Attracting Tomorrow

TDK

Report No.: 202311C0456A

Testing Report

--- PBAT /PLA physical and chemical properties Analysis

Tested by: Xueling Chen
Checked by: Youjin Lu
Approved by: Chengyuan Luo
SAE Magnetics (HK) Ltd.
A TDK Group Company
Material Science Laboratory
Mar. 16, 2023

Sample Information and Experimental

- **Applicant information**
  - **Customer:** 新疆中高绿色生物科技股份有限公司
  - **Applicant:** Ms. Xinxie Wang
  - **Telephone:** 18601948613
  - **Email:** zglc23@126.com

- **Laboratory Information**
  - **Laboratory:** SAE Technologies Development (Dongguan) Co., Ltd.
    Material Science Laboratory
  - **Address:** Winnerway Industry Area, Nancheng, Dongguan City, Guangdong Province, PRC.
  - **Telephone:** 86-769-22810033
  - **Postal code:** 523087

Sample Information and Experimental

- **Sample information**
  - **Sample Name:** PLA Bottle、PBAT Masterbatch and PBAT film
  - **Sample Quantity:** PLA Bottle(polylactic acid), PBAT masterbatch (with Calcium powder), PBAT Masterbatch(without Calcium powder), PBAT film
  - **Date of Receipt:** Nov. 10, 2023
  - **Date of Test:** Nov. 10, 2023
  - **Analysis Purpose:** To Analyze the composition and physical properties of biodegradable materials PLA and PBAT

- **Sample Photo**

Sample Information and Experimental

Reference Standards

- ASTM E1252-2021: Standard Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis
- ASTM E1078-14: Standard Guide for Specimen Preparation and Mounting in Surface Analysis.
- ASTM D3850-19: Standard Test Method for Rapid Thermal Degradation of Solid Electrical Insulating Materials By Thermogravimetric Method (TGA)
- GB/T 17359-2012: Micro beam analysis--Quantitative analysis using energy dispersive spectrometry.
- GB4806.7-2016: National Food Safety Standard - Plastic Materials and Products in Contact with Food
- EPA6010D: INDUCTIVELY COUPLED PLASMA—OPTICAL EMISSION SPECTROMETRY

Instruments

- FTIR--Thermo Scientific NICOLET 6700
- SEM/EDS--JOEL 6700 Scanning Electronic Microscopy OXFORD EDS
- TGA---TA TGA Q50
- ST---SHIMADZU AGS-J 1000N
- HAZE METER—Micro Light MH-500 (Wavelength 380~780nm)
- ICP-OES--THEMO iCAP PRO XP

Component analysis-FTIR-PLA:

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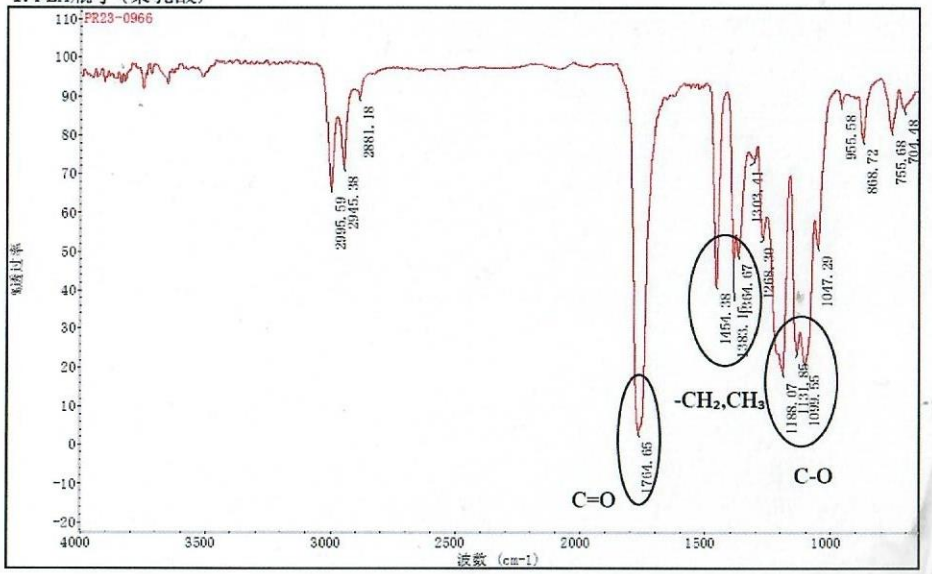
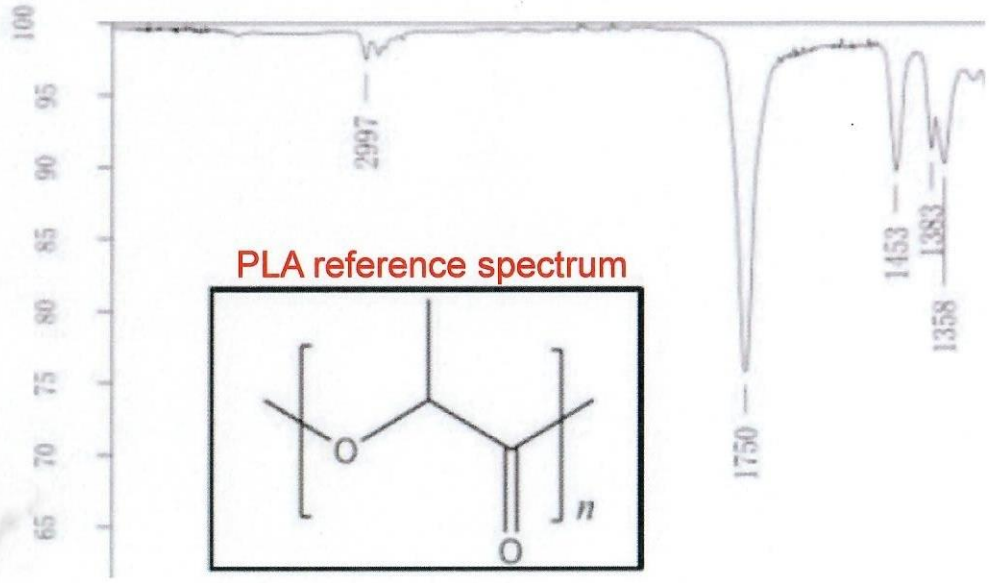
1. PLA瓶子(聚乳酸)





The infrared spectrum shows that the main peak positions of the PLA sample are similar to the reference spectrum

Component analysis-FTIR-PBAT (with Calcium powder)

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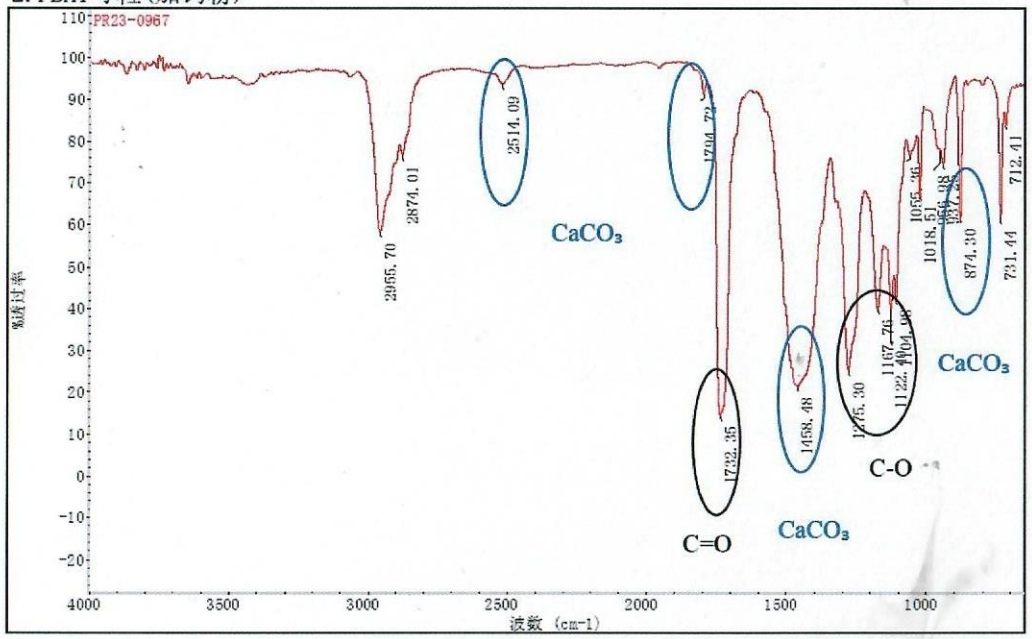
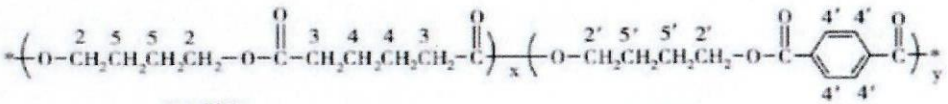
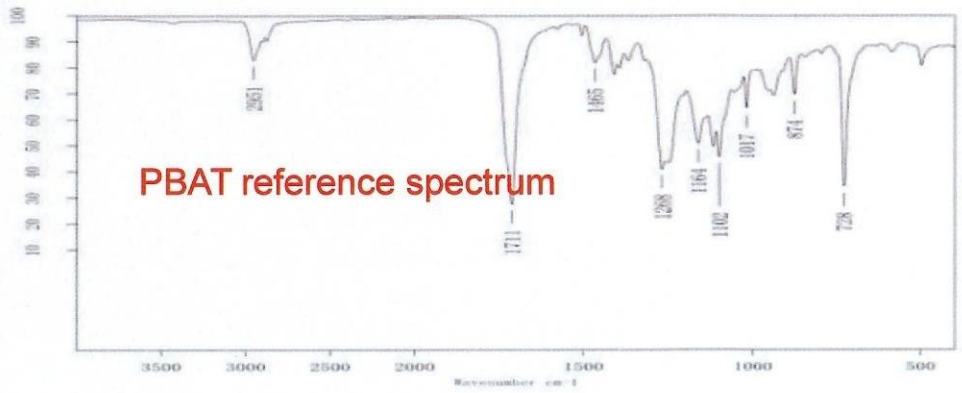
2. PBAT母粒(加钙粉)





PBAT的结构式



PBAT标准红外谱图

The infrared spectrum shows that the main peak positions of the sample are similar to the reference spectrum, and there is also a peak of CaCO3

Component analysis-FTIR-PBAT (without Calcium powder):

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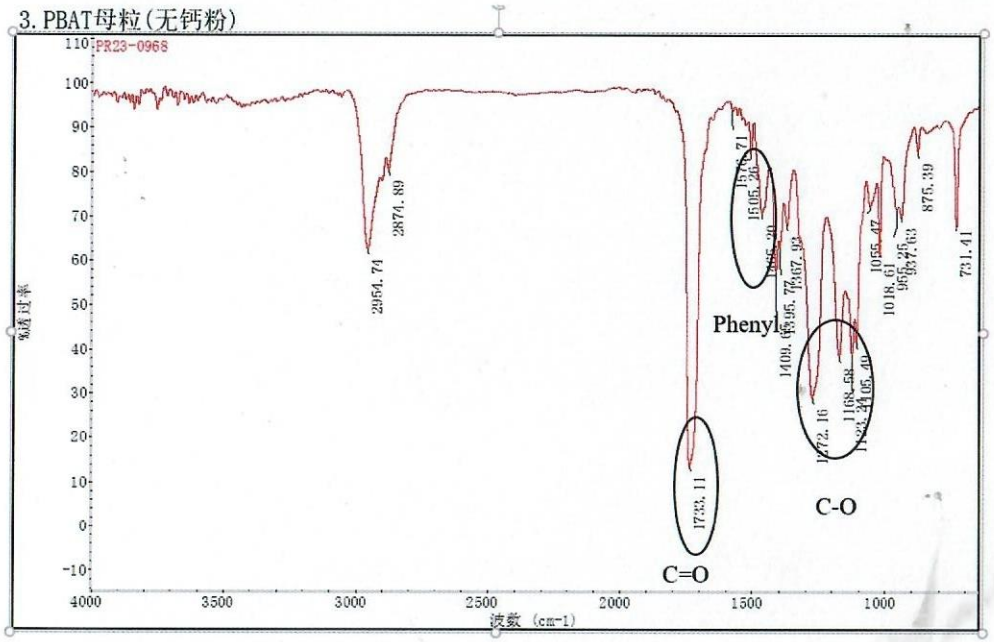
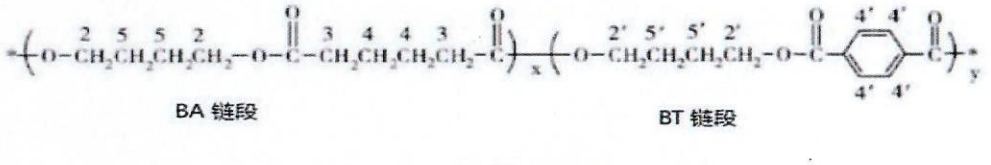
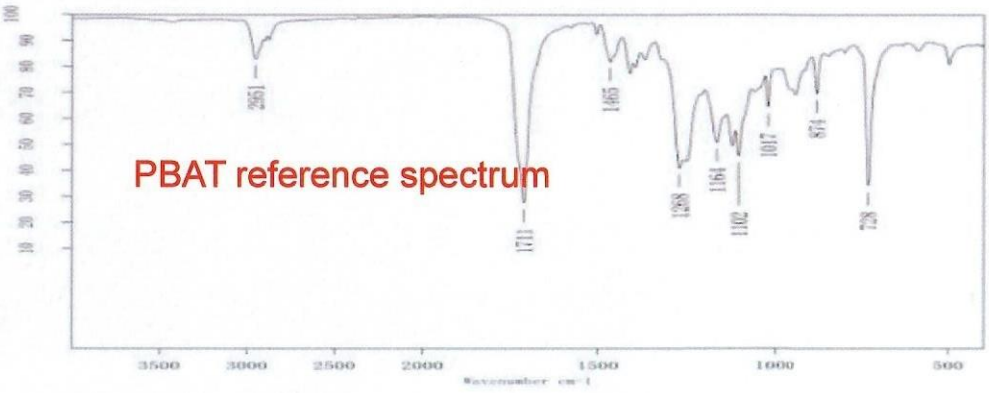




PBAT的结构式



PBAT标准红外谱图

The infrared spectrum shows that the main peak positions of the sample are similar to the reference spectrum

Component analysis-FTIR- PBAT film：

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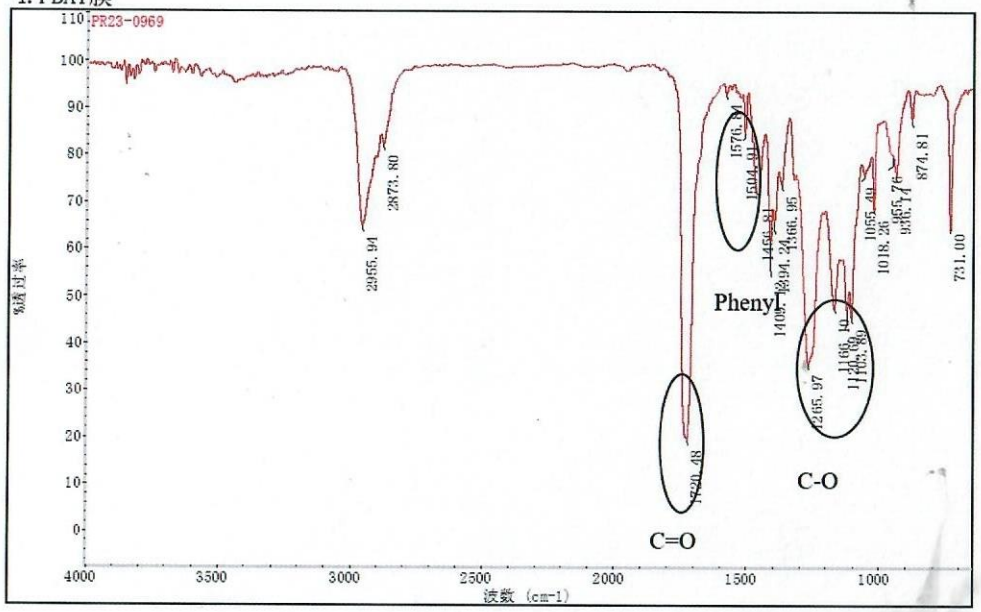
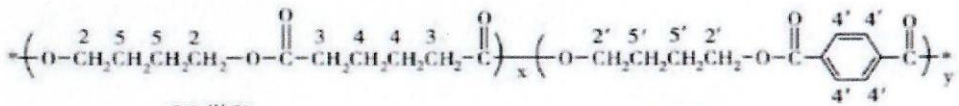
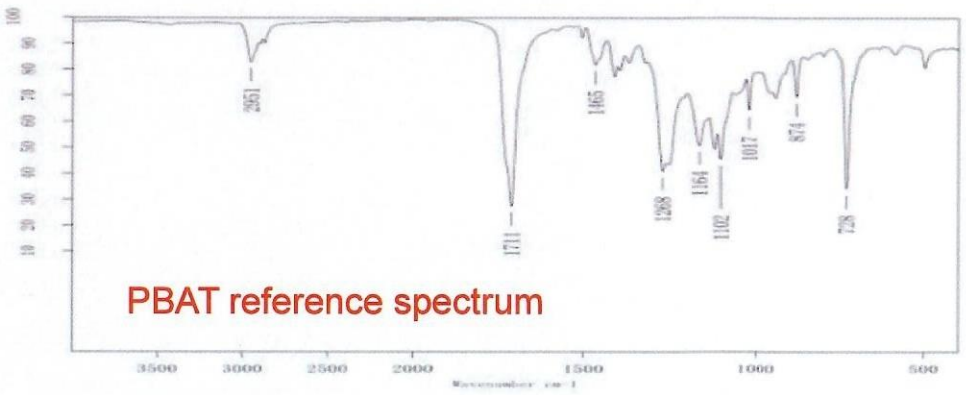
4. PBAT膜





PBAT的结构式



PBAT标准红外谱图

The infrared spectrum shows that the main peak positions of the sample are similar to the reference spectrum

PBAT residual Component analysis -EDS:

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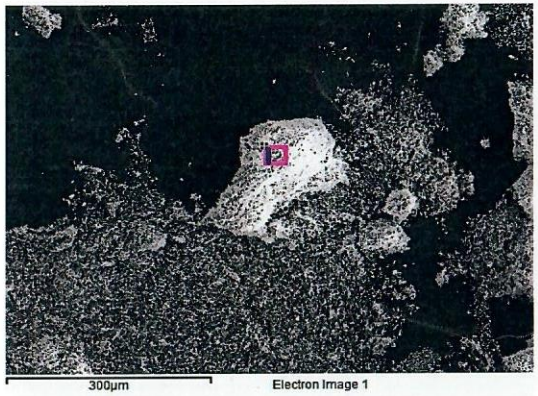

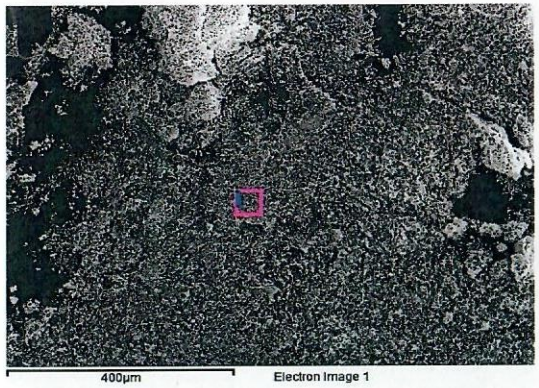

Element	C	O	F	Mg	Si	Ca	Cu	Total
Data 1	4.53	40.80	4.48	1.07	0.37	48.57	0.18	100.00
Data 2	12.64	40.05	2.86	0.92	0.28	42.94	0.31	100.00

The EDS results of the residue indicate that the main filler for PBAT masterbatch is Calcium carbonate ($CaCO_3$)

Physical performance testing (Lab, transmittance, and haze)

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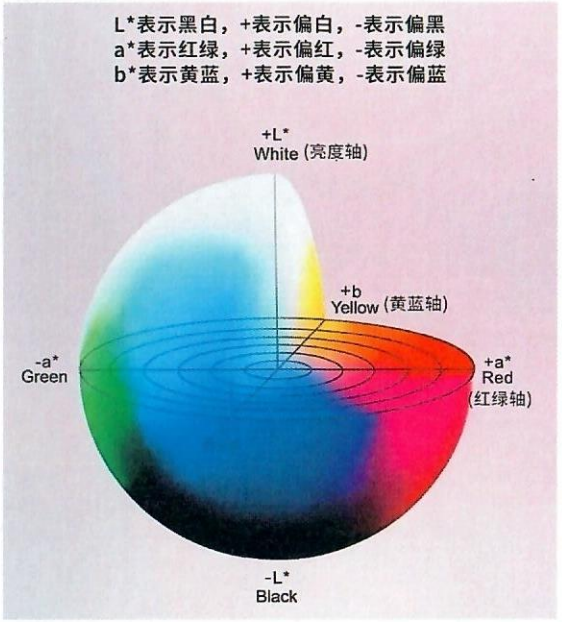
Optical indicators						
Sample	L	a	b	YI(yellow)	Transmittance (380~780nm)	HAZE (380~780nm)
PET	94.07	-0.3	-1.66	-3.01	85.88	1.43
PLA	96.46	0.01	0.84	1.17	93.91	3.28

Comparing the optical properties of PET and PLA, the Transmittance of PLA is higher



Optical indicators						
Sample	L	a	b	YI(yellow)	Transmittance (380~780nm)	HAZE (380~780nm)
PP film	92.9	0.15	0.58	0.81	100	45.26
PBAT film	92.9	0.04	0.80	1.15	100	61.06

Comparing the optical properties of PP film and PBAT film, the haze of PBAT film is higher

PHYSICAL PROPERTY TEST-TGA:

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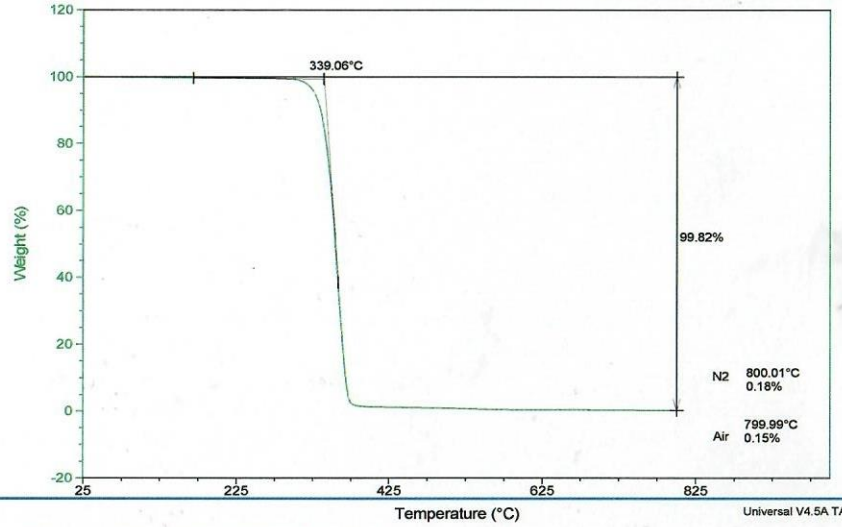
Sample	decomposition temp.(° C)				volatile content %				Residue content%	
	1	2	3	4	High	Middle		combustible	N2	Air
PLA	339.1	/	/	/	99.8	/	/	/	0.2	0.2
PBAT(with Calcium powder)	327.9	438.7	521.2	626.1	56.1	6.0	9.6	11.7	16.6	16.6
PBAT(without Calcium powder)	364.5	/	512.7	/	89.6	/	/	9.1	1.4	1.4
PBATfilm	363.5	/	501.4	/	88.9	/	/	9.6	1.6	1.5

Sample: PLA 瓶子（聚乳酸）
Size: 5.4040 mg

TGA

File: C:...\202311J0071-中高绿色生物\PLA 瓶子（聚

Run Date: 13-Nov-2023 15:30
Instrument: TGA Q50 V20.13 Build 39



Sample: PBAT 母粒 （加钙粉）
Size: 8.3550 mg

TGA

File: C:...\202311J0071-中高绿色生物\PBAT 母粒 （

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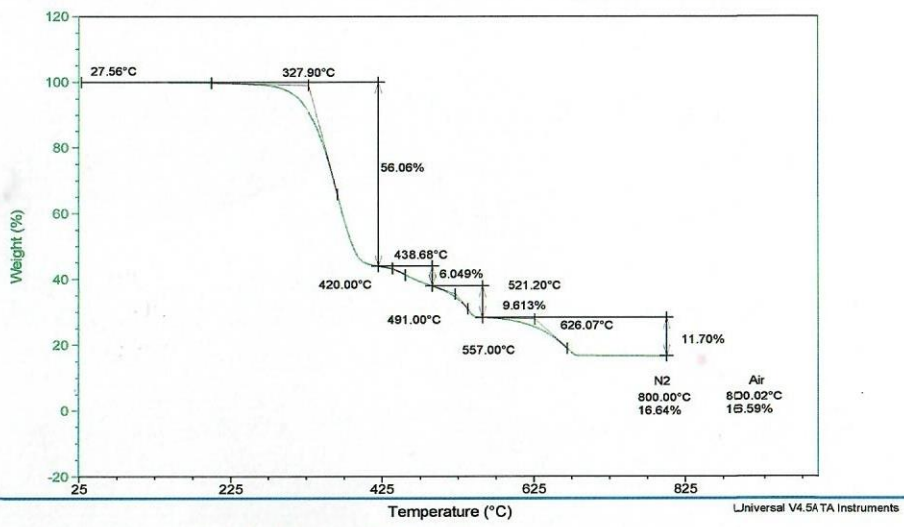
Instrument: TGA Q50 V20.13 Build 39



PHYSICAL PROPERTY TEST-TGA:

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Report No.: 202311C0456A

Sample	decomposition temp.(° C)				volatile content %				Residue content%	
	1	2	3	4	High	Middle		combustible	N2	Air
PLA	339.1	/	/	/	99.8	/	/	/	0.2	0.2
PBAT(with Calcium powder)	327.9	438.7	521.2	626.1	56.1	6.0	9.6	11.7	16.6	16.6
PBAT(without Calcium powder)	364.5	/	512.7	/	89.6	/	/	9.1	1.4	1.4
PBATfilm	363.5	/	501.4	/	88.9	/	/	9.6	1.6	1.5

Sample: PBAT 母粒 （无钙粉）
Size: 5.8350 mg

TGA

File: C:...\202311J0071-中高绿色生物\PBAT 母粒 （

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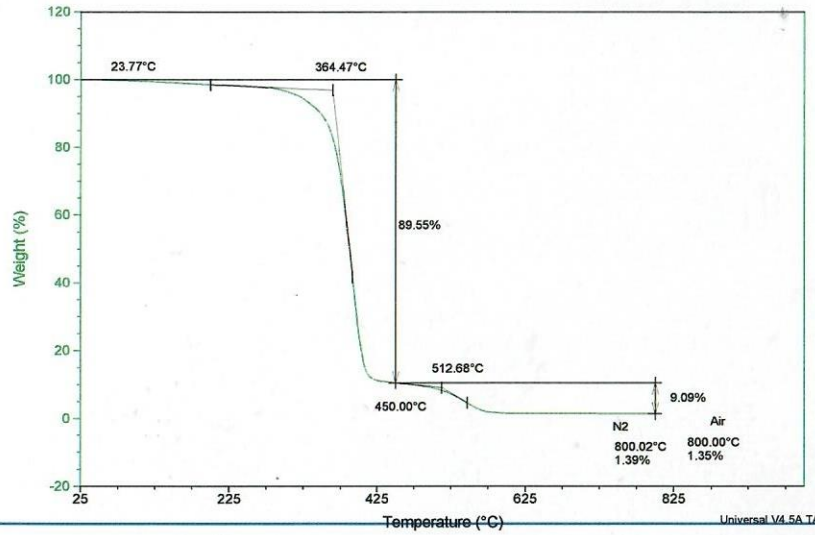

Sample: PBAT膜
Size: 3.1820 mg

TGA

File: C:...\Nov.2023\202311J0071-中高绿色生物\PBA

Run Date: 14-Nov-2023 10:22
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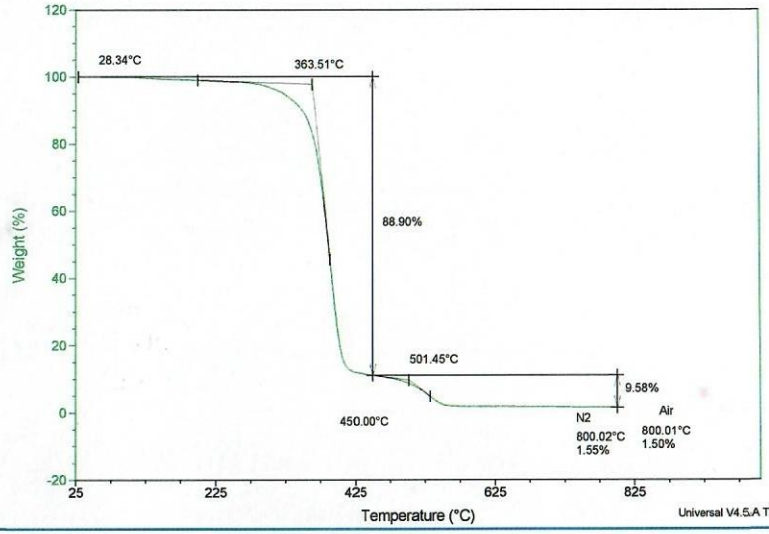

PHYSICAL PROPERTY TEST- TENSILE PROPERTY

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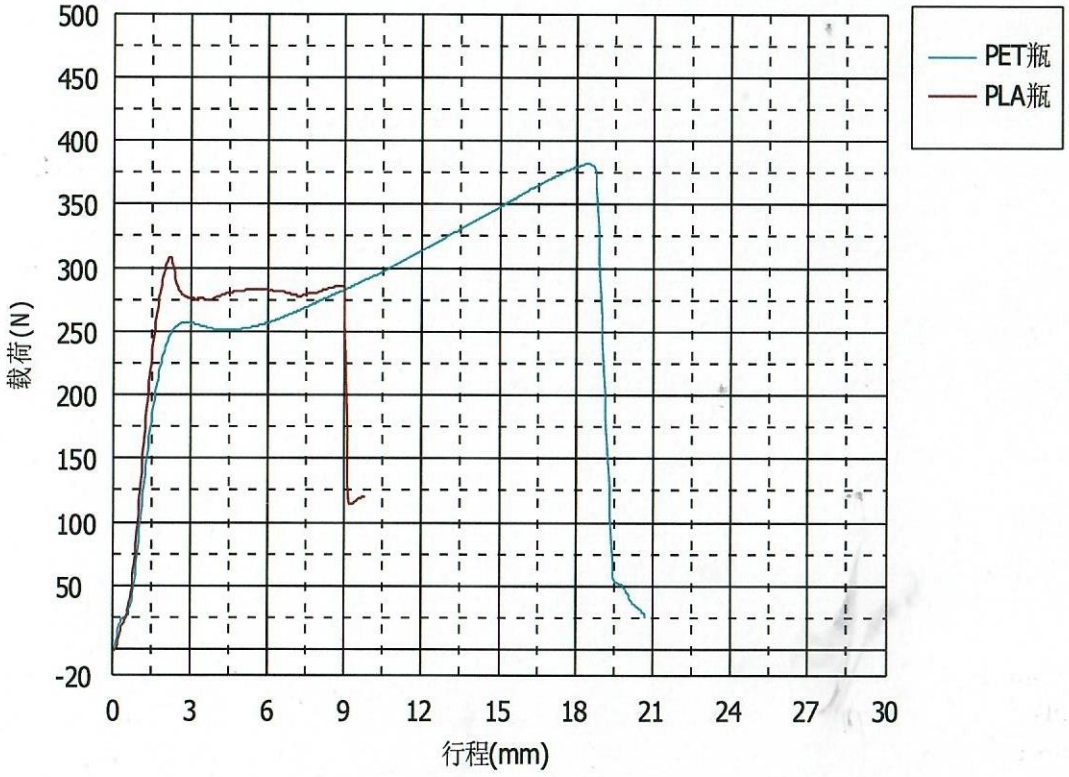

Name	Tensile strength (Mpa)	Elongation at break (%)
PET	38.3	61.47
PLA	30.9	7.41

The tensile results indicate that the elongation at break of PLA bottles is lower than PET films

PHYSICAL PROPERTY TEST-TENSILE PROPERTY:

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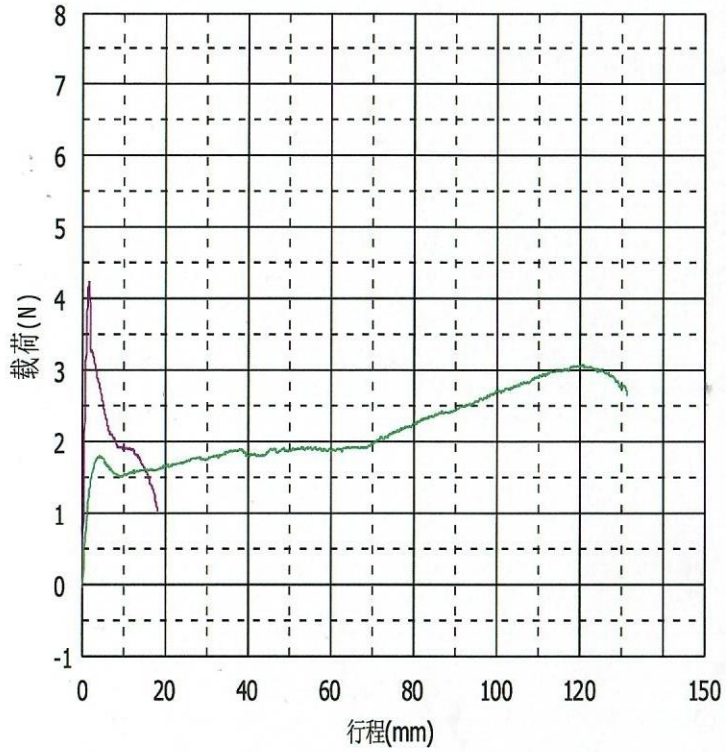

Name	Tensile strength (Mpa)	Elongation at break, %
PET Film	0.43	5.54
PBATFilm	0.31	400.96

The tensile results indicate that the elongation at break of PBAT film can reach 400%

Analysis of heavy metal -PLA

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Take 11 grams of PLA sample, immerse it in 250 milliliters of 4% acetic acid solution, heat the acid solution to 60 degrees @2 hours. to test the solution by ICP-OES, the results are as below

Item/ Element	Hg	Cd	Cr	Pb	Al	Fe	Ni	Cu	Zn	Mn	Co	Sn	Ca	Na
Unit	mg/kg													
Result	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MDL	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

No any heavy metal found in PLA bottle.

-- End of report --