Self-Disintegrating Polymers

Adaptive Biodegradable Units (ABU)

Plastic is an all-purpose material. Cheap, light in weight, strong, and is highly versatile, it is used in numerous ways. In 2016, plastic production amounted to 335 million tons, 1.4 times more than in 2005 and 215 times more than in 1950. And it's growing. According to the United Nations, only 9% of all plastics produced in the world are recycled, about 11% are incinerated, and the rest end up in landfills or the environment. More than 98% of plastics come from petroleum derivatives, natural gas, or coal; and they are non-renewable.

ABU: PATENTED, STARCH-BASED PRODUCT

The formulation of a patented, starch-based product with biodegradable fatty acids that reduces the degradation period of the different end products naturally. It's called ABU. *Adaptive Biodegradable Units.*

BIODEGRADABLE & SELF-DISINTEGRATING

BENEFITS

- ABUs are a biodegradable/self-disintegrating polymer without needing any composting process.
- Independent from petroleum sources, manufactured from farming molecules with no environmental impact.
- Scope replaces single-use plastics and other applications.
- No PLA or compostable plastics are used.
- Hydrocarbon-free (petroleum, artificial organic molecules).
- Does not generate toxic effluents/emissions during process.
- Zero water impression during technology.
- Biodegradability in 1 to 4 months per factory design. Under vacuum storage it remains stable for 2+ years.

PROPERTIES

- Waterproof.
- Sealable like conventional petroleum-based plastic.
- Heat/cold resistant under normal household conditions such as freezer to microwave.
- High tensile strength.
- Economic from raw material manufacture points, final product, and social and environmental costs.
- Fits in existing plastic machinery without modification.
- Scalable to different combinations and additions of organic materials without losing self-biodegradability.
- Not dependent on import of raw materials.

MAIN IMPACT AREAS

① Fully biodegradable, requires no processing once discarded. Avoids carbon footprint, investment in recycling plants.

② Uses current technologies/machinery in the plastics industry. Guarantees continuity of the industry, workforce labor security and involves industry adaptation without extra investment.

③ Environmental impact of replacing single-use plastic and Low-Density Polyethylene at comparable plastic cost.

④ Can be blown into films or molded into shapes making them the most feasible alternative to plastics. Manufactured using any existing plastic production facility.

CONTACT

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CSIR - Central Food Technological Research Institute, Mysuru 570 020, India

23.10.2020

To

Dr. Sandanamudi Anudeep
Co-founder
Dhriti Bio Solutions, Mysuru

Sub: Reg. Biodegradability tests report

Ref: email dated Jan 27, 2020 from M/s Dhriti Bio Solutions, Mysuru

With respect to above topic, Please find the detailed report on biodegradability tests conducted in the Institute as per the standards.

Dr Rajesh S Matche
Chief Scientist, Food Packaging Dept.

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REPORT

ON

BIODEGRADATION STUDY OF ADAPTIVE BIODEGRADABLE UNITS(ABU'S)

FOR

DHRITI BIO SOLUTIONS, MYSORE

R&D UNIT, POTENTIAL HEALTH DEVELOPMENT Pvt. Ltd

BENGALURU

BY

CSIR-CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE

MYSORE-570002

OCTOBER 2020

1. Test Method:

The test for determining biodegradability was conducted as per "**ISO 17088:2008 Specifications for compostable plastics".** ISO 16929: Determination of the degree of disintegration of plastic materials under defined composting conditions in a pilot- scale test" was employed as the standard for determining the disintegration level of the plastics. ISO 14855-1: Determination of ultimate biodegradability of plastic materials under controlled composting conditions – Method by analysis of evolved carbon dioxide" was used as a standard for the determination of ultimate aerobic biodegradability of plastics

2. ISO 16929 - Determination of degree of disintegration of plastic materials under defined composting conditions in a pilot-scale test

2.1 Experimental Conditions:

- Temperature: During the first week the temperature was less than 70^0C and thereafter it was greater than 65^0C
- pH: The pH was between 5 to 7 throughout the course of the test
- Testing Mixture: Mature compost from nursery compost unit was obtained. The moisture content was greater than 50% by mass, C/N ratio was 26 and pH was 5.6.
- Testing Sample: The sample was whitish and translucent and was received in film form.
- 1% on wet mass basis of test material in its final form is taken for analysis.
- Origin of compost: Nursery compost
- Age of compost: 2-4 months

2.2 Validity criteria

- The maximum temperature during composting remains below 75^0 C during the first week. and below 65^0 C thereafter ☒ O YES O NO
- The temperature remains above 40^0 C for at least 4 consecutive weeks.
  ☒ YES O NO
- The pH increases to a value above 7 during the test and does not fall below 5.
  ☒ YES O NO

2.3 Test Results

The degree of disintegration is found to be 90.668 and 9.3% of the original dry mass remains after sieving through 2.0mm sieve after 84 days of test.

3. ISO 14855-1 Determination of the ultimate aerobic biodegradability of plastic materials under controlled composting conditions- Method by analysis of evolved carbon dioxide

3.1 Experimental Conditions

- Reference material: TLC grade cellulose
- Origin of compost: Nursery compost
- Age of compost: 2-4 months
- Volume of test vessels: 2-4 months
- Method of CO_2 determination: titration using barium hydroxide
- Temperature: The temperature was maintained at $58^0C \pm 2^0C$ throughout the experiment.
- pH: The pH was between 7.0 to 9.0 throughout the course of the test.
- Testing mixture: Mature compost from nursery compost unit was obtained. The moisture content was greater than 50% by mass, C/N ratio was 26 and pH was 5.6.
- Testing Sample: The sample was whitish and translucent and was received in film form

3.2 Validity criteria

- Degree of biodegradation of reference material after 45 days >70%? ☒ Yes ○ No
- Difference between percentage biodegradation of reference material in the different vessels at end of test <20 %? ☒ Yes ○ No
- Mean C02 production in the blank vessels after 10 days in the range 50 mg to 50 mg C02/g volatile solids? ☒ Yes ○ No

3.3 Test Results

The degree of aerobic biodegradability under controlled composting conditions is found to be 91.17%.

Table 1: Degree of biodegradation calculated from CO_2 evaluation

DAY	MEAN BIODEGRADATION OF THE TEST MATERIAL (%)	MEAN BIODEGRADATION OF THE SAMPLE (%)
0	0	0
10	13.1	23.3
20	19.3	36.8
30	26.6	41.2
40	32.1	54.1
50	37.8	76.4
60	41.3	81.7
70	52.3	59.3
80	63.4	93.9
90	72.1	98.8
100	83.3	99.3
110	89.6	100
120	90.7	100
130	91.5	100
140	91.6	100
150	91.6	100
160	91.7	100
170	91.7	100
180	91.7	100

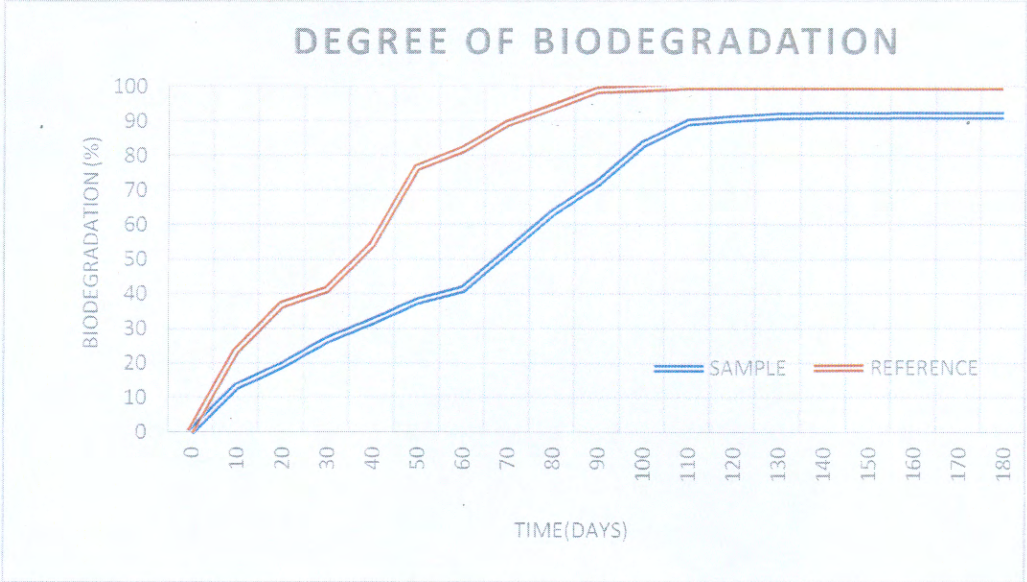

Table 2: Mean biodegradation rates

Sample	Mean biodegradation %	Test duration (Days)
Test material	91.7	180
Reference	100	180

4. SUMMARY

The sample after 84 days of test retains less than 10% of original dry mass after sieving through a 2.0mm sieve, as required by ISO 16929.

The sample after 180 days of test resulted biodegradable in mature compost, having reached an average biodegradation value higher than 90% as required by ISO 14855-1.

Dr Rajesh S Matche
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none : 0821-2514972

ई–मेल : E-mail : csc@cftri.res.in

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सी एस आई आर – केन्द्रीय खाद्य प्रौद्योगिक अनुसंधान संस्थान, मैसूरु – 570 020

CSIR-Central Food Technological Research Institute, Mysuru - 570 020, India

Giving Food a Future

TEST REPORT

CFTRI CUSTOMER SERVICE CELL

CSC0220-2020

ULR	T	C	5	2	5	3	2	0	0	0	0	0	0	2	2	0	A	--

1	5	0	3	2	1

Name & Address of the Customer	:	**M/s. Dhrithi Bio Solutions Incubate Suite 3, NPIC- CIF, CFTRI Mysore**	**Page 1 of 1**
Name of the Product/Sample@	:	**Adaptive Biodegradable Units (ABUS)**	
Sample Receipt Date	:	01.02.2021	

SAMPLE NOT DRAWN BY US

Test Parameter	Simulant (Temp/ Time)	Amount of Extractives		Test Method
		mg/in^2	ppm	
Global Migration Test	Distilled Water (40°C/ 10 days)	3.24	32.4	IS : 9845 : 1998 (2004)
	n- Heptane (38°C/ 0.5 hrs.)	0.13	1.3	

SV : SA = 1: 1

Conclusion: There is no limits specified for Bio-degradable packaging polymers as per IS. The test has been conducted as per IS 9845 : 1998 (2004), for intended use for contact with aqueous (water) and fatty foods/ beverages at room temperature filling and storing.

@Information as given by the customer.

Please Note: The results contained in this Test Report relate only to the sample tested. This Report is intended only for your guidance and not valid for legal purposes or for advertisement.

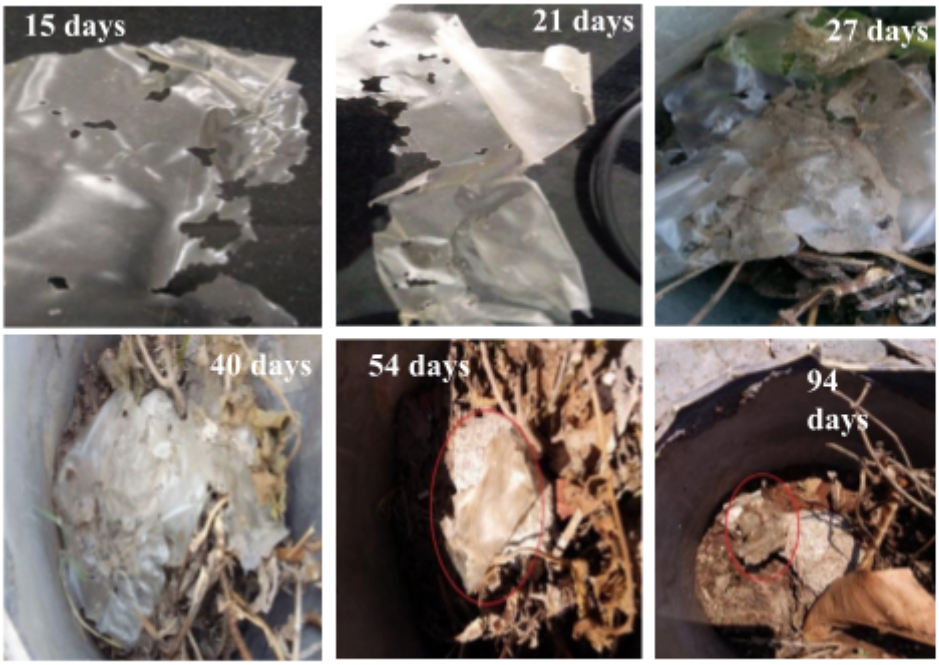
Asha Martin

Head 15.3.21

Food Safety & Analytical Quality Control Laboratory

FTRI, MYSORE-570 013

Home composting study of Phimer ABUS



Bio degradable studies of Biopolymer performed in nature at CFTRI, Mysore

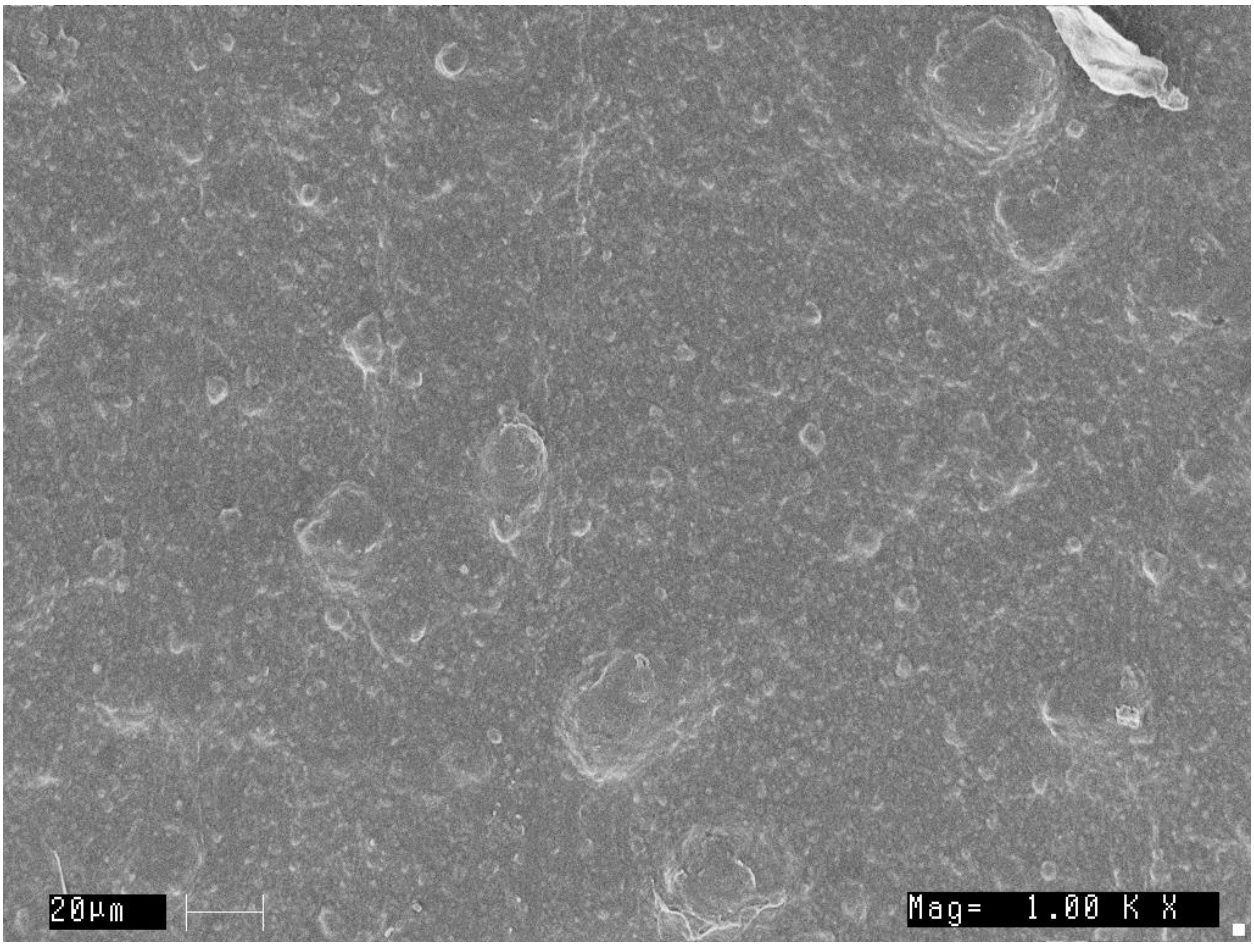
Temperature: 23°C to 32°C
Humidity: 22%-35%

The Biodegradable cycle of ABUS completes by 240 days and there is absolutely nothing left beyond the degradation period of 240 days.

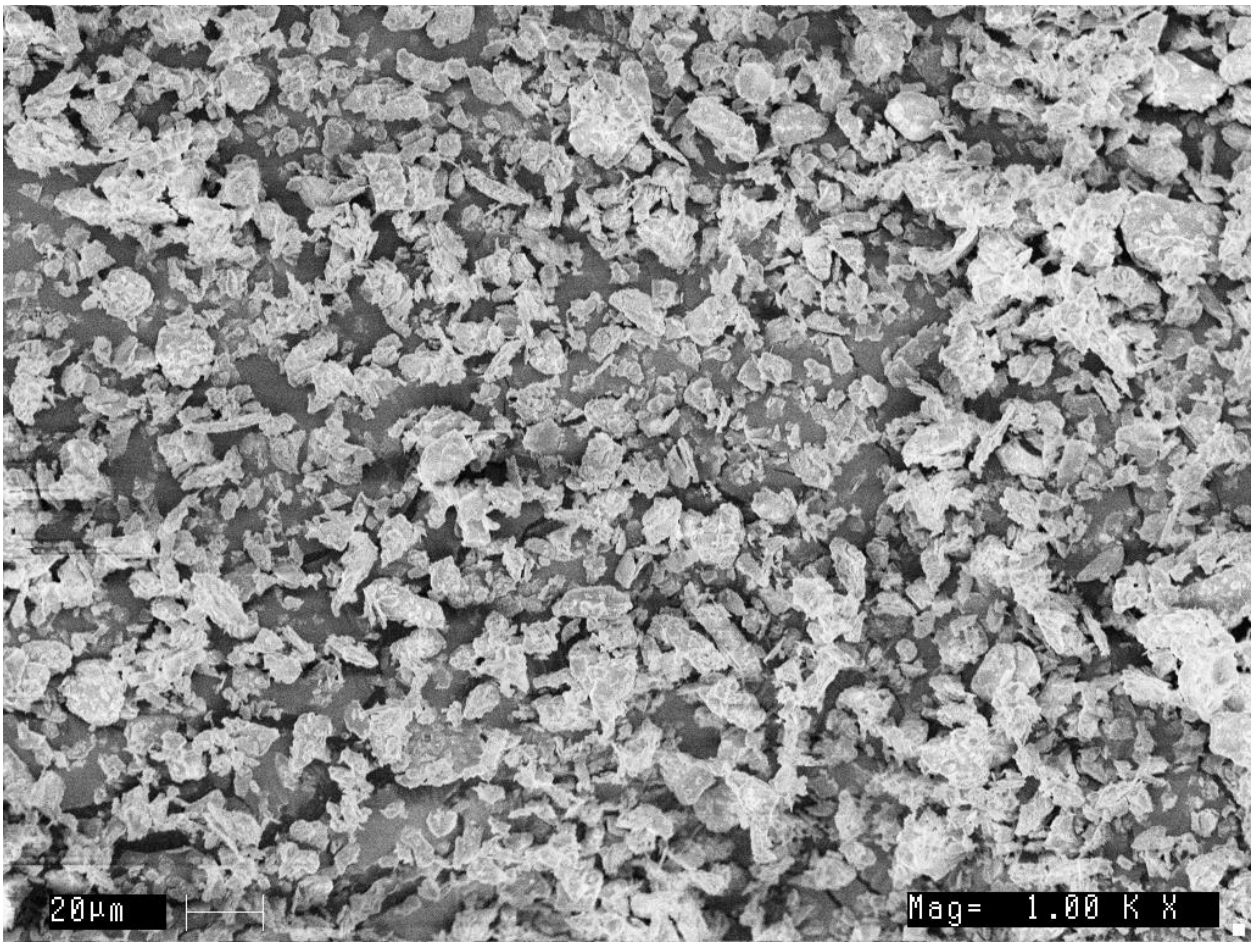
Potential Health Development
INSPIRING GREATER LIVING

SEM REPORT

Scanning Electronic Microscopic data:



The Image was taken at 0 days for ABUS D55 film



The image was taken at 180 days for ABUS D55 film

SEM images taken during biodegradable studies reveal the biodegradability nature of the material.

SEM images of microplastic during the 6 months study time results in a globular-smooth surface structure. The above SEM data reveals rough and crystalline surfaces indicating the material under study is under the process of degradation without the generating microplastics. The Biodegradable cycle of ABUS completes by 200 days, and there is absolutely nothing left beyond the degradation period of 200 days.

Commonly Asked Question

Certification of material source, Certification of compost ability, Possibility of food law compliance

DM - It corresponds with American and European food contact safety standards EN13432 and ASTM D6400 standards. Its shelf life is 12 months.

SP - Food grade - Maize Starch / Tapioca starch

SL NO	Name of the certification	Standard	Description	Issuing Body
1	**Biodegradability**	**ISO 17088:2008**	**ISO 16929** - Determination of degree of disintegration under defined composting conditions **ISO 14855-1** Determination of ultimate biodegradability under controlled composting conditions	**CSIR-CFTRI - ISO 9001:2008, 14001:2004, and 17025:2005 (NABL accredited) Organization**
2	**Food migration certificate**	**IS 9845 : 1998 (2004)**	The test has been conducted as per **IS 9845 1998 (2004)** for intended use for contact with aqueous (water) and fatty foods/ beverages at room temperature filling and storing.	**CSIR-CFTRI - ISO 9001:2008, 14001:2004, and 17025:2005 (NABL accredited) Organization**
3	**SEM Report** (Scanning Electron Microscopy)	**Extended data**	SEM (Scanning Electron Microscopy) images of microplastic during the 6 months study time results in a globular-smooth surface structure. The above SEM data reveals rough and crystalline surfaces indicating the material under study is under the process of degradation without the generating microplastics. The Biodegradable cycle of ABUS completes by 200 days, and there is absolutely nothing left beyond the degradation period of 200 days.	**CSIR-CFTRI - ISO 9001:2008, 14001:2004, and 17025:2005 (NABL accredited) Organization**

Moisture sensitivity/resistance
Water resistant

Achievable Properties of blown film made of ABUs. (50µm film)

PROPERTIES FOR 50µm FILM	UNIT	VALUE
Tensile strength	Kg/cm2	Min 330
Elongation	%	Min 500
OTR	(cc/m2/24 hr)	1380
WVTR	(g/m2/24 hr)	21

Avoidance of any catalytic or enzymatic degradable additives

We do not use any catalytic or enzymatic medium or any additives for degradation.

Any current commercial applications

Films, carry bags, straws , injection molding articles, Injection Blow molding articles.

Commercial available quantities

Phimers _ ABUS - D55 current capacity is up 100 tons per day.

Global availability of materials

Supply of ABUS-D55 currently available across India and Ohio in the US.

Any granted/filed intellectual property

Patents Filed (status: pending)

Has Phimer done any feature, sustainable or economical comparisons against known compostable brands such as Ecopond C200 (Kingfa), Natureflex (Futamura), Mater-Bi (Novamont), ecovio (BASF) ecoflex (BASF)?

We have 60 to 80 % of biobased material, so comparatively Phimer grades are more sustainable to above said brands. We are more competitive in pricing in comparison with the above brands. Will share more details shortly.

What concentration of fiber is used in the rigid application?

Based on the application profile, the fiber % varies between 30 to 60%.

Which grade is used for rigid application (with fiber)? Would need TDS and MSDS

We are finalizing the grade of Phimer with Natural fiber. We will share the TDS soon after the results. (within 2 weeks)

What raw material is supplied from external sources, and which ones are created in-house and how?

All the raw materials are purchased commercially. The final product, Phimer is developed in-house.

What is the bio-content of each raw material used?

Phimer material has 50 to 80% of bio-based material in all its grades.

What Amylose content in the Starch material?

In the future, Sugar polymer may not contain amylose in Phimer grades. However current Phimer grade ABUS D55 has 20-30% of amylose content.

Describe the process steps from raw material entrance to the end product?

All the raw materials are compounded through an extrusion method. https://www.steerworld.com/index.html#link2 (Link to more information to understand about our extruder)

How do you engineer the compound for the different mechanical and melt flow properties?

We have our R&D team to formulate the trials for different mechanical and melt flow properties.

We can develop different grades of Phimer based on your requirements.

Can you disclose the formulation components with concentrations?

Yes, Phimer grades typically consist of sugar polymer (20-50%), polyester (20-50%), natural fibers (20-50%) based on the desired properties or end products.