R&D and Commercialization Center in Los Angeles

Established in 2021

Beyondplastic.com

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# What are PHA's?

PHA (Polyhydroxyalkanoates) bioplastics are a type of biodegradable polymer produced **naturally** by microorganisms through **fermentation** processes. These polymers are **synthesized** by bacteria as intracellular carbon and energy storage compounds, serving functions like those of conventional plastics but with the added benefit of being Recyclable, Compostable and Biodegradable under nearly all* environmental conditions.

**Key characteristics of PHA bioplastics include:**

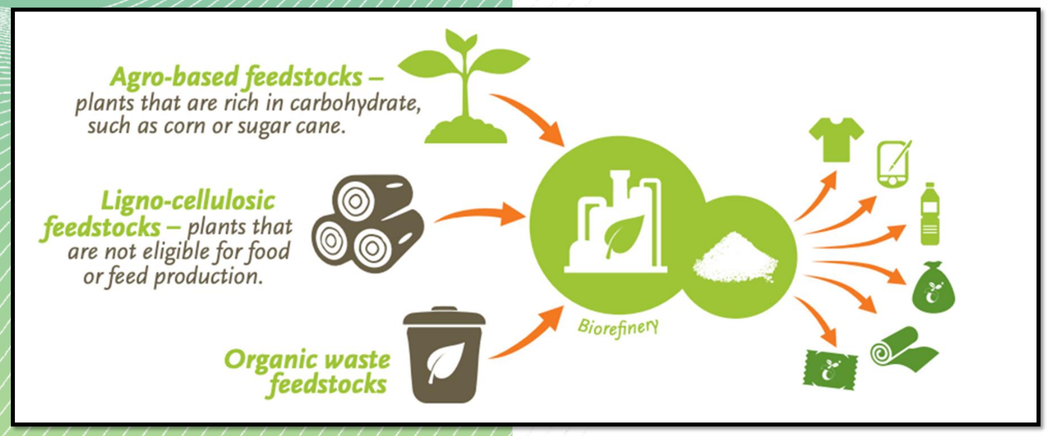
1. **Versatility**: Beyond Plastic PHA bioplastics are engineered to have a wide range of properties, making them suitable for various applications, including single use packaging, cosmetic and nearly all standard applications to be a direct replacement for HDPE #2, LDPE #4, #5 PP.

3. **Compatibility with Existing Infrastructure**: PHA bioplastics can often be processed on conventional plastic manufacturing equipment with small modifications, making them easy to integrate into existing supply chains and manufacturing processes.

3. **Renewable Sourcing**: PHA are produced from renewable feedstocks, such as plant sugars, vegetable oils, or even waste streams from agricultural or industrial processes, including biogas such as Methane and CO2 thus reducing reliance on fossil fuels.

5. **Reduced Environmental Impact**: Compared to conventional plastics derived from petroleum-based sources, PHA bioplastics do not add plastic pollution to the environment. It requires less energy to process, lower melt temps. Some blends can be made naturally hydrophobic, drying is not critical

6. **Natural Biodegradability**: PHA bioplastics can be broken down by common microorganisms into carbon dioxide and water under a wide range of natural conditions, such as in composting environments or anaerobic digestion facilities and in the most sensitive of biomes! Our Oceans.




Recyclable

Biodegradable

Compostable

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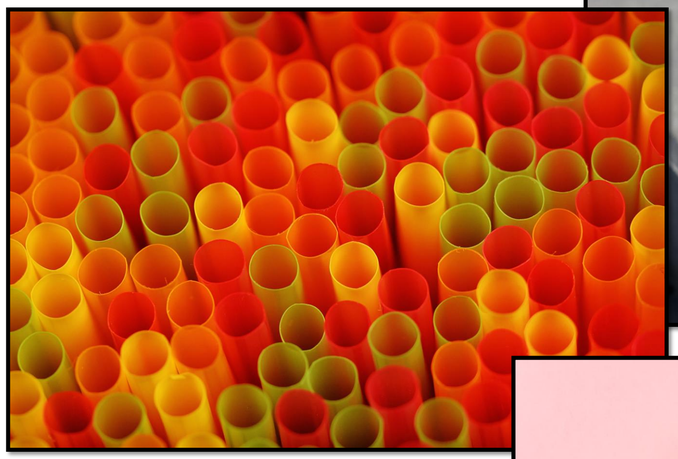
# What Can you Make with PHA?



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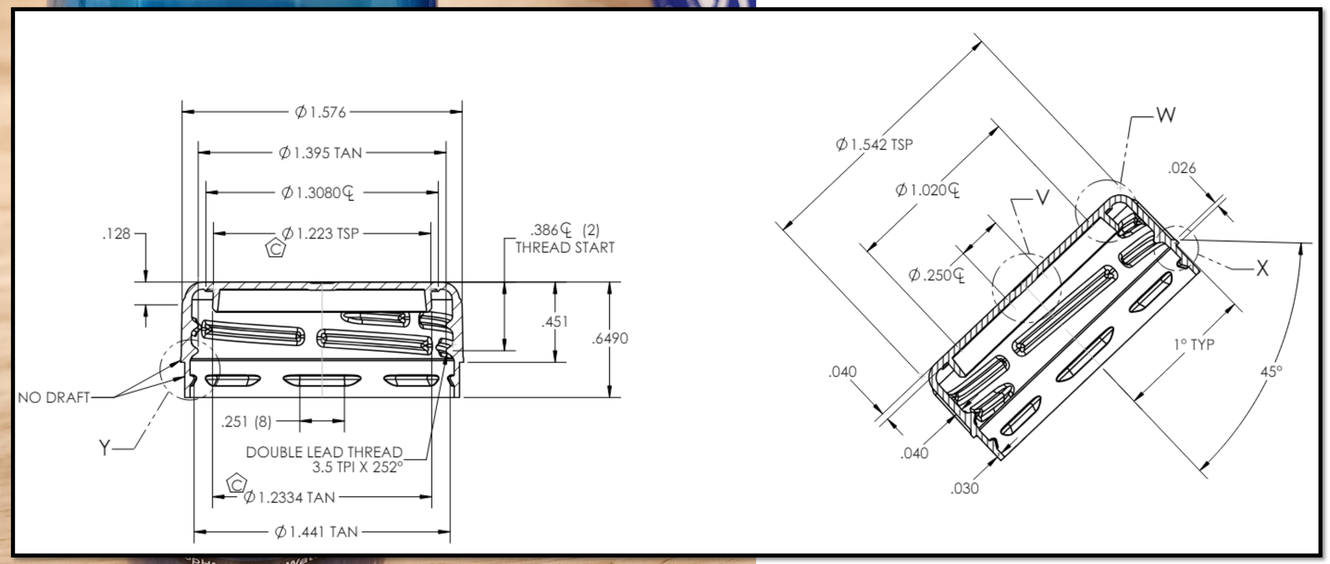
| | |
|---|---|
| **10-2021** | • Launch Designs Requirements: Direct Replacement of a HDPE 38 MM Cap suited for a water brand |
| **01-2022** | • 1st PHA Single Cavity Mold In test: 1st mold revision & 1st Material Revision |
| **2022 - Q2 2023** | • 13 Custom Compound Revisions, 3 natural color trials, 6 mold design revisions |
| **09-2023** | • 1st Commercial Filling-capping trials, completed at Unix Packaging in Montebello CA |
| **6 Months** | • Stability, Sensory, Exposure, FCN testing, TUV-Marine |
| **12-2023** | • Completed 16 cavity Injection Molding & CCM Equipment Delivery (Phase #2) |

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# Technical Challenges

HDPE & PP caps are a commodity item, made and consumed by millions daily.

Water product while being technically the easiest to fill, in comparison to a CSD or Hot Fill product.
It is in fact the most sensitive to flavors and smells.

Zero tolerance for any residuals or volatiles. Therefore, working with clean materials is a must.

Shrink Ratios are a variance of the PHA material blends, therefore needs to be measured with very high precision and tracked.

CJ Bio Amorphous material while being a minor component in terms its average mass within the cap. Plays a key role in ensuring the performance of a plastic cap.

The end goal is a PHA caps, to looks, feels, performance in every identical fashion as a regular cap. But with the added advantage of being compostable, and the safety net of being Marine Biodegradable.

TUV Marine (Austria)– OWS Labs (Belgium) were used for final certification.

Initial testing completed by Retired Prof Joseph Greene, author of Sustainable Plastics: Environmental Assessments of Biobased, Biodegradable, and Recycled Plastics. And former teacher at California State University, Chico.

ISO 17025 ACCREDITED LABORATORY

ANAB ANSI National Accreditation Board ACCREDITED ISO/IEC 17025 TESTING LABORATORY

MARINE OK bio-degradable TÜV AUSTRIA MARINE

GO!PHA Global Organization for PHA

bioPHA Plant-Based Biodegradable Material

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# Third Party Testing

Normec OWS

*Table 5. Biodegradation percentages after 42 days*

| Test series | Average $C_{input}$ (mg) | Average $C_{gaseous}$ (mg) | Biodegradation (%) | | | 95% CL |
|---|---|---|---|---|---|---|
| | | | AVG | SD | REL | |
| Cellulose | 25.4 | 22.9 | 89.9 | 0.7 | 100.0 | 1.6 |
| F0149 | 34.3 | 28.2 | 82.0 | 0.1 | 91.2 | 0.8 |

*Table 7. Disintegration of reference item after 4 weeks and test item after 12 weeks*

| Test series | Thickness (µm) | Grammage ($g/m^2$) | Disintegration (%) | | |
|---|---|---|---|---|---|
| | | | Replicate | AVG | SD |
| Cellulose filter paper | 207 | 90 | 100.0 | 100.0 | 0.0 |
| | | | 100.0 | | |
| | | | 100.0 | | |
| F0149 | 206 | n.d. | 99.4 | 91.9 | 10.7 |
| | | | 96.8 | | |
| | | | 79.7 | | |

*Table 2. Mobility and immobility of Daphnia neonates after 24 hours and 48 hours*

| Test series | 24 hours | | | 48 hours | | |
|---|---|---|---|---|---|---|
| | Mobility (%) | | Immobility (%) | Mobility (%) | | Immobility (%) |
| | AVG | SD | AVG | AVG | SD | AVG |
| SFW | 95 | 10 | 5 | 95 | 10 | 5 |
| Control | 100 | 0 | 0 | 100 | 0 | 0 |
| F0149 - 1000 mg (dry weight)/l | 100 | 0 | 0 | 100 | 0 | 0 |

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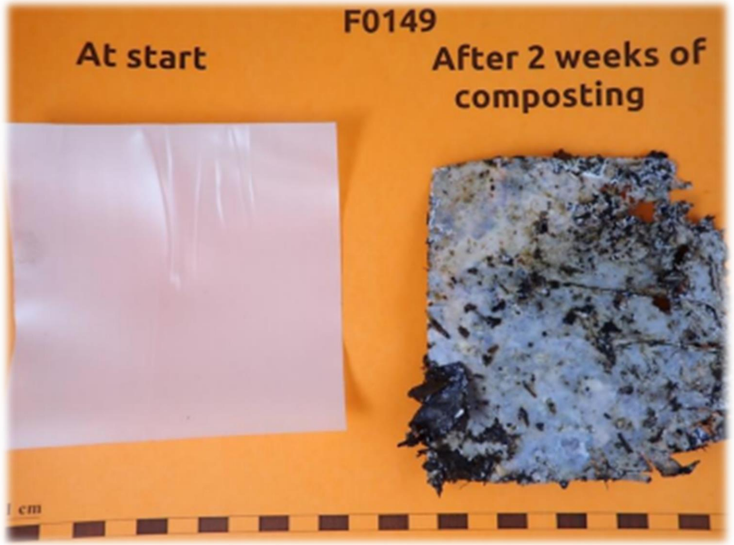
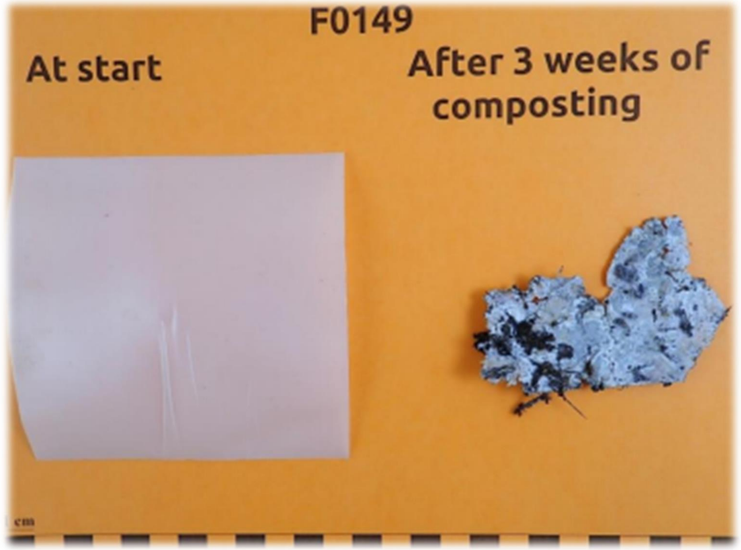
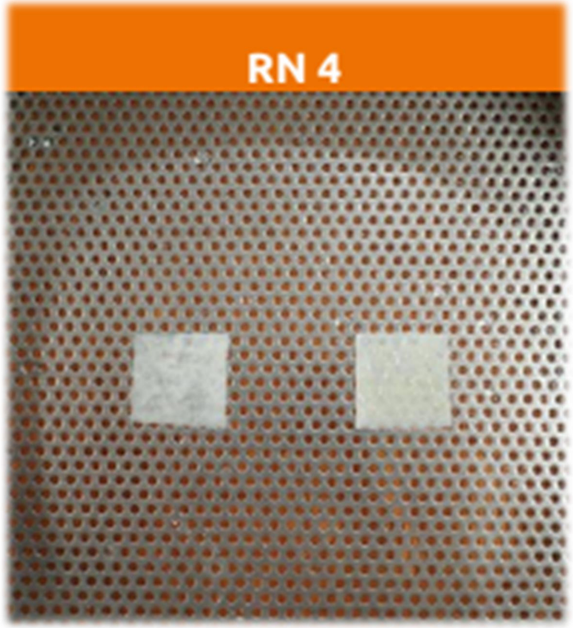
# Third Party Testing

Normec OWS

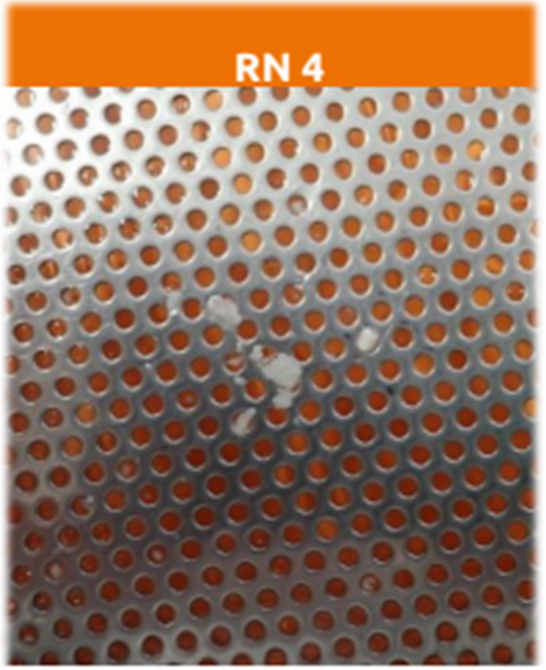



Week 4

Week 12



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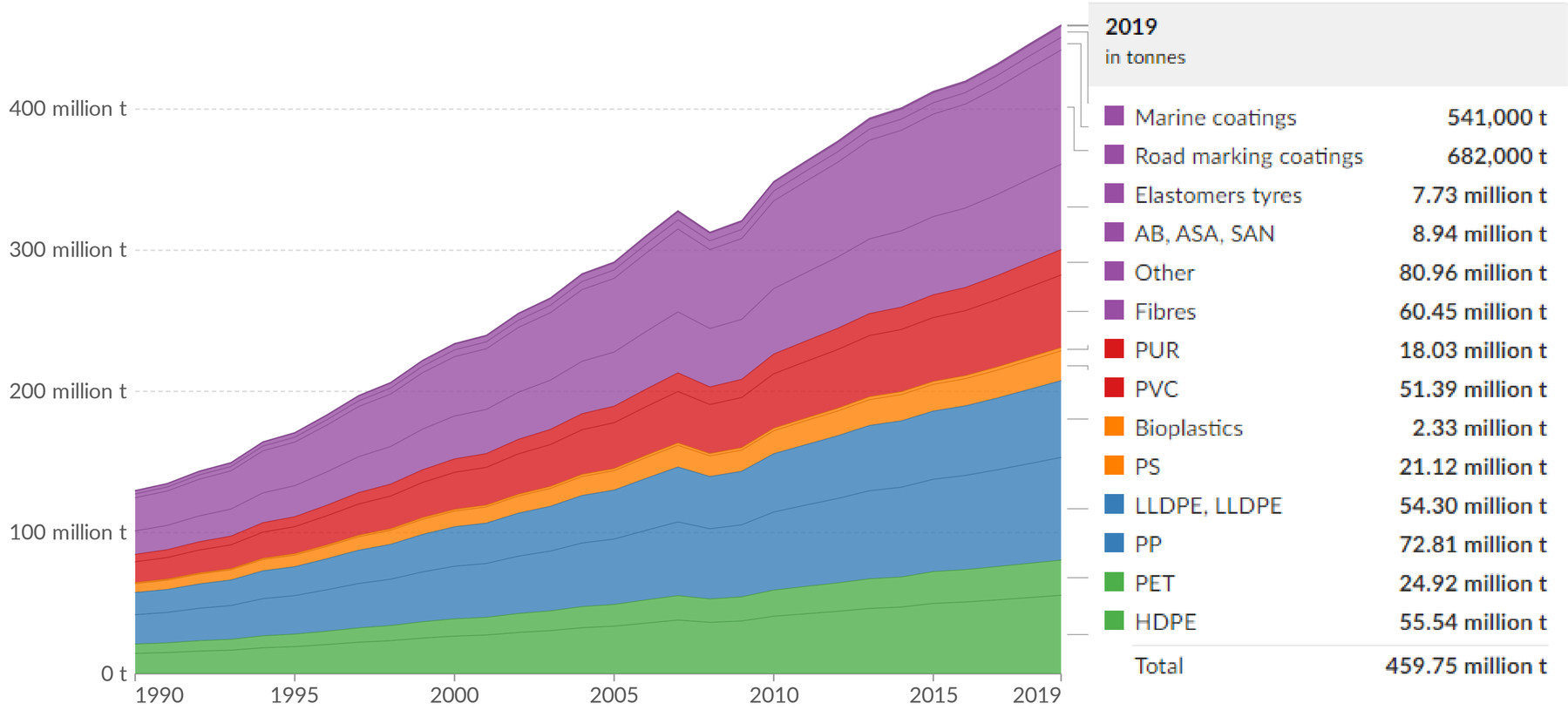
# Why Should We Replace PP, LDPE and HDPE?

## Global primary plastic production by polymer, 1990 to 2019

Our World in Data

Polymers are color-coded to indicate recyclability: green for widely recycled, blue for moderately recycled, orange for limited recyclability, red for usually non-recycled, and violet for unknown recyclability.




**Data source:** OECD (2022)

OurWorldInData.org/plastic-pollution | CC BY

LDPE, HDPE, and PP collectively accounted for 39% of all plastic pollution since 1950.

While their contribution has maintained a consistent rate, since 1990, the consumption and subsequent introduction into the environment have surged by 354%.

Combined, they represent 182 Millions Tons of Material and growing.

Source: https://ourworldindata.org/plastic-pollution

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# Why a bottle Cap?

# Major Contributor to Pollution

HDPE & PP caps are the 5th common plastic trash collected on US Shores.
Globally, its 4th on the list.

Source:
The Ugly Journey of a plastic bottle cap
Weight of Most Common Items Found in Global Oceans
Albatross Ate Plastic
Beaches Whales filled with Plastic

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# First ever RCB PHA bottle cap.

## PHA Compound Molded into "World's First" Biodegradable Bottle Closures

Beyond Plastic and partners have created a certified biodegradable PHA compound that can be injection molded into 38-mm closures in a sub 6-second cycle from a multicavity hot runner tool.

By Tony Deligio
*Executive Editor*

After three years of research — including the creation and testing of 174 different compounds — Beyond Plastic LLC, Commerce, California, says it has arrived at a completely biodegradable injection-molded closure based on polyhydroxyalkanoate (PHA), with phase two research looking at compression molding of the bioplastic caps. The PHA resin has been supplied by CJ Biomaterials Inc., a division of South Korea-based CJ CheilJedang. Heading up the project is Fred Pinczuk, Beyond Plastic's chief technology officer, who has more than four decades of experience in packaging, including stints at major injection molding and blowmolding machinery OEMs.

In his three years at Beyond Plastic, Pinczuk has led that company's research efforts to commercialize PHA for packaging — largely based on the material's end-of-life biodegradability. "We don't want to be in the closure business," Pinczuk says. "We're in the business to make formulations that can go mass market, be mass produced and replace petrochemical products currently used."

Pinczuk acknowledges that bioplastics in general and PHA in particular are not new, but he feels PHA's properties — and his company's research — put the material in a new position to replace fossil fuel-based plastics currently used in single-use packaging applications, like closures.

He is also aware of the challenges posed by processing bioplastics, noting that in the early days, the industry didn't do itself any favors by often positioning bioplastics as drop-in replacements for traditional resins. "In the past, companies made PHA compounds and sold them as having similar properties to PP," Pinczuk says. When processors attempted to run these bioresins using the same machine settings they'd apply for commodity polyolefins, the result was, as Pinczuk puts it, "a fiasco."

Many of PHA's strengths are also potential challenges to its processing and end-use application. Pinczuk notes that the material can be as soft as an amorphous rubber or as hard as a crystalline acrylic, depending on formulation and its temperature profile in processing. In its development work, Beyond Plastic began with a single-cavity closure tool as it sought to identify PHA's shrink ratio. It molded caps, compensated for ►


**Beyond Plastic says its injection-molded PHA bottle caps are the first 100% biodegradable closure. Source: Beyond Plastic**

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## Breakthrough Bottle Cap Made from Bacteria Fermentation

A plastic-like polyhydroxyalkanoate (PHA) biopolymer cap that's recyclable, compostable, and biodegradable yields zero microplastics.

Rick Lingle, Senior Technical Editor
March 19, 2024

3 Min Read


BEYOND PLASTIC/CANVA

Canva



### Editor's Choice

AUTOMOTIVE & MOBILITY
Marelli Opens Interior Innovation Center in Japan
MAR 28, 2024

BUSINESS
Chemours Files Twice-Delayed Annual Report

**R**ecyclable

**B**iodegradable

**C**ompostable

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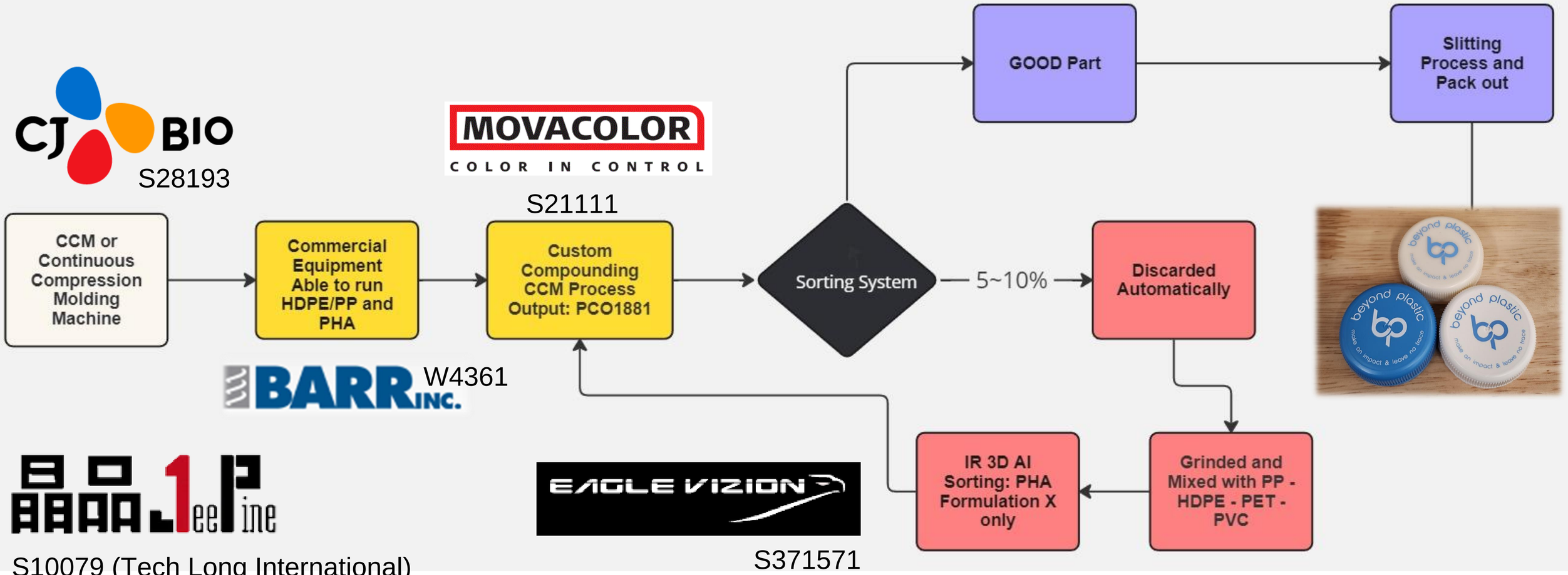
# Second Generation of RCB PHA bottle cap.



# Other Projects


# THANK YOU