Test Report

Report No : TUV(I)/BLR-1354/23-24/9072310474 Part A

Date: 21 August 2023

TUV India Pvt. Ltd.
TUV NORD Group
#8, VK Commerce, 2nd Floor, lll Main Road,
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Bangalore - 560 010
Phone : 080-40823000, Fax : 91-080-40823031
Website : www.tuv-nord.com /www.tuvindia.co.in

Name and address of customer	:	**ITC LTD PAPERBOARDS & SPECIALITY PAPERS DIVISION** ITC BHADRACHALAM HOUSE, SANDHU APARTMENT, 106, SARDAR PATEL ROAD, KALASIGULA, SECUNDERABAD, Telangana - 500003
Name of the sample	:	**FILOBEV 1S/2S - GDQ0732935**
CA No.	:	9072310474
Date of sample receipt	:	12 July 2023
Date(s) of analysis	:	12 July 2023 - 21 August 2023
Discipline	:	Chemical
Products Category	:	Miscellaneous
Objectives Of Examination	:	1.To test for compliance with US FDA 21.CFR.176.170 - Chloroform - soluble extractive residues test as per Amendment Regulation April 1, 2020. 2) Testing as per Commission Regulation (EU) No. 10/2011 amendment regulation of 14 January 2011, EU 2016/1416, EU 2015/174,EU 202/2014, EU 1183/2012 & EU 1282/2011 and hence Article 3 of European Regulation No. 1935/2004
Sample drawn by	:	Customer
Test Requested	:	Selected test(s) as requested by client.
Result Summary	:	

Test Requested	Conclusion
1.US FDA 21.CFR.176.170 - Chloroform - soluble extractive residues test as per Amendment Regulation April 1, 2020.	**Complies**
2.(EU) No. 10/2011 amendment regulation of 14 January 2011, EU 2016/1416, EU 2015/174,EU 202/2014, EU 1183/2012 & EU 1282/2011 and hence Article 3 of European Regulation No. 1935/2004 - Overall Migration	Overall Conclusion-PASS
a) Overall Migration	**Complies**

1.US FDA 21.CFR.176.170 - Chloroform - soluble extractive residues test

Sr. No.	Total Extractive Test Using Simulants	Temperature & Condition	Result	Unit	LOQ	Limits as per US FDA 21.CFR.176.170	Test Method
1	Distilled Water	250 °F- 2 hr	< LOQ	$mg/inch^2$	0.25	0.5	Based on TUVB/02/SOP/27 USFDA 21.CFR.176.170
		70 °F- 48hr	< LOQ	$mg/inch^2$	0.25	0.5	
		120 °F-24hr	< LOQ	$mg/inch^2$	0.25	0.5	
2	8 % Ethanol	150 °F- 2 hr	< LOQ	$mg/inch^2$	0.25	0.5	
		70 °F- 48hr	< LOQ	$mg/inch^2$	0.25	0.5	
		120 °F-24hr	< LOQ	$mg/inch^2$	0.25	0.5	
3	50 % Ethanol	150 °F- 2 hr	< LOQ	$mg/inch^2$	0.25	0.5	
		70 °F- 48hr	< LOQ	$mg/inch^2$	0.25	0.5	
4	n - Heptane	150 °F- 2 hr	< LOQ	$mg/inch^2$	0.25	0.5	
		120 °F- 0.5hr	< LOQ	$mg/inch^3$	0.25	0.5	
		70 °F- 0.5hr	< LOQ	$mg/inch^2$	0.25	0.5	

Note : 1) Sample Complies with US.FDA 21.CFR.176.170 as per amendment regulation April 1, 2020 for above tested parameters. USFDA 21 CFR 176.180 Components of paper and paperboard in contact with dry food. Test simulants selected as per US FDA 21.CFR.176.170 for dry food contact with paper and paperboard
2) Sample kept in contact with Simulants above test condition.
3) Limits are as per USFDA 21.CFR.176.170

2.Overall Migration as per (EU) No. 10/2011

Sr. No.	Name of Test	Temperature & Condition	Result	Unit	LOQ	Limits as per EC 10 2011	Test Method
1	3 % Acetic Acid	70 °C- 2 hr	< LOQ	mg/dm^2	5.0	10.0	Based on TUVB/02/SOP/27 BS EN 1186(P-3) 2002
		40 °C- 10 Days	< LOQ	mg/dm^2	5.0	10.0	
2	20 % Ethanol	70 °C- 2 hr	< LOQ	mg/dm^2	5.0	10.0	
		40 °C- 10 Days	< LOQ	mg/dm^2	5.0	10.0	
3	Vegetable Oil	70 °C- 2 hr	< LOQ	mg/dm^2	5.0	10.0	Based on TUVB/02/SOP/27 1186(P-2) 2002
		40 °C- 10 Days	< LOQ	mg/dm^2	5.0	10.0	

Note : 1) The sample conforms with EU-10/2011 for above tested parameters.
2) Sample kept in contact with Simulants above test condition.
3) Limits are as per Article 12 of the Commission Regulation (EU) No. 10-2011 of 14th Jan. 2011.
4) LOQ : Limit of Quantification

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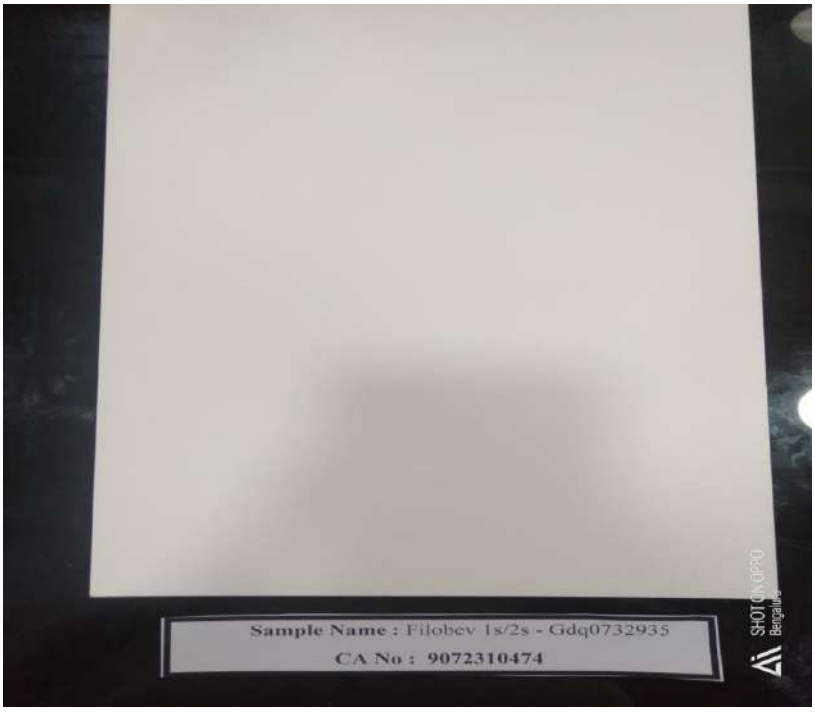


Sample image is authentic only for the original test report

Authorized by

RaghuRam Semmalai
Assistant Manager – Material Testing Service

Terms and Conditions:

1. Test Results are based on & related only to the particular sample(s) tested.
2. This Report cannot be re-produced, except when in full, without the written permission from TUV India Pvt. Ltd.
3. This Certificate reflects our findings at the time and place of testing.
4. Sample(s) will be retained by us for a period of one month for non-perishable items only. Perishable items will be destroyed after completion of tests.
5. This Report, in full or in part, shall not be used to make any misleading claims or for any legal purposes.
6. All terms and conditions of our quotation on the basis of which this testing service has been provided are deemed to be fully accepted by the customer and are deemed to be in full force and effect.
7. This Report is exclusively for the use of the customer whose name and address is indicated above. No third party can derive rights against the company on the basis of this report. No third party has any right to raise any claims on the company.
8. For Biological and mycotoxin Analysis: Our analytical findings reflect the quality of the sample at the time of testing. No responsibility can be accepted for the possible consequences of further development of micro-organisms or mycotoxin which may depend upon storage, handling & weathers conditions which may influence the results at a later date/time respectively.
9. The laboratory tests are conducted by TUV India as per mutual agreement without any implied warranty of merchantability and fitness for any general or particular use. TUV India will not be liable for any claims for indirect, incidental or consequential damages including but not limited to loss of revenue, loss of profits and similar claims. TUV India will also not be liable under any strict liability, product liability or negligence. The total liability, scientifically and legally proven, if any, of TUV India, in any case, shall not exceed the invoiced amount for the services provided and paid for.

***** End of Report *****

FINAL REPORT

EN 13432
Requirements for packaging recoverable through composting and biodegradation
Test scheme and evaluation criteria for the final acceptance of packaging

ENVIRONMENTAL DIVISION LABORATORY, MUMBAI

INTERTEK INDIA PRIVATE LIMITED

Client: ITC LIMITED PAPERBOARDS & SPECIALTY PAPERS DIVISION

Sample registration date:09/09/2022

Analysis starting date: 09/09/2022 **Analysis completed on:** 09/05/2023

Name of product: Filobev / Filotub

Quantity received and packing: - 1 packet

Sample details: Filobev / Filotub Lab reference no.15739824

Test Required: EN 13432 - Requirements for packaging recoverable through composting and biodegradation (Test scheme and evaluation criteria for the final acceptance of packaging)

Sampling done by: Sample not drawn by Intertek

Report No. MUM/003115B3/2022

LABORATORY

Testing as presented in this report was conducted by Environmental division of Intertek India Private Limited. The testing facility is located at F wing, 2nd Floor, Chandivali Saki vihar Road, Andheri (East), Mumbai – 400 072, India.

SAMPLE RECEIPT

The sample was received on 09/09/2022 at the Intertek testing facility. The sample was sent through courier. Sample was at ambient temperature in good condition with no evidence of damage or contamination. No temperature preservation was required.

SAMPLE DESCRIPTION:

Figure 1: Filobev / Filotub

PROCEDURE:

Filobev / Filotub samples were submitted by ITC Limited Paperboards & Specialty Papers Division for testing under EN-13432.

To determine the Compostability of materials as per EN 13432 (2000-12) is by addressing four characteristics:

1) biodegradability

2) disintegration during biological treatment,

3) effect on the biological treatment process and

4) effect on the quality of the resulting compost.

REQUIREMENTS:

1. **Characterization:**

Packaging material under testing should be identified and characterized prior to testing:

- Information and identification
- Determination of the presence of hazardous substance such as heavy metal.
- Determination of organic content, total dry solids and volatile solids of the packaging material used for biodegradation and disintegration.

2. **Biodegradation:**

Biodegradation under controlled composting condition is carried out using ISO 14855:1

3. **Disintegration during composting:** A plastic product or material will disintegrate during composting such that any remaining plastic residuals are not readily distinguishable from the other organic materials in the finished product. Additionally, the material or product must not be found insignificant quantities during screening prior to final distribution of the compost.

4. **No Adverse Impacts on Ability of Compost to Support Plant Growth**—The tested materials shall not adversely impact on the ability of composts to support plant growth, when compared to composts derived from bio waste without any addition of tested products or reference materials. Plant Growth test as per OECD 208 should be used as described in Annex E.

CRITERIA:

- **Disintegration during Composting**—A plastic product is considered to have demonstrated satisfactory disintegration if after twelve weeks (84 days) in a controlled composting test, no more than 10 % of its original dry weight remains after sieving on a 2.0-mm sieve.
- **Ultimate Aerobic Biodegradation**—A plastic product must demonstrate a satisfactory rate and level of biodegradation by achieving the following ratio of conversion to carbon dioxide given below(a) within 180 days. For all polymers, Ninety percent (90 %) of the organic carbon shall be converted to carbon dioxide by the end of the test period when compared to the positive control. Both the positive control, and test sample to be composted for the same length of time
- **Eco-toxicity—** A plastic product can demonstrate satisfactory terrestrial safety if it fulfills the requirements below

  - The plastic or product shall have concentrations of regulated metals less than 50 % of those prescribed for sludge's or composts in the country where the product will be placed on the market or disposed of.

  - The germination rate and the plant biomass of the sample composts shall be no less than 90% that of the corresponding blank composts for two different plant species following OECD Guideline 208

Ultimate Aerobic Biodegradation as per ISO 14855:

Principle of Biodegradation:

Filobev / Filotub were submitted by ITC Limited Paperboards & Specialty Papers Division for testing under standard ISO/IS 14855-1. The test method determines the ultimate biodegradability and degree of disintegration of test material under conditions simulating an intensive aerobic composting process. During the aerobic biodegradation of the test material. Carbon dioxide. water, mineral salts, and new microbial cellular constituents (biomass) are the ultimate biodegradation products. The carbon dioxide produced is continuously monitored. or measured at regular intervals. in test and blank vessels to determine the cumulative carbon dioxide production. The percentage biodegradation is given by the ratio of the carbon dioxide produced from the test material to the maximum theoretical amount of carbon dioxide that can be produced from the test material. The maximum theoretical amount of carbon dioxide produced is calculated from the measured total organic carbon (TOC) content.

Compost Inoculum:

Well aerated compost from a property operating aerobic composting plant shall be used as the Inoculum. The inoculum shall be homogeneous and free from large inert objects such as glass, stones, or pieces of metal. Remove them manually and then sieve the compost on a screen of about 0.5cm to 1 cm. Determine the total dry solids and the volatile-solids content of the inoculum.

The total dry solids content shall be between 50 % and 55 % of the wet solids and the volatile solids no more than about 15 % of the wet or 30 % of the dry solids Adjust the water content, if necessary, before the compost is used by adding water or gentle drying, e.g., by aerating the compost with dry air. Prepare a mixture of 1 part of inoculum with 5 parts of deionized water MIX by shaking and measure the pH immediately, it shall be between 7,0 and 9,0. The compost inoculum should produce 50-150 mg of CO_2 per gram of volatile solids over the first 10 days of the test and an ash content of less than 70% and a pH between 7 and 8.2 is desired. The amount of total dry solids may range from 50 to 55%.

Figure 2: compost inoculum

Carbon Dioxide Analysis:

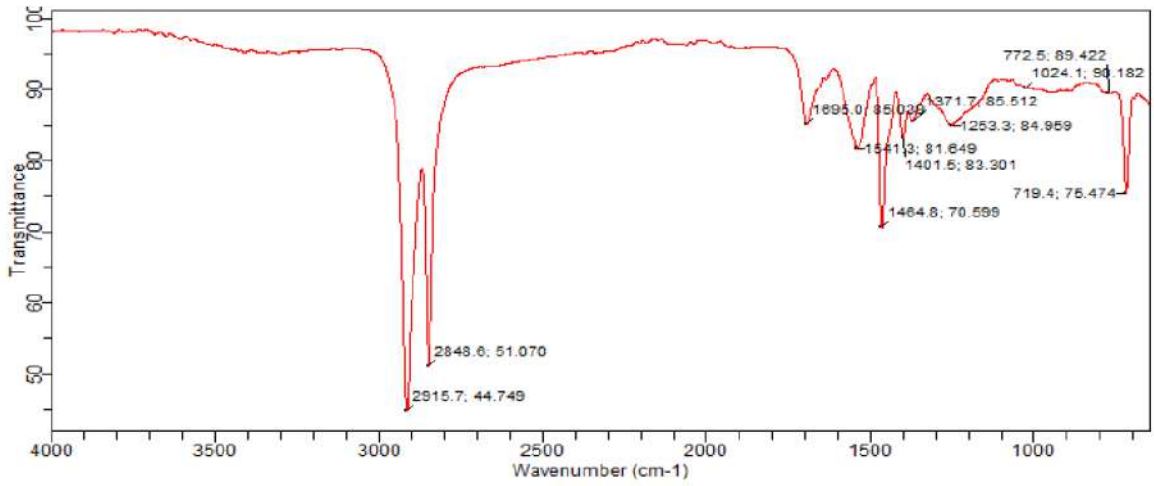
The carbon dioxide (CO_2) produced in each vessel reacted with $Ba(OH)_2$ and will be precipitated as barium carbonate ($BaCO_3$).The amount of carbon dioxide produced will be determined by titrating the remaining barium hydroxide with 0.05 N hydrochloric acid to a phenolphthalein end point. Data obtained from the titration will be used to calculate the amount of CO_2 produced.

RESULTS:

Chemical Characterization:

Table 1: Heavy Metal and volatile solid concentration in sample

Heavy Metals	Unit	Limits	Concentration
Volatile solids	%	Min 50	39.60
Zinc	mg/kg	150	1.45
Copper		50	1.07
Nickel		25	<0.10
Lead		50	<0.10
Mercury		0.5	<0.10
Chromium		50	1.42
Molybdenum		1	<0.10
Arsenic		0.75	<0.10
Selenium		5	<0.10
Cadmium		100	<0.10



Graph 1: FTIR graph of the Filobev / Filotub

The heavy metals and other toxic and hazardous waste are well within the précised limits of EN 13432 standards. FTIR spectra of **Filobev / Filotub** shown in **Graph 1** shows the IR bands characteristics.

Disintegration during Composting:

After 12 weeks, **Filobev / Filotub** sample started to disintegrate. After passing through 2mm sieve, the degree of disintegration of the test material **Filobev / Filotub** was found to be 98.0 %. Only 2 % was retained on the 2mm sieve.

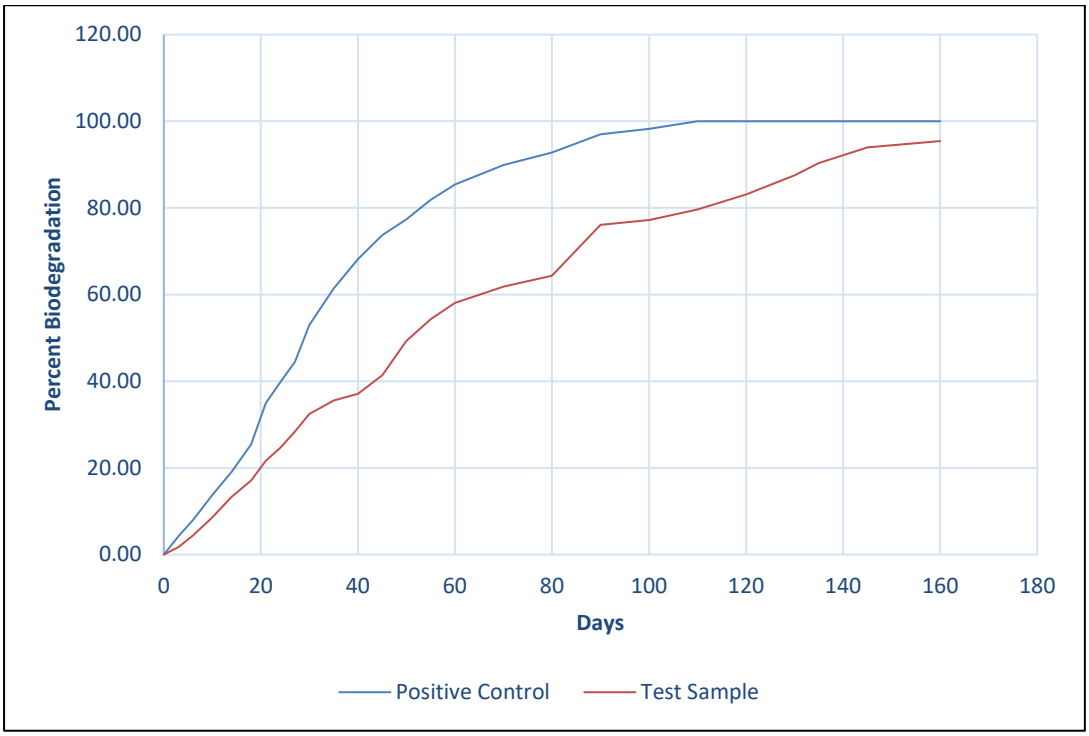
Ultimate Aerobic Biodegradation:

The **Filobev / Filotub** were subjected to biodegradation as per ISO 14855-1: biodegradability under controlled composting conditions at 58°C ± 2 °C and biodegradability was determined by measuring the actual metabolic conversion of the compostable material into carbon dioxide using the standard test method.

Table 2: Percentage Biodegradation of Positive control and Test samples

Day	% Biodegradation	
	Positive Control	Test samples
0	0.00	0.00
3	4.24	1.73
6	7.95	4.39
10	13.78	8.63
14	19.08	13.33
18	25.44	17.10
21	34.98	21.65
24	39.75	24.63
27	44.52	28.40
30	53.00	32.47
35	61.38	35.53
40	68.21	37.07
45	73.74	41.42
50	77.35	49.26
55	81.87	54.28
60	85.37	58.05
70	89.93	61.81
80	92.75	64.32
90	96.99	76.09
100	98.23	77.19
110	100.00	79.63
120	-	83.15
130	-	87.54
135	-	90.36
145	-	93.96
160	-	95.43

After 160 days of incubation under dry (58 °C ± 2 °C), aerobic controlled compositing conditions using test method ISO 14855-1, the reference (Positive control), and **Filobev / Filotub sample** were gradually biodegraded. The reference sample was degraded more than 100 % after 160 days while the **Filobev / Filotub sample** showed only 95.43 % after 160 days.



Graph 2: Percentage biodegradation of Filobev / Filotub Sample under aerobic composting

Quality of Compost:

Metal analysis of compost of test sample was done to check the toxic levels after biodegradation (Table 3). Seeds grown in compost prepared from samples showed more than 90% germination rate as compared to control. Root and shoot length of plant was similar or slightly more than controls (Table 4). There was no visual injury found in the roots and shoot of the plant due to the test substance.

Table 3: Analysis of compost residue collected after biodegradation.

PARAMETERS	UNIT	Test sample
pH	-	7.28
Mg	PPM	9953
Ca	PPM	26190
P	PPM	4105
Mn	PPM	833.9
Cu	PPM	114.1
Zn	PPM	250.6
Ni	PPM	48.35
Cd	PPM	<1.00
Pb	PPM	50.52
Hg	PPM	<1.00
Se	PPM	<1.00
As	PPM	<1.00
K	PPM	6053
Volatile solids	%	42.38
Dry Solids	%	42.67
Total Nitrogen	%	0.76

Impact of compost on plant growth:

Table 4: Germination Rate and Biomass of Brassica Juncea and Triticum aestivum seeds after 21 days.

	Plant species	Dose	Germination Rate (%)	Shoot Length (cm)	Root Length (cm)
Control	*Brassica juncea*	25%	99	12	10
		50%	98	10	10
	Triticum aestivum	25%	98	20	14
		50%	96	20	16

	Plant species	Dose	Germination Rate (%)	Shoot Length (cm)	Root Length (cm)
Test Sample	*Brassica juncea*	25%	98	12	10
		50%	95	12	12
	Triticum aestivum	25%	96	20	16
		50%	94	22	18

The above study was conducted at 25˚C ± 4 ˚C temperature, 66% ± 10% humidity and 54.07 FC light intensity with 16 hours of light. The above results showed that **Filobev / Filotub** Sample has no effect on the plant growth as well as no visible damage to the plants.

	
Control 25%	**Control 50%**
	
Test 25%	**Test 50%**

Figure 5: Effect of compost Filobev / Filotub *sample on Triticum aestivum* growth

	
Control 25%	**Control 50%**
	
Test 25%	**Test 50%**

Figure 6: Effect of compost Filobev / Filotub *sample on Brassica Juncea* growth

CONCLUSION:

In accordance to the conditions set forth in EN 13432, **Filobev / Filotub** samples submitted by **ITC LIMITED PAPERBOARDS & SPECIALTY PAPERS DIVISION** showed 95.43 % conversion of organic carbon to carbon dioxide after 160 days relative to the positive control. Filobev / Filotub sample disintegrated and after passing through 2mm sieve, the degree of disintegration of the test material was found to be 98.00 % after 12 weeks. Toxicity test was conducted as per OECD 208 on compost containing **Filobev / Filotub** sample residue. The compost sample did not show any effect on the seedling emergence, seedling growth and heavy metal toxicity test.

---------- **End of Report** ----------

Authorized Signatory

Jayashree Acharya
Assistant Manager- Environment Services

TEST REPORT

Intertek India Private Limited
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Tel : +91 22 42450100
www.intertek.com

Report No.: MUM/001222/2024	**Sample No:**17773689	**Report Date:** 31/12/2024

Sample Registration Date	22/03/2024
Analysis Starting Date	22/03/2024
Analysis Completed on	31/12/2024
Sampling Done by	Sample drawn and supplied by customer
Deviation from the test methods:	None
Packaging Condition/sealed/unsealed	Sealed
Sample Image	 **Figure 1: FILOBEV 2s**

DETAILS PROVIDED BY THE CUSTOMER

Customer Name:	INTERTEK INDIA PRIVATE LIMITED
Contact Person:	Ravikant PVS
Address:	17/F, II Stage, Industrial Suburb, Bangalore Karnataka 560022 India
Sample submitted as	FILOBEV 2s
Description on label/Sample Bottle	FILOBEV 2s
Sample type	Paper Board Sample
Quantity	1 Packet
Mode of Packaging	Plastic pouch
Sample condition	Sample was at ambient temperature in good condition
Test Method	AS 5810 - 2010 Biodegradable plastics -Biodegradable plastics suitable for home
Procedure number	NA

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LABORATORY

Testing as presented in this report was conducted by Environmental division of Intertek India Private Limited. The testing facility is located at F wing, 2nd Floor, Chandivali Saki vihar Road, Andheri (East), Mumbai – 400 072, India.

SAMPLE RECEIPT

The sample was received on 22/03/2024 at the Intertek testing facility. The sample was sent through courier. Sample was at ambient temperature in good condition with no evidence of damage or contamination. No temperature preservation was required.

PROJECT DESCRIPTION:

FILOBEV 2s was submitted by INTERTEK INDIA PRIVATE LIMITED for testing under for testing under AS5810:2010. This Standard specifies requirements and procedures to determine whether a plastic material is biodegradable in-home composting conditions and provides the basis to allow labelling of materials or products made from plastics as 'home compostable' for use in home composting systems. This Standard stipulates pass/fail criteria addressing biodegradability, disintegration during biological treatment, effect on the biological treatment process and effect on the quality of the resulting home compost. Home composting systems vary considerably in their design, construction and operation; hence their performance also varies considerably compared to commercial composting facilities. In order to compost satisfactorily, a product or material must demonstrate each of the characteristics given below,

- Characterization
- Biodegradability.
- Disintegration.
- Compost quality (including toxicity).

OBSERVATIONS

Chemical Characteristics

The characteristics of Test sample and Reference material (Cellulose) were studied. Chemical characteristics such as Volatile solids, maximum concentration of regulated metals and fluorine were determined in the test material. The maximum thickness is measured for 10 specimens at the same measuring point, from the same lot and the mean value is reported.

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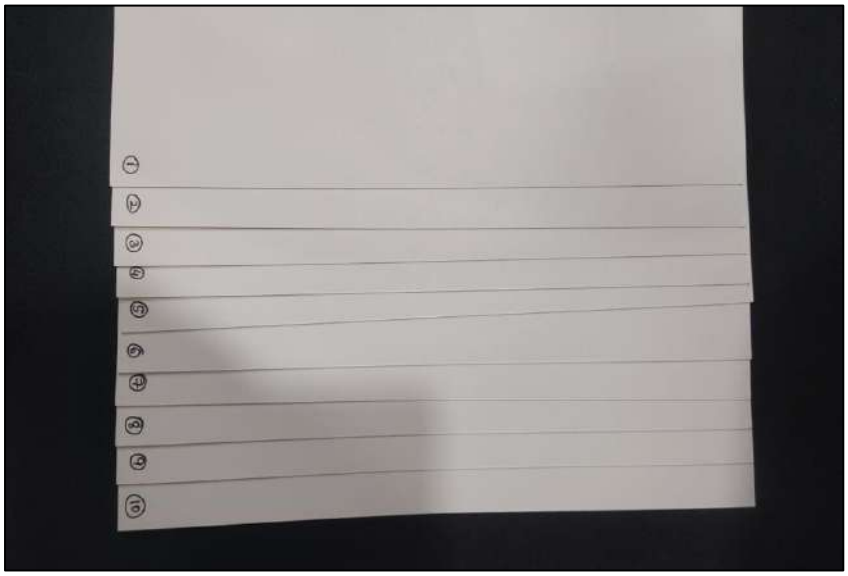
Table 1: Characteristic of the Test sample and Reference material (Cellulose)

Characteristic	**Test Sample**	**Reference material (Cellulose)**
Name	FILOBEV 2s	Microcrystalline Cellulose
Carbon content (By CHNS analyzer)	43.63 %	42.07 %
Shape or Visual Appearance	Paper Board	Powder
Total Organic Carbon (mg C/g) milligram of Carbon per gram	436.3	420.7

Table 2a: Chemical characteristics of the Test sample – Thickness

Parameters	**Unit**	**Limits**	**Results**
Thickness of FILOBEV 2s	mm	-	0.36 ± 0.01

Thickness of FILOBEV 2s



FILOBEV 2s

Figure 2: Images of Test sample (Thickness of FILOBEV 2s)

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Table 2b: Chemical characteristics of the Test sample

Parameters	**Unit**	**Limits**	**Results**
pH	-	-	7.98
Volumetric weight	g/ml	-	0.41
Volatile solids	%	Min 50	99.85
Ash Content		-	0.15
Dry solids		-	90.78
Total Nitrogen		-	0.05
Ammonium Nitrogen	mg/kg	-	<0.01
Phosphorus		-	<0.01
Magnesium		-	0.01
Potassium		-	<0.01

Table 3: Heavy metal concentration in the test sample

Heavy Metals	**Unit**	**Limits**	**Concentration**
Zinc	mg/kg	150	1.57
Copper		50	<0.01
Nickel		25	<0.01
Lead		50	<0.01
Mercury		0.5	<0.01
Molybdenum		1	<0.01
Arsenic		5	<0.01
Selenium		0.75	<0.01
Cadmium		0.5	<0.01
Chromium		50	1.05
Cobalt		38	<0.01
Fluorine		100	<1.00

The above results showed that metal concentrations in the **FILOBEV 2s** Sample is well with the specified values is well within the specified values in Table 1 as mentioned in AS 5810:2010.

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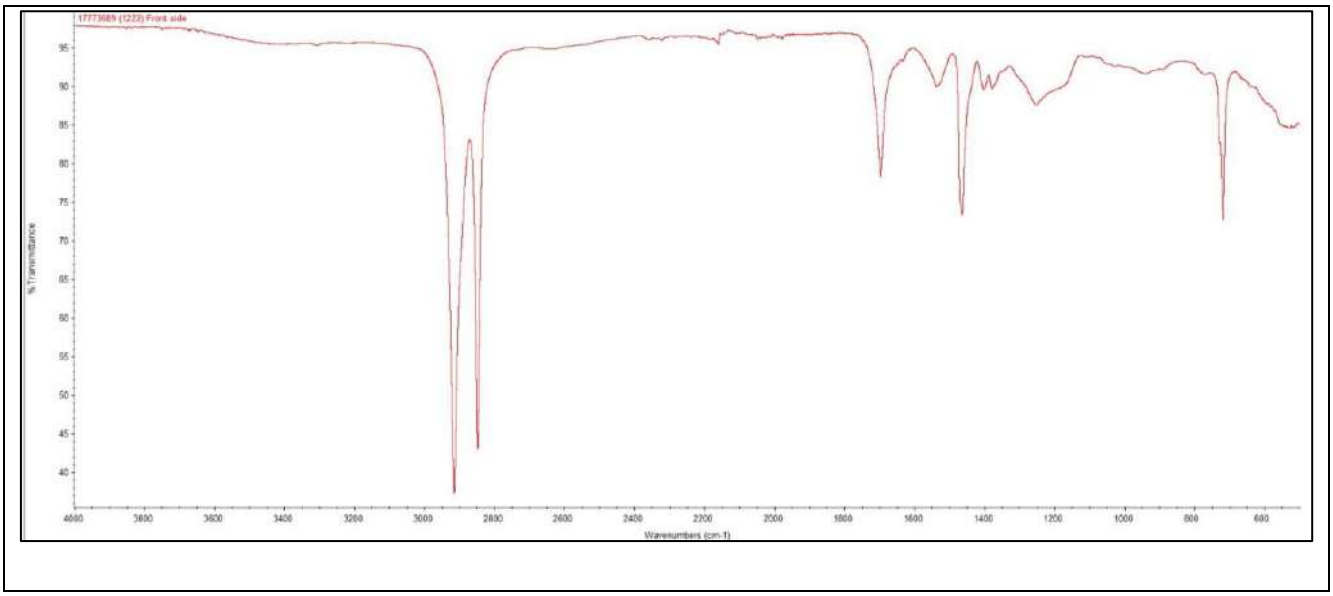
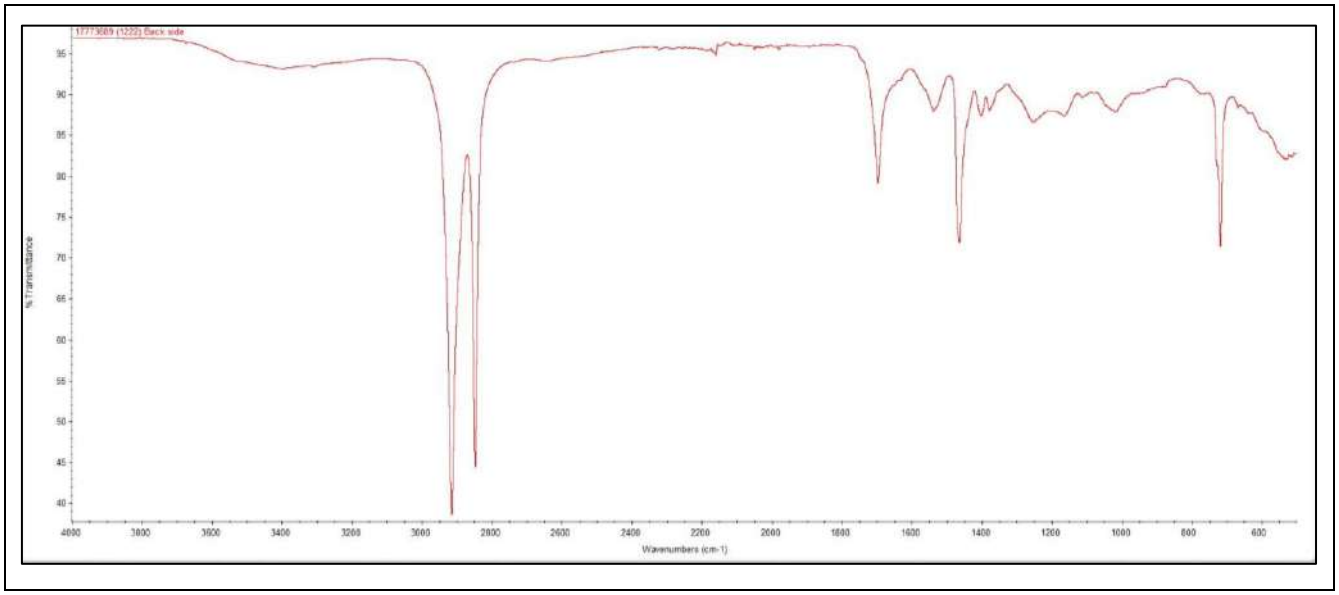


Graph 1: FTIR graph of the FILOBEV 2s (Front side)



Graph 2: FTIR graph of the FILOBEV 2s (Back side)

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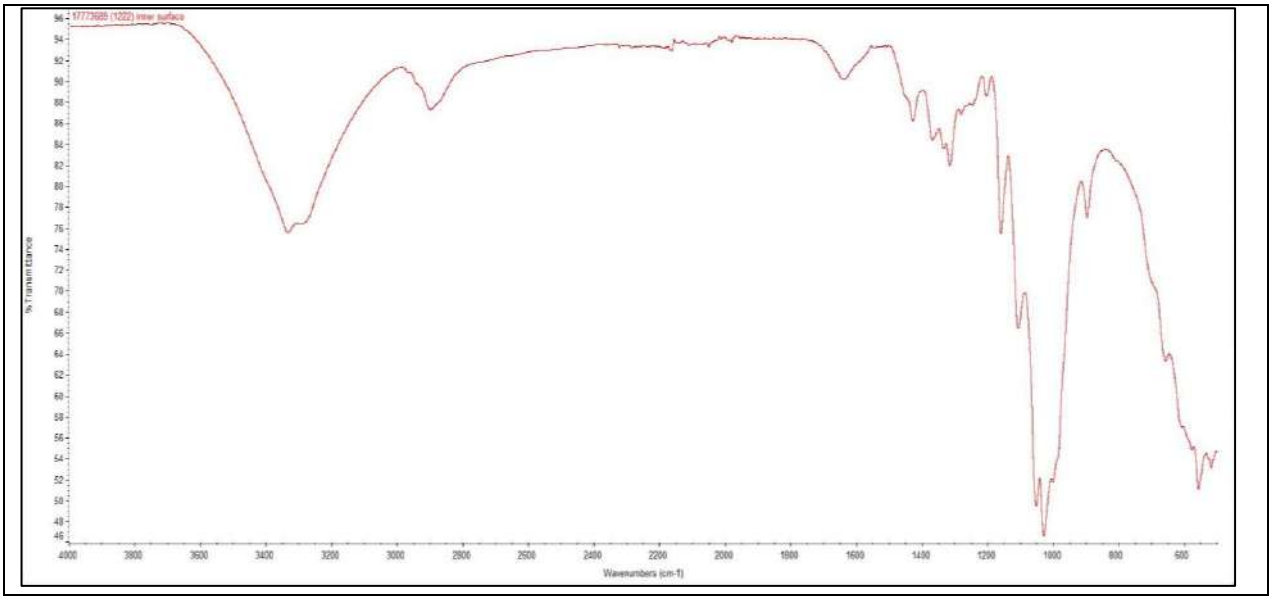

Graph 3: FTIR graph of the FILOBEV 2s (Inner Surface)

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Ultimate Aerobic Biodegradation:

The test method determines the ultimate biodegradability of test material under conditions simulating an intensive aerobic composting process. The inoculum used consists of stabilized, mature compost derived, if possible, from composting the organic fraction of solid municipal waste. The test material is mixed with the inoculum and introduced into a static composting vessel where it is intensively composted under optimum oxygen, temperature and moisture conditions for a test period not exceeding 12 months. During the aerobic biodegradation of the test material, carbon dioxide, water, mineral salts, and new microbial cellular constituents (biomass) are the ultimate biodegradation products. The carbon dioxide produced is continuously monitored, or measured at regular intervals, in test and blank vessels to determine the cumulative carbon dioxide production. The percentage biodegradation is given by the ratio of the carbon dioxide produced from the test material to the maximum theoretical amount of carbon dioxide that can be produced from the test material. The maximum theoretical amount of carbon dioxide produced is calculated from the measured total organic carbon (TOC) content. The percentage biodegradation does not include that amount of carbon converted to new cell biomass which is not metabolized in turn to carbon dioxide during the test. Additionally, the degree of disintegration of the test material is determined at the end of the test, and the loss in mass of the test material may also be determined.

Apparatus Setup:

A series of 09 composting vessels of 2-liter volume (1 blank i.e. compost, 1 positive i.e. cellulose mixed with compost, and 1 test plastic sample mixed with compost, all in 3 replicates). The entire composting vessel were kept in Incubator capable of maintaining the temperature of composting vessels at 25 °C ± 5 °C and initiate aeration using water-saturated, carbon-dioxide-free air. This can be produced by passing the air through wash-bottles filled with sodium hydroxide solution CO_2 evolved will be absorbed by Barium hydroxide $Ba(OH)_2$ and the amount of CO_2 will be determined by titrating with Hydrochloric acid (HCl).

Compost Inoculum:

Well aerated compost from a properly operating aerobic composting plant shall be used as the inoculum. The inoculum shall be homogeneous and free from large inert objects such as glass, stones or pieces of metal. Remove them manually and then sieve the compost on a screen of about 0.5 cm to 1 cm. The total dry solids content shall be between 50 % and 55 % of the wet solids and the volatile solids shall be more than about 15 % of the wet (or 30 % of the dry) solids. Adjust the water content, if necessary, before the compost is used by adding water or gentle drying,

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e.g., by aerating the compost with dry air. Prepare a mixture of 1 part of inoculum with 5 parts of deionized water. Mix by shaking and measure the pH immediately. It shall be between 7.0 and 9.0.

Figure 2: compost inoculum

Procedure:

The amount of test mixture, containing inoculum and test material, used in the test will depend on the quality of the test material and the size of the composting vessels. Normally, a minimum of 50 g of total dry solids containing 20 g of TOC is required per vessel. The ratio of the dry mass of the inoculum to the dry mass of the test material shall be about 6:1. Be sure that the same amount of compost is in each vessel. Prepare composting vessels which have a volume of about 2 litres, weigh out an amount of inoculum containing 600 g of total dry solids and an amount of test material containing 100 g of dry solids and mix well. The test mixture shall have the same water content (about 50 %) as the inoculum. It should feel somewhat sticky and have some free water available when gently pressed by hand. Adjust the moisture content of the mixture, if required, by adding water or by aerating with dry air. Introduce the mixture into the composting vessels.

Place the composting vessels in the test environment at 25 °C ± 5 °C and initiate aeration using water-saturated, carbon-dioxide-free air. This can be produced by passing the air through wash-bottles filled with sodium hydroxide solution. Use a sufficiently high flow rate to ensure that aerobic conditions are maintained during the test throughout each composting vessel. Check the air flow regularly at each outlet, e.g., by using wash-bottles, to ensure that there are no leaks in any part of the system. Handle the reference material (Cellulose) in the same way as the test material. The vessels for the blank contain only inoculum. It shall have the same amount of total dry solids as the vessels with test material.

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Measure the amount of carbon dioxide evolved from the exhaust air of each composting vessel at intermediate time intervals directly using a gas chromatograph, a TOC or an infrared analyzer or, alternatively, measure the cumulative carbon dioxide evolved as dissolved inorganic carbon (DIC) after absorption in sodium hydroxide solution. The frequency of measurement will depend on the measurement method used, the desired precision of the biodegradation curve and the biodegradability of the test mixture. If direct measurement is used, the carbon dioxide evolved at least twice per day at time intervals of about 6 h during the biodegradation phase and once per day later on during the plateau phase. Shake the composting vessels weekly to prevent extensive channeling and to ensure uniform attack of the microorganisms on the test material. Ensure that the humidity of the test mixture in the composting vessels is neither too high nor too low by visual observation.

During the weekly agitation of the composting vessels and at the end of the test period, record any visual observations with regard to the appearance of the compost, such as structure, moisture content, colour, fungal development, smell of the exhaust air and disintegration of the test material.

Incubate the composting vessels for a period not exceeding 12 months at a constant temperature of will be 25 °C ± 5 °C which is representative of full-scale composting. The incubation period can be extended until a constant plateau phase is reached, if significant biodegradation of the test material is still observable. Alternatively, the incubation period can be shortened if the plateau phase is reached earlier.

CALCULATIONS:

Calculation of the theoretical amount of carbon dioxide

Calculate the theoretical amount of carbon dioxide $ThCO_2$, in grams per vessel, which can be produced by the test material using Equation:

$$\mathbf{ThCO_2 = M_{TOT} \times C_{TOT} \times 44/12}$$

Where,

M_{TOT} is the total dry solids, in grams, in the test material introduced into the composting vessels at the start of the test;

C_{TOT} is the proportion of total organic carbon in the total dry solids in the test material, in grams per gram;

44 and 12 are the molecular mass of carbon dioxide and the atomic mass of carbon, respectively.

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Calculation of the percentage biodegradation

From the cumulative amounts of carbon dioxide released, calculate the percentage biodegradation Dt of the test material for each measurement interval using Equation (2):

$$Dt = \frac{(CO_2)_T - (CO_2)_B}{ThCO_2} \times 100$$

Where,

$(CO_2)_T$ is the cumulative amount of carbon dioxide evolved in each composting vessel containing test material, in grams per vessel;

$(CO_2)_B$ is the mean cumulative amount of carbon dioxide evolved in the blank vessels, in grams per vessel;

$ThCO_2$ is the theoretical amount of carbon dioxide which can be produced by the test material, in grams per vessel.

If the differences between the individual results are less than 20 %, calculate the average percentage biodegradation.

Use the same equation to calculate the degree of biodegradation of the reference material (Cellulose).

Calculate the percentage loss in mass of the test material (Optional), i.e.,

The percentage degree of biodegradation Dv calculated from the loss in volatile solids,

$$Dv = \frac{mat_{deg}}{mat_{vfs}} \times 100$$

Where,

mat_{deg}: the amount of degraded test material

mat_{vfs}: the total volatile solids

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Table 4: Information of inoculum used in the study

Parameters	Requirement	Result
Source	-	Well aerated Compost
Age	-	1 months old
Date of Collection	-	14.02.2024
Pre- treatment	-	Sieve with 0.5 to 1 cm
Storage and handling	-	4^{o} C ± 2^{o} C
Stabilization	-	Stabilized
TOC of inoculum	-	1.95 %
Total Dry Solids	50 % and 55 % of the wet solids	53.75 %
Volatile Solids	>15 % of the wet	28.31 %
	>30 % of the dry solids	49.64 %
pH of the Inoculum	7.0 to 9.0	7.32
Total Nitrogen Content	-	0.92 %
Volatile Fatty Acid	-	<0.1 mg/kg

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Table 5: Details of the reactor

Particulars	**Test sample**			**Reference material (Cellulose)**		
	SET I	**SET II**	**SET III**	**SET I**	**SET II**	**SET III**
Weight ratio of Inoculum to Sample	6:1					
Amount of inoculum used for study	300.53 g	300.64 g	300.10 g	300.27 g	300.51 g	300.29 g
Amount added	50.2375 g	50.2353 g	50.2174 g	50.0825 g	50.1348 g	50.0531 g
Volume of the vessel	2000 ml	2000 ml	2000 ml	2000 ml	2000 ml	2000 ml
Weight of vessel	1057 g	1055 g	1058 g	1054 g	1055 g	1059 g
Total weight of each vessel	1407.77 g	1405.88 g	1408.32 g	1404.35 g	1405.64 g	1409.34 g
Test Environment and incubation conditions	25 ^{o}C ± 5 ^{o}C					
Equipment used to determine the CO2 evolved from composting vessel	Absorbed in Barium hydroxide $Ba(OH)_2$ solution and the amount of CO_2 will be determined by titrating with Hydrochloric acid (HCl).					
$ThCO_2$ in mg	79988.33	79988.33	79988.33	77128.33	77128.33	77128.33
Total weight of each vessel after biodegradation	1362.38 g	1359.29 g	1364.17 g	1369.03 g	1372.05 g	1363.56 g

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Table 6: Net CO_2 Evolution Data of Reference material (Cellulose) and Test samples

Days	Net Carbon dioxide evolved (in milligram)							
	Reference Material (Cellulose)			Average	Test sample			Average
	SET I	SET II	SET III		SET I	SET II	SET III	
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3757.60	3753.20	3740.00	3750.27	1368.40	1302.40	1368.40	1346.40
6	7598.80	7612.00	7594.40	7601.73	2851.20	2785.20	2802.80	2813.07
8	11510.40	11567.60	11488.40	11522.13	3819.20	3784.00	3766.40	3789.87
10	15281.20	15298.80	15232.80	15270.93	4950.00	4835.60	4822.40	4869.33
14	19368.80	19421.60	19342.40	19377.60	6419.60	6331.60	6358.00	6369.73
18	23636.80	23658.80	23588.40	23628.00	7999.20	7876.00	7937.60	7937.60
21	27750.80	27777.20	27676.00	27734.67	9187.20	9064.00	9130.00	9127.07
24	31710.80	31719.60	31614.00	31681.47	10463.20	10362.00	10441.20	10422.13
27	35657.60	35679.60	35591.60	35642.93	12342.00	12254.00	12364.00	12320.00
30	39718.80	39758.40	39613.20	39696.80	14146.00	14097.60	14198.80	14147.47
34	43472.00	43564.40	43379.60	43472.00	16390.00	16363.60	16464.80	16406.13
37	47555.20	47678.40	47454.00	47562.53	18986.00	18906.80	19052.00	18981.60
40	51334.80	51471.20	51255.60	51353.87	21142.00	21054.00	21199.20	21131.73
45	55246.40	55356.40	55105.60	55236.13	23201.20	23157.20	23320.00	23226.13
48	58009.60	58071.20	57833.60	57971.47	24816.00	24820.40	24930.40	24855.60
52	60601.20	60649.60	60420.80	60557.20	26074.40	26118.40	26206.40	26133.07
60	63932.00	63962.80	63769.20	63888.00	28226.00	28314.00	28327.20	28289.07
67	67830.40	67848.00	67702.80	67793.73	30998.00	31028.80	31086.00	31037.60
72	71293.20	71302.00	71200.80	71265.33	33611.60	33602.80	33699.60	33638.00
80	75103.60	75116.80	74993.60	75071.33	36647.60	36586.00	36678.40	36637.33
90	78663.20	78667.60	78584.00	78638.27	39894.80	39894.80	39947.60	39912.40
97	81738.80	81677.20	81642.00	81686.00	42614.00	42627.20	42640.40	42627.20
102	-	-	-	-	45205.60	45227.60	45245.20	45226.13
110	-	-	-	-	47691.60	47726.80	47731.20	47716.53
120	-	-	-	-	50199.60	50155.60	50234.80	50196.67
127	-	-	-	-	53204.80	50982.80	51057.60	51748.40
135	-	-	-	-	54964.80	52725.20	52852.80	53514.27
142	-	-	-	-	57362.80	55105.60	55250.80	55906.40
150	-	-	-	-	59470.40	57195.60	57354.00	58006.67
157	-	-	-	-	61789.20	59571.60	59690.40	60350.40
165	-	-	-	-	64116.80	61912.40	62026.80	62685.33
172	-	-	-	-	67148.40	64952.80	65027.60	65709.60

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Days	Net Carbon dioxide evolved (in milligram)							
	Reference Material (Cellulose)			Average	Test sample			Average
	SET I	SET II	SET III		SET I	SET II	SET III	
175	-	-	-	-	69172.40	66941.60	67082.40	67732.13
182	-	-	-	-	71768.40	69546.40	69674.00	70329.60
190	-	-	-	-	74725.20	72472.40	72613.20	73270.27
197	-	-	-	-	77052.80	74830.80	74923.20	75602.27
206	-	-	-	-	78733.60	76529.20	76639.20	77300.67
212	-	-	-	-	80220.80	77963.60	78117.60	78767.33
220	-	-	-	-	81778.40	79464.00	79640.00	80294.13
225	-	-	-	-	83217.20	80845.60	81026.00	81696.27

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Table 7: Percent Biodegradation of Reference material (Cellulose) and Test samples

Days	Percent Biodegradation							
	Reference Material (Cellulose)			Average	Test sample			Average
	SET I	SET II	SET III		SET I	SET II	SET III	
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	4.84	4.83	4.81	4.83	1.68	1.60	1.68	1.65
6	9.75	9.77	9.75	9.76	3.47	3.38	3.41	3.42
8	14.71	14.79	14.68	14.73	4.57	4.53	4.51	4.53
10	19.51	19.53	19.45	19.50	5.90	5.75	5.74	5.79
14	24.71	24.78	24.68	24.72	7.64	7.53	7.56	7.57
18	30.14	30.17	30.08	30.13	9.51	9.36	9.44	9.44
21	35.32	35.35	35.22	35.30	10.85	10.70	10.78	10.77
24	40.36	40.37	40.24	40.33	12.36	12.23	12.33	12.31
27	45.38	45.41	45.30	45.36	14.61	14.50	14.64	14.58
30	50.54	50.59	50.40	50.51	16.76	16.70	16.83	16.76
34	55.25	55.37	55.13	55.25	19.42	19.38	19.51	19.44
37	60.41	60.57	60.28	60.42	22.53	22.43	22.62	22.53
40	65.21	65.38	65.10	65.23	25.13	25.02	25.20	25.11
45	70.16	70.30	69.98	70.15	27.59	27.54	27.74	27.62
48	73.58	73.66	73.35	73.53	29.45	29.45	29.59	29.50
52	76.82	76.89	76.59	76.77	30.91	30.97	31.08	30.99
60	81.01	81.05	80.79	80.95	33.47	33.58	33.60	33.55
67	85.91	85.93	85.74	85.86	36.79	36.83	36.90	36.84
72	90.30	90.31	90.18	90.26	39.96	39.95	40.07	39.99
80	95.08	95.10	94.94	95.04	43.61	43.53	43.65	43.59
90	99.60	99.61	99.50	99.57	47.57	47.57	47.64	47.59
97	100.00	100.00	100.00	100.00	50.82	50.84	50.86	50.84
102	-	-	-	-	53.93	53.96	53.98	53.96
110	-	-	-	-	56.89	56.93	56.94	56.92
120	-	-	-	-	59.88	59.82	59.92	59.87
127	-	-	-	-	63.52	60.75	60.84	61.70
135	-	-	-	-	65.58	62.78	62.94	63.77
142	-	-	-	-	68.38	65.56	65.74	66.56
150	-	-	-	-	70.87	68.02	68.22	69.04
157	-	-	-	-	73.63	70.86	71.01	71.83
165	-	-	-	-	76.41	73.65	73.80	74.62
172	-	-	-	-	80.05	77.31	77.40	78.25

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Days	Percent Biodegradation							
	Reference Material (Cellulose)			Average	Test sample			Average
	SET I	SET II	SET III		SET I	SET II	SET III	
175	-	-	-	-	82.49	79.70	79.88	80.69
182	-	-	-	-	85.59	82.81	82.97	83.79
190	-	-	-	-	89.18	86.36	86.54	87.36
197	-	-	-	-	92.00	89.22	89.33	90.18
206	-	-	-	-	93.95	91.20	91.34	92.16
212	-	-	-	-	95.67	92.84	93.04	93.85
220	-	-	-	-	97.49	94.60	94.82	95.63
225	-	-	-	-	99.12	96.16	96.39	97.22

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Table 8: Average Percentage Biodegradation of Reference material (Cellulose) and Test samples

Day	Percent Biodegradation	
	Reference material (Cellulose)	Test sample
0	0.00	0.00
3	4.83	1.65
6	9.76	3.42
8	14.73	4.53
10	19.50	5.79
14	24.72	7.57
18	30.13	9.44
21	35.30	10.77
24	40.33	12.31
27	45.36	14.58
30	50.51	16.76
34	55.25	19.44
37	60.42	22.53
40	65.23	25.11
45	70.15	27.62
48	73.53	29.50
52	76.77	30.99
60	80.95	33.55
67	85.86	36.84
72	90.26	39.99
80	95.04	43.59
90	99.57	47.59
97	100.00	50.84
102	-	53.96
110	-	56.92
120	-	59.87
127	-	61.70
135	-	63.77
142	-	66.56
150	-	69.04
157	-	71.83
165	-	74.62
172	-	78.25
175	-	80.69

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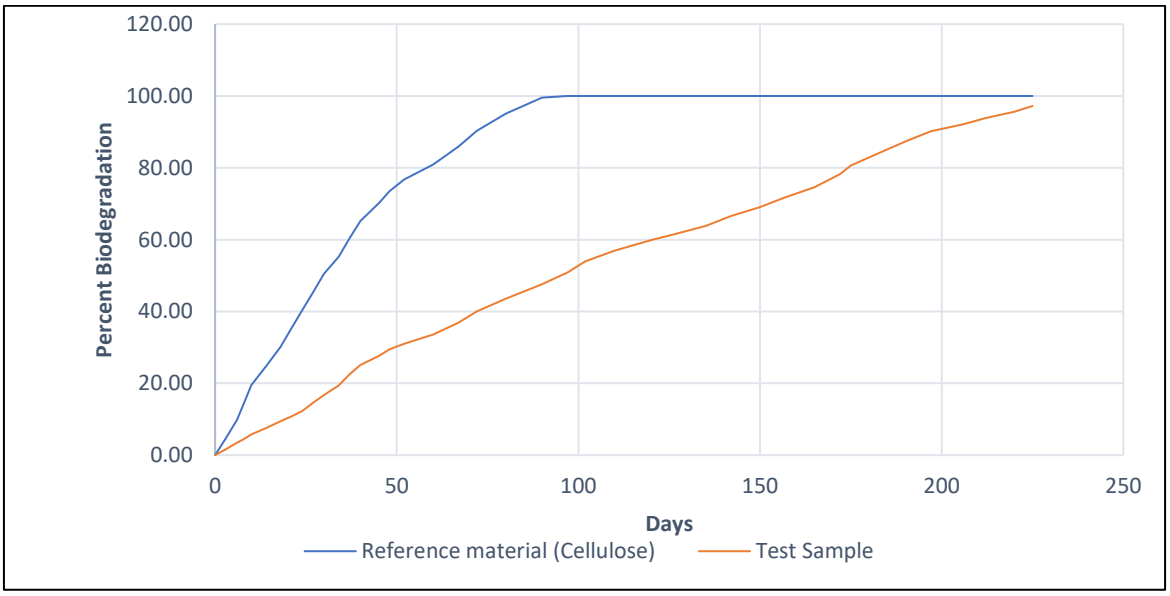
Day	**Percent Biodegradation**	
	Reference material (Cellulose)	**Test sample**
182	-	83.79
190	-	87.36
197	-	90.18
206	-	92.16
212	-	93.85
220	-	95.63
225	-	97.22

The FILOBEV 2s was subjected to biodegradation as per AS ISO 14855-1 biodegradability under controlled composting conditions at 25 ± 5°C and biodegradability was determined by measuring the actual metabolic conversion of the compostable material into carbon dioxide using the standard test method. After incubation, the reference material (Cellulose) and FILOBEV 2s gradually biodegraded. The reference material (Cellulose) showed around 100 % after 97 days while the FILOBEV 2s showed 97.22 % after 225 days. (Graph 4).



Graph 4: Percentage biodegradation of FILOBEV 2s under aerobic composting conditions

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Table 9: Mass loss determination

Test vessel	Initial amount of Test sample	Final amount of Test sample	Mass loss
SET I	50.2375 g	No Mass retained	> 99 %
SET II	50.2353 g	No Mass retained	> 99 %
SET III	50.2174 g	No Mass retained	> 99 %

Table 10: Characteristics of biowaste at start and end of the test

Characteristics	Result		
	Unit	Before	After
Total solids (TS, %)	%	53.75	51.09
Moisture content (%)	%	56.26	54.64
Volatile solids (VS, % on TS)	%	84.19	78.49
pH	-	7.32	7.95
Odour	Organoleptic	Mild acidic odour	Mild acidic odour
Color	Visual	Light brown to light yellow	Light brown
Visual appearance	Visual	Paper Board	No Mass retained
Fungal Development	-	No fungal Growth	No fungal Growth

Table 11: Validity of the test:

Test parameter	Acceptance criteria	Results
Degree of biodegradation of the reference material (Cellulose)	> 70% after 45 days	70.15
Difference in the percentage of biodegradation across three replicates of the reference material (Cellulose)	< 20 %	< 20 %
Carbon Dioxide produced by Inoculum in the blank over the first 10 days of the test (mg CO_2 produced per g of volatile solids)	50 – 150 mg CO_2 / g	71.87

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Disintegration during Composting

PRINCIPLE:

The method determines the degree of disintegration of test materials in a laboratory scale composting under conditions simulating a controlled and monitored aerobic composting process. The solid matrix used consists of a synthetic solid waste inoculated with mature compost taken from a municipal or industrial composting plant. Pieces of the plastic test material are incubated with this prepared solid matrix. The degree of disintegration is determined after a composting cycle, by sieving the final matrix through a 2 mm sieve in order to recover the non-disintegrated residues. The reduction in mass of the test sample is considered as disintegrated material and used to calculate the degree of disintegration.

SYNTHETIC SOLID WASTE

Well aerated compost from a municipal or industrial aerobic composting plant shall be used as the inoculum. The compost inoculum shall be homogeneous and free from large inert objects such as glass, stones, or pieces of metal. Remove any such objects manually and then sieve the compost on a screen of mesh aperture between 0.5 cm and 1 cm. It is recommended that compost from a plant composting the organic fraction of solid municipal waste be used in order to ensure sufficient diversity of microorganisms. The synthetic waste shall have a carbon: nitrogen (C/N) ratio of between 20:1 and 40:1.

Material	**Dry mass %**
Sawdust	40
Rabbit-feed	30
Ripe compost	10
Corn starch	10
Saccharose	5
Cornseed oil	4
Urea	1
Total	**100**

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COMPOSTING REACTOR

Prepare a minimum of three reactors for each test material in composting reactor is a box made of conventional plastic (polypropylene). The box is covered with a lid assuring a tight seal to avoid excessive evaporation. Additionally, any gap between box and lid is sealed with adhesive tape. In the middle of the two 20 cm wide sides, a hole of 5 mm diameter is made approximately 6.5 cm from the bottom of the box. These two holes provide gas exchange between the inner atmosphere and the outside environment and shall not be blocked.

PROCEDURE:

Cut up test material to give pieces with the dimensions defined below, based on the thickness of the material. Dry the pieces of test material in an oven at (40 ± 2 °C) under vacuum for the length of time needed to reach constant mass. Do not compress the mixture, allowing efficient gas exchange with the interior of the bed.

Take between 5 g and 20 g of test material per reactor, depending on the volume occupied by the test material, and mix it with 1 kg of wet synthetic waste. The ratio of the mass of test material to the mass of wet synthetic waste shall be in the range from 0.5 % to 2 %. Place the mixture on the bottom of the reactor, forming a homogeneous layer.

Thickness of test material	**Dimensions of pieces mm**
< 5mm	(25 to 50) × (25 to 50) × original thickness
>5 mm	(15 to 25) × (15 to 25) × thickness (from 5 mm to 15 mm)

There are two modes of incubation. Type 1: the reactors are incubated at constant temperature and Type 2: the reactors are incubated at two different temperatures

Record the mass of test material in each reactor. To ensure a good composting process, aerates the composting matter whilst maintaining sufficient water content. The gross mass of the reactor filled with the mixture is determined at the beginning of the composting process. At each scheduled point in time, the reactor is weighed and, if needed, the initial mass restored totally or in part by adding chlorine-free tap water, de-ionized water, or distilled water. It is important to note that the optimum water concentration is obtained when the composting matter is wet, but no free water is present. The composting reaction is monitored by inspecting the composting matter when mixing and adding water. The diagnostic parameters will be recorded.

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Table 12: Information of inoculum used in the study

Parameters	Requirement	Result
Source	-	Biowaste
Age	Maximum 4 months old	3 months
Date of Collection	-	09.01.2024
Stabilization	Fresh or stabilized	Stabilized
Pre- treatment	None or filtration if necessary	Filtration
Storage and handling	-	Stored at ambient temperature (18 - 25°C), typically used immediately, or kept at a lower temperature if storage is required
TOC of inoculum	-	1.97 %
Total Dry Solids	50 % and 55 % of the wet solids	53.43 %
Volatile Solids	>15 % of the wet	85.19 %
	>30 % of the dry solids	37.64 %
pH of the Inoculum	7.0 to 9.0	7.75
Total Nitrogen Content	-	0.08 %
C/N ratio	-	25:1
Odour	-	Mild acidic odour
Visual appearance	-	Light brown to light yellow

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Table 13: Details of the Bioreactor

Details	**Result**
Bioreactor used	Conventional plastic (e.g. polypropylene)
Dimensions of the Bioreactor	30 cm × 20 cm × 10 cm (*l*, *w*, *h*)
Sieves Used	0.5 cm, 1 cm, 2 mm, 5 mm, and 10 mm

Table 14: Details of the reactor

Details	**Reactor 1**	**Reactor 2**	**Reactor 3**
Serial Number	1773689 A	1773689 B	1773689 C
Designation	Pilot scale	Pilot scale	Pilot scale
Amount of Synthetic waste	1000 g	1000 g	1000 g
Amount of Sample	10.5315 g	10.4973 g	10.3458 g
Amount of Sample (Cryo-grinded)	90.0217 g	90.1032 g	90.0316 g
Total Amount of Synthetic waste + Sample	1100.55 g	1100.60 g	1100.38 g
Initial Mass of the reactor	1899.67 g	1897.43 g	1895.70 g

Table 15: Characteristics of the synthetic solid waste before composting

Parameters		**Results**
Odour		Mild acidic odour
Visual appearance		Light brown to light yellow
Chemical analysis	pH	7.75
	Total Carbon / Total Nitrogen (C/N ratio)	25:1
Dry Mass		53.43 %
Volatile solid		85.19 %

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Termination of the test and measurement of the degree of disintegration

Remove lids from reactors. If the contents are wet, leave at room temperature for 2-3 days to dry. Break up lumps of compost gently, avoiding damage to test material. Stop drying when constant mass is achieved. Start sieving with a 10 mm sieve. Examine the fraction that doesn't pass through. Break up lumps gently and allow particles to pass through. Collect and store test material that doesn't pass through. Repeat sieving with 5 mm and 2 mm sieves, following the same procedure Pool collected test material, clean off compost, and wash if necessary. Dry the test material in an oven at (40 ± 2) °C under vacuum until constant mass is reached. Record final mass.

The compost from each reactor shall be sieved, using standard sieves.

Table 16: Characteristic of final compost after sieving

Characteristics	Reactor 1	Reactor 2	Reactor 3
Odour	Mild acidic odour	Mild acidic odour	Mild acidic odour
pH	6:51	6:83	6:71
C/N ratio	10:1	10:1	10:1
Total mass	1048.94 g	1047.45 g	1051.77 g
Dry Mass	49.29 %	48.12 %	50.95 %
Volatile solid content	46.58 %	45.04 %	45.84 %
Decrease R in total volatile solid content	58.77 %	61.17 %	58.23 %

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Table 17: Composting procedure

Days	Reactor 1			Reactor 2			Reactor 3		
	Mass of reactor (g)	Amount of water added (g)	Observation (Turning) (yes)	Mass of reactor (g)	Amount of water added (g)	Observation (Turning) (yes)	Mass of reactor (g)	Amount of water added (g)	Observation (Turning) (yes)
0	1899.67	-	Yes	1897.43	-	Yes	1895.70	-	Yes
7	1887.27	12.4	Yes	1885.93	11.5	Yes	1882.40	13.3	Yes
15	1885.17	14.5	Yes	1881.73	15.7	Yes	1879.50	16.2	Yes
21	1885.77	13.9	Yes	1884.43	13	Yes	1883.60	12.1	Yes
28	1888.47	11.2	Yes	1885.03	12.4	Yes	1881.50	14.2	Yes
35	1882.87	16.8	Yes	1881.53	15.9	Yes	1879.30	16.4	Yes
42	1885.57	14.1	Yes	1882.13	15.3	Yes	1881.30	14.4	Yes
49	1887.17	12.5	Yes	1885.83	11.6	Yes	1882.30	13.4	Yes
56	1887.37	12.3	Yes	1883.93	13.5	Yes	1881.70	14	Yes
73	1886.07	13.6	Yes	1884.73	12.7	Yes	1883.90	11.8	Yes
84	1889.27	10.4	Yes	1885.83	11.6	Yes	1882.30	13.4	Yes
95	1889.97	9.7	Yes	1888.63	8.8	Yes	1886.40	9.3	Yes
115	1890.47	9.2	Yes	1887.03	10.4	Yes	1886.20	9.5	Yes
125	1889.47	10.2	Yes	1888.13	9.3	Yes	1884.60	11.1	Yes
150	1890.57	9.1	Yes	1887.13	10.3	Yes	1884.90	10.8	Yes
160	1890.07	9.6	Yes	1888.73	8.7	Yes	1885.90	9.8	Yes
175	1889.07	10.6	Yes	1888.93	8.5	Yes	1886.50	9.2	Yes

The following table represents the photos of FILOBEV 2s taken during the composting process.

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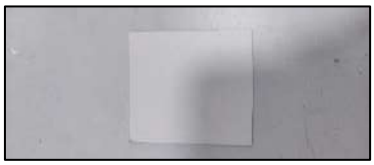
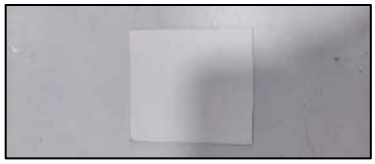
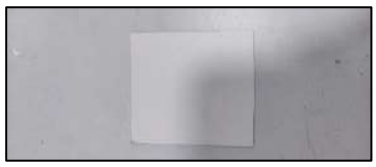
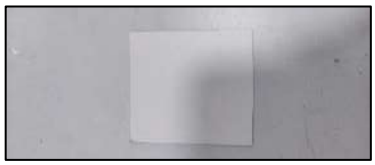
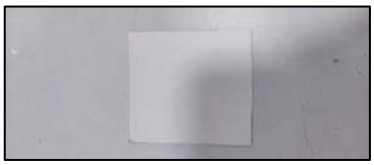
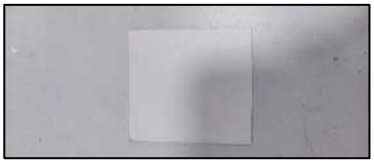
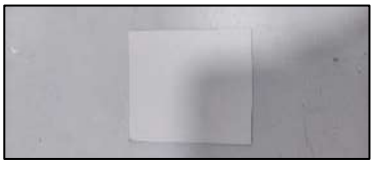
Table 18: Represents photos of FILOBEV 2s evolving in composting process.

Days	Initial Image of test sample	Image of test sample after test Intervals	Observation
15th day			The material turned brown and soft
30th day			The material turned Extremely soft and fragile and
45th day			The edges of the material also began to be worn out
70th day			Some smaller fragments were detected
95th day			Few fragments were found during visual inspection
120th day			Very few and small fragments were found during visual inspection
145nd day			Very few and small fragments were found during visual inspection

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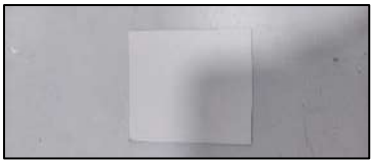
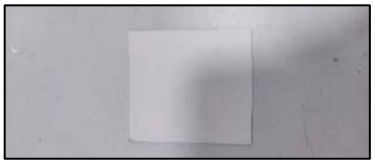
160th day			Very few and small fragments were found during visual inspection
180th day			Very few and small fragments were found during visual inspection

Visual perceptions and disintegration

The mixture in the composting bin was regularly turned by spatula or a common spoon, at which time the visual appearance of the different test items was carefully checked. Figure 3 gives a visual presentation of a FILOBEV 2s at start of the test and after 180 days, FILOBEV 2s has disintegrated and 0.90 % of its original dry weight is retained after sieving on a 2.0-mm sieve.

(A)

(B)

Figure 3: Visual presentation of FILOBEV 2s at start of test (Image A) and after 180 days of composting (Image B).

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Calculation of degree of disintegration

The plastic material recovered from the sieving procedure is considered to be non-disintegrated material. The material which passed through the sieves is considered to have disintegrated. The degree of disintegration, *D*, is calculated, in %, using Formula below

$$D = \frac{mi - mr}{mi} \times 100$$

Where,

*m*i = is the initial dry mass of the test material.

*m*r = is the dry mass of the residual test material recovered by sieving.

Table 19: Degree of Disintegration

Test vessel (Reactor)	Initial amount of Test sample	Final amount of Test sample	Disintegration
Reactor 1	10.5315 g	0.0914 g	99.13 %
Reactor 2	10.4973 g	0.0839 g	99.20 %
Reactor 3	10.3458 g	0.1058 g	98.98 %

Table 20: Average Degree of Disintegration

Initial amount of Test sample	Final amount of Test sample	Degree of disintegration
10.4582 g	0.0937 g	99.10 %

After 142 days, the degree of disintegration for the FILOBEV 2s is 99.10 %.

Table 21: Validity of the test

Test parameter	Acceptance criteria	Results
Decrease in Volatile solid content	> 30%	59.39 %
Difference in the degrees of disintegration for the three replicates	< 20%	<20 %

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NO ADVERSE EFFECTS OF COMPOST ON TERRESTRIAL ORGANISMS

In order to ensure that the composting of plastic products or materials does not have any harmful effects on the finished compost or on the environment, all requirements specified shall be met.

Ecotoxicity test scheme: Ecotoxicity tests are performed with compost samples produced with and without the addition of a plastics product or a material to determine and assess possible harmful effects on terrestrial organisms. The test scheme considers:

- All relevant terrestrial organism groups such as plants, earthworms (invertebrates) and microorganisms.

Organism group	**Test methods**
Plants: - higher plants	Plant growth test according to OECD 208, Annex. E of EN 13432)
Invertebrates: - earthworms	Acute earthworm test according to ASTM E1676

The sample shall have no adverse effect on the environment, which includes terrestrial organisms. After disintegration, the FILOBEV 2s was subjected to eco-toxicity testing to check its effect on the environment. The results of Ecotoxicity are mentioned in Table 22 to 27.

PRINCIPLE OF OECD 208:

Seeds are placed in contact with soil treated with the test substance and evaluated for effects following 14 to 21 days after 50% emergence of the seedlings in the control group. Endpoints measured are visual assessment of seedling emergence, biomass (fresh or dry shoot weight, or shoot height) and visual detrimental effects (chlorosis, mortality, plant development abnormalities, etc.). Measurements are made at least weekly or more often when recording the emergence of the seeds and compared to those of untreated control plants.

VALIDITY OF THE TEST:

For the test to be considered **Valid,** the following performance criteria must be met in the controls:

- the seedling emergence is at least 70%.
- the seedlings do not exhibit visible phytotoxic effects (e.g. chlorosis, necrosis, wilting, leaf and stem deformations) and the plants exhibit only normal variation in growth and morphology for that particular species.
- the mean control survival is at least 90% for the duration of the study.
- environmental conditions for a particular species are identical and growing media contain the same amount of soil matrix, support media, or substrate from the same source.

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DESCRIPTION OF THE METHOD

Production of compost:

After 142 days of disintegration, Test sample compost and blank compost are sieved through a standard 10 mm sieve individually. Separate the sieved material further by sieving it through a standard 2 mm sieve. Compost obtained is used for the toxicity test as per the ratio mentioned in preparation of sample and blank mixtures.

Preparation of mixtures of sample and blank compost:

For preparing the mixture use reference soil with 25% and 50% (m/m or v/v) of the compost. Compost obtained after disintegration of the test material (sample compost) and the blank compost obtained from the parallel process after addition of test material. Prepare the concentration as mentioned below.

As per EN 13432 Annex E

1) **Test Sample:**

   Mixture 1 - 25 % (25 % of Sample compost after disintegration + 75 % reference soil)

   Mixture 2 - 50 % (50% of Sample compost after disintegration + 50 % reference soil)

2) **Blank:**

   Mixture 1 - 25 % (25% of Blank compost + 75 % reference soil)

   Mixture 2 - 50 % (50% of Blank compost + 50 % reference soil)

SELECTION OF PLANT SPECIES

PLANT SPECIES USED:

1. **Monocot**

   Family: *Brassicaceae*

   Species: *Brassica sinapis alba*

   Common name: Mustard

2. **Dicot**

   Family: *Poaceae*

   Species: *Triticum aestivum*

   Common name: Wheat

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PROCEDURE:

Fill each tray with a minimum of 200 g of the sample and add as a minimum 100 seeds on the top. Cover the seeds with a thin layer of inert material such as siliceous sand or perlite. Perform the test in triplicate for each mixture. Add water until 70% to 100 % of the water holding capacity is reached. Supply evaporated water periodically during the whole test duration as needed.

TEST CONDITIONS:

The test conditions should approximate those conditions necessary for normal growth for the species and varieties tested.

The following conditions are generally recommended for greenhouse testing:

• temperature: 22°C ± 10°C

• humidity: 70 % ± 25%

• photoperiod: minimum 16-hour light

• light intensity: 350 ± 50 µE/m2 /s

The Test Sample and Blank must be kept under the same environmental conditions; however, adequate measures should be taken to prevent cross exposure.

The texture of the compost used is sandy with organic carbon 2.65 % and pH 7.14 and salt content as electrical conductivity is 3.38 (mS/cm).

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Impact of compost on plant growth:

Table 22: Germination Rate and Biomass of *Brassica sinapis alba* and *Triticum aestivum* seeds after 21days.

	Plant species	Dose	Germination Rate (%)	Biomass (g)	Shoot Length (cm)	Root Length (cm)
Blank	*Brassica sinapis alba*	25%	100	0.0699	10.2	4.6
		25%	100	0.0711	12.4	5.2
		25%	99	0.0745	11.3	4.1
		50%	100	0.0744	10.0	5.1
		50%	99	0.0621	9.1	4.3
		50%	99	0.0711	10.5	5.2
	Triticum aestivum	25%	100	0.1541	13.4	7.3
		25%	99	0.1441	14.7	6.5
		25%	99	0.1584	13.5	6.1
		50%	99	0.1422	12.4	5.2
		50%	99	0.1423	12.2	6.1
		50%	99	0.1501	15.1	7.2

	Plant species	Dose	Germination Rate (%)	Biomass (g)	Shoot Length (cm)	Root Length (cm)
Test Sample	*Brassica sinapis alba*	25%	96	0.0651	10.5	4.9
		25%	95	0.0681	9.3	4.2
		25%	95	0.0732	9.6	3.1
		50%	96	0.0695	8.2	5.3
		50%	95	0.0613	9.1	3.2
		50%	95	0.0675	10.2	4.4
	Triticum aestivum	25%	96	0.1501	10.4	6.1
		25%	98	0.1411	11.5	6.3
		25%	97	0.1499	11.7	7.5
		50%	96	0.1413	12.2	5.6
		50%	97	0.1385	11.6	6.1
		50%	96	0.1436	12.2	5.6

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Table 23: Average germination Rate and Biomass of *Brassica sinapis* alba and *Triticum aestivum* seeds after 21days.

	Plant species	**Dose**	**Germination Rate (%)**	**Biomass (g)**	**Shoot Length (cm)**	**Root Length (cm)**
Blank	*Brassica sinapis alba*	25%	100	0.0718	11.3	4.6
		50%	99	0.0692	9.9	4.9
	Triticum aestivum	25%	99.33	0.1522	13.9	6.6
		50%	99.00	0.1449	13.2	6.2

	Plant species	**Dose**	**Germination Rate (%)**	**Biomass (g)**	**Shoot Length (cm)**	**Root Length (cm)**
Test Sample	*Brassica sinapis alba*	25%	95	0.0688	9.8	4.1
		50%	95	0.0661	9.2	4.3
	Triticum aestivum	25%	97	0.1470	11.2	6.6
		50%	96	0.1411	12.0	5.8

	Plant species	**Dose**	**Germination rate (%) as compared with Blank**	**Dry biomass (%) as compared with Blank**
Test Sample	*Brassica sinapis alba*	25%	96	96
		50%	96	96
	Triticum aestivum	25%	98	97
		50%	97	97

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Blank 25%	**Blank 50%**
	
Test Sample 25 %	**Test Sample 50%**

Figure 4: Effect of compost FILOBEV 2s on *Triticum aestivum* growth

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Blank 25%	**Blank 50%**
	
Test Sample 25%	**Test Sample 50%**

Figure 5: Effect of compost FILOBEV 2s on *Brassica sinapis alba* growth

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Acute earthworm test according to ASTM E1676

PRINCPLE

Eisenia fetida species of earthworm are used for earthworm toxicity testing. The artificial test involves keeping earthworms in samples of a precisely defined artificial soil to which a range of concentrations of the test substance has been applied. Mortality is assessed 14 days after application. Control is used to assure that effects observed are associated with or attributed only to the test substance exposure. The earthworm is brought from Vermicomposting beds. The mean survival of all controls should be more than 90 percent at the end of the test. The toxicity of test soils or the bioavailability of contaminants are assessed during the continuous exposure of terrestrial organisms.

Soils tested may be the following:

1. soils collected from potentially contaminated sites,
2. soils collected from reference sites,
3. artificial soil (see Annex A2) spiked with compounds,
4. site soil spiked with compounds,
5. reference soil spiked with compounds,
6. site soil diluted with artificial soil,
7. site soil diluted with reference soil, or
8. reference soil diluted with artificial soil.

A negative control of artificial or reference soil is used for the following:

1. to yield a measure of the acceptability of the test;
2. to provide evidence of the health and relative quality of the test organisms.
3. to determine the suitability of test conditions, food, and handling procedures; and
4. to provide a basis for interpreting data obtained from the test soils.

Specified data are obtained to determine the toxic effects on survival or sublethal endpoints for 7 to 28-day exposures or containment bioaccumulation for 28-day exposures to terrestrial lumbricids and the toxic effects on survival or sublethal endpoints for 4 to 42-day exposures to enchytraeids.

Validity:

The mortality in the controls should not exceed 10 percent at the end of either test.

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Earthworm Species used: *Eisenia fetida*

Preparation of compost:

After 142 days, test soil is sieved through a standard 10 mm sieve, Separate the sieved material further by again sieving it through a standard 2 mm sieve. Compost obtained is used for the test. The mixture prepared a concentration of 25% and 50% (m/m or v/v) of the sample compost.

For each test, 700 g of the test medium is placed into each glass container and ten earthworms are placed on the test medium surface.

The containers are covered with perforated plastic film to prevent the test medium from drying and kept under the test conditions for 14 days. The test duration is 14 days (assessment of mortality at 7 and 14 days), and the test temperature is 22° ± 3°C. Testing is done in continuous light (to ensure that worms remain in the test medium throughout duration of test). The mortality and biomass changes is assessed at 7 and 14 days. emptying test medium onto a glass tray or plate, sorting worms from the medium and testing their reaction to a mechanical stimulus at the front end. After the 7-day assessment worms and medium are replaced in the test container. The behavioral or pathological symptoms are studies and noted.

The earthworm acute results are as follow:

Table 24: pH, Temperature and Moisture content of Test soil before and after study.

Concentration	Test Initiation Moisture content (%)	Test Initiation pH	Test Initiation Temperature °C	Test Termination Moisture content (%)	Test Termination pH	Test Termination Temperature °C
Blank	39.73	7.20	22.1	37.26	7.26	22.2
Test Sample	40.15	7.29	22.0	38.48	7.37	22.1

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Table 25: Average weight of earthworms before and after study and difference in weight.

Particulars		**Average Initial weight (g)**	**Average Final weight (g)**	**Mean difference in weight (g)**	**Percentage weight**
Blank	**25 %**	0.5568	0.5738	0.0170	3.06
	50 %	0.5318	0.5448	0.0131	2.45
Test Sample	**25 %**	0.5604	0.5750	0.0146	2.60
	50 %	0.5424	0.5621	0.0197	3.63

The average weight of earthworms increased as compared to control, no weight loss was observed at the end of the test duration.

Table 26: Mortality rate of earthworms after study

Particulars		**Mortality (%)**
Blank	**25 %**	0
	50 %	0
Test Sample	**25 %**	0
	50 %	0

The mortality rate was found to be 0%.

Table 27: Percent Survival rate

Particulars		**7 days**	**14 days**
Blank	Average no. of earthworm survived	40	40
Test Sample	Average no. of earthworm survived	40	40
	Survival rate (%)	100	100

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INTERPRETATION:

The FILOBEV 2s submitted by INTERTEK INDIA PRIVATE LIMITED meets all the criteria for disintegration, biodegradation and did not show any adverse effect on the seedling emergence, seedling growth and earthworm acute toxicity test in accordance to the conditions set forth in AS 5810:2010.

Reviewed By

Alok Pandey
Assistant Manager – Biodegradability Services

Authorized Signatory

Ushadevi Yadav
Deputy Manager – Biodegradability Services

---------- **End of Report** ----------

केन्द्रीय लुग्दी एवं कागज अनुसंधान संस्थान
Central Pulp & Paper Research Institute
An autonomous organisation under the administrative control of
Ministry of Commerce & Industry, Govt. Of India
(Registered under Societies Act)

CPPRI/ SPPM Div/2019-20/R-12

31.05.2019

TEST REPORT

Sample received from:	ITC LIMITED PAPERBOARDS & SPECIALTY PAPERS DIVISION, 106, Sardar Patel Road, ITC Bhadrachalam House, Secunderabad, Telangana
Ref. No. & Date:	Email Dated 18.04.2019
Sample Detail:	**ITC INDOBASE - CUPSTOCK F&B (WBC)**
Testing Required:	Repulpability Test

Procedure:

For repulpability test, the **ITC INDOBASE - CUPSTOCK F&B (WBC)** sample was slushed in hydrapulper. Two approaches were undertaken for repulping based on pulper types used by mills i.e. low consistency repulping and high consistency repulping. The conditions maintained during evaluation are as follows:

Parameters	Low consistency repulping	High consistency repulping
Consistency (Cy), %	5	12
Temp, °C	Ambient	Ambient
Slushing time, min.	30	30

The pulp thus obtained was passed through sommerville vibratory screen having 0.15 mm slot and was tested for fibre yield and reject content. The results are summarized below:

Result:

Cy. (%)	Recovered Fibre Yield (%)	Reject (Unslushed Paper) %	Other losses (Fines & fillers) %
5	91-95.7	2.8-3.5	1.5-5.5
12	97-98.5	0.2-0.25	1.3-2.75

Remarks:

(i) The maximum achievable fibre recovery is around 98.5%.
(ii) The reject content i.e. unslushed paper in **ITC INDOBASE - CUPSTOCK F&B (WBC)** sample is around 0.2%, which can be recycled back to the system.
(iii) High consistency repulping i.e. 10-12% is recommended to obtain higher fibre recovery.
(iv) Hansheet formation of screened pulp is good. Handsheet of 100 gsm is enclosed.

Rtandon 3.6.19

(Rita Tandon)
Scientist-G & Head
PCPB and SPPM Division

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Phone - (011)-49027213, 9910909169

ITC INDOBASE - CUPSTOCK F&B (WBC)

SCS Global Services *does hereby certify that an independent audit has been completed and conformity to the applicable standard(s) has been confirmed for:*

ITC Limited - Paperboards & Specialty Papers Division

106 Sardar Patel Road, Secunderabad, Telengana 500003, India
Please see addendum for additional certified locations.

This multi-site certificate covers the production of paper and paper board using the transfer and credit systems. It also covers the sale of FSC Controlled Wood and a risk assessment for the control of wood sourced from all districts of Andhra Pradesh, Telangana and Karnataka state and the sourcing of pre- and post-consumer reclaimed material.

The facility(s) are hereby Chain of Custody certified to sell products as:

FSC 100%; FSC Mix; FSC Controlled Wood; FSC Recycled

The assessment has been conducted by SCS Global Services in accordance with the protocols of the Forest Stewardship Council® A.C. (FSC®).

FSC Standard: FSC-STD-40-003; FSC-STD-40-004; FSC-STD-40-005; FSC-STD-40-007; FSC-STD-50-001

Certificate Code: SCS-COC-007023 Trademark License Code: FSC-C064218

CW Code: SCS-CW-007023

Valid from: 13 March 2020 Expiry date: 12 March 2025

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