0	$450.0	Series C	US
TIPA Sustainable Packaging	$118.8	N/A	Series C	Israel
Natural Fiber Welding	$118.0	$330.0	Series B3	US
Ecovative	$97.4	N/A	Series D	US

Source: PitchBook | Geography: Global
*As of September 28, 2022

Key VC deals in sustainable packaging since 2020

Company	Deal size ($M)	Post value ($M)	Most recent deal type	Country
UBQ Materials	$170.0	N/A	Series B	Israel
TemperPack	$140.0	$600.0	Series D	US
RWDC Industries	$133.0	N/A	Series B1	Singapore
RWDC Industries	$95.1	N/A	Series B2	Singapore
TBM	$72.7	$908.8	Late-stage VC	Japan
TIPA Sustainable Packaging	$70.0	N/A	Series C	Israel
Ecovative	$60.0	N/A	Series D	US
Natrify	$50.0	N/A	Seed round	Egypt
MycoWorks	$45.0	$125.0	Series B	US
Checkerspot	$36.0	$121.0	Series B	US

Source: PitchBook | Geography: Global
*As of September 28, 2022

Most active investors in sustainable packaging VC deals since 2013

Investor	Investor type	Investment count	Country
Sky Ocean Ventures	Impact investing	9	US
Viking Global Investors	Hedge fund	8	US
Horizons Ventures	VC	7	Hong Kong
ImpactAssets	Impact investing	6	US
SOSV	VC	5	US
SJF Ventures	VC	5	US
Main Sequence Ventures	VC	5	Australia

Source: PitchBook | Geography: Global
*As of September 28, 2022

Regulations and corporate commitments

For sustainable packaging to succeed, it must offer most, if not all, of the benefits of plastic packaging at a comparable price. Today, single-use plastics provide consumer goods companies with a low-cost input that does not reflect its full external environmental costs. While alternatives are likely to remain more expensive than traditional plastics for the near future, policy changes can help bridge the gap by incentivizing the use of sustainable materials that are biodegradable, compostable, or capable of being processed through materials waste management programs.

Many countries have taken steps to discuss, study, or implement sustainable packaging regulations. Existing regulations include specifications such as the material composition, attributes such as biodegradability, and end-to-end supply chain specifications which include raw material sourcing and recycling targets.[18] According to the UN, 127 countries have adopted legislation to regulate plastic bag usage, and 27 have enacted bans on single-use plastics.[19]

In the US, packaging is regulated by the Food and Drug Administration (FDA), the EPA, and many local and state-level regulators, such as the California Department of Resources Recycling and Recovery. Over 100 cities have instated regulations to ban PS containers and utensils.[20] Other regulations include bans on plastic bags and utensils, as well as harmful materials such as heavy metals. The chemical BPA is used to make polycarbonate, a type of hard, clear plastic, as well as epoxy resins used to line food and beverage containers. The material was determined to be a harmful endocrine disrupter. Over 30 states, including Minnesota and Connecticut, ban the material in food packaging, however, the FDA considers BPA safe at current levels.[21]

18: "Sustainability in Packaging: Global Regulatory Development Across 30 Countries," *McKinsey & Company*, Celine Cherel-Bonnemaison, et al., February 7, 2022.
19: "Legal Limits on Single-Use Plastics and Microplastics: A Global Review of National Laws and Regulations," UN Environment Programme, Carole Excell, et al., December 5, 2018.
20: "US Packaging Regulations," Qorpak, n.d., accessed October 10, 2022.
21: "Bisphenol A (BPA)," FDA, June 27, 2018.

Regulations and advocacy from shareholders and consumers have led some large global food companies to address plastic packing use. Many companies have committed to increasing their use of sustainable packaging materials by 2025 or 2030. These include PepsiCo, Nestlé, and Mars, which each committed to transitioning to 100% recyclable, reusable, or compostable packaging by 2025; Unilever, which committed to transitioning 25% of plastic packaging to sustainable alternatives by 2025; and P&G, which committed to reducing virgin petroleum plastic by 50% by 2030.[22]

Coca-Cola has detailed the steps it is taking to transition to sustainable packing, including:

- Transitioning to bottles made from 100% recycled plastics instead of virgin plastic
- Using clear plastic instead of green to improve recyclability
- Using recycled plastic made from recovered ocean and river plastic
- Developing bottles that combine virgin plastic with plant-based and recycled plastics
- Producing media campaigns to encourage recycling[23, 24]

Other movements, such as the recently announced Business Coalition for a Global Plastics Treaty, are putting pressure on corporations to align business practices around reduced plastic consumption.[25] The coalition brings together 85 businesses to accelerate progress toward circular economy practices. Such coordination among stakeholders may be necessary given the complexity of redesigning packaging supply chains to be more sustainable.

Shareholder activism has been an important driving force behind corporate commitments. Numerous proxy proposals for major public consumer goods companies have cited findings from a 2020 report, Breaking the Plastic Wave, by Pew Charitable Trusts that forecasts a tripling of ocean plastics by 2040, even with existing commitments.[26] So far in 2022, shareholder advocacy group As You Sow Foundation and environmental, social, and governance fund administrator Green Century Management have sponsored over 15 proxy resolutions to address plastic packaging, targeting companies including Coca-Cola, Kraft Heinz, and Kroger.[27] Although some of these resolutions have already failed or been withdrawn, there have been successes, including a resolution in March 2022 for Jack in the Box to issue a report on sustainable packaging. The resolution garnered support from 95% of the participants. Another resolution, requesting that Coca-Cola issue a plan to rapidly shift to reusable bottles, was undercut by the company when it preemptively issued a goal to reach 25% reusable or refillable bottles by 2030.[28] The resolution was withdrawn thereafter.

22: "Sustainable Packaging Materials," FTW Ventures, Brian Frank, et al., n.d., accessed September 28, 2022
23: "World Without Waste - Sustainable Packaging," Coca-Cola, n.d., accessed October 10, 2022.
24: "Introducing a World-First: A Coke Bottle Made with Plastic from the Sea," Coca-Cola, October 2, 2019.
25: "Global Businesses & NGOs Endorse a Common Vision for an Ambitious Global Plastics Treaty," Ellen MacArthur Foundation, n.d., accessed October 4, 2022.
26: "Breaking the Plastic Wave: Top Findings for Preventing Plastic Pollution," *PEW*, Simon Reddy and Winnie Lau, July 23, 2020.
27: "Big Brands Targeted for Plastic Reduction and Refill Commitments in 2022 Proxy Season," *FoodDive*, Cole Rosengren, May 2, 2022.
28: "The Coca-Cola Company Announces Industry-Leading Target for Reusable Packaging," Coca-Cola, February 10, 2022.