TERRYL™ BIO-BASED NYLON: DEVELOPMENT, PRODUCTION AND GROWTH POTENTIAL

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PRESIDENT

JUNE, 2013

CATHAY INDUSTRIAL BIOTECH

AGENDA

- ***Bio-plastics——driving the evolution of plastics***
- ***A broad range of renewable nylons & monomers***
- ***Cathay Industrial Biotech Introduction***

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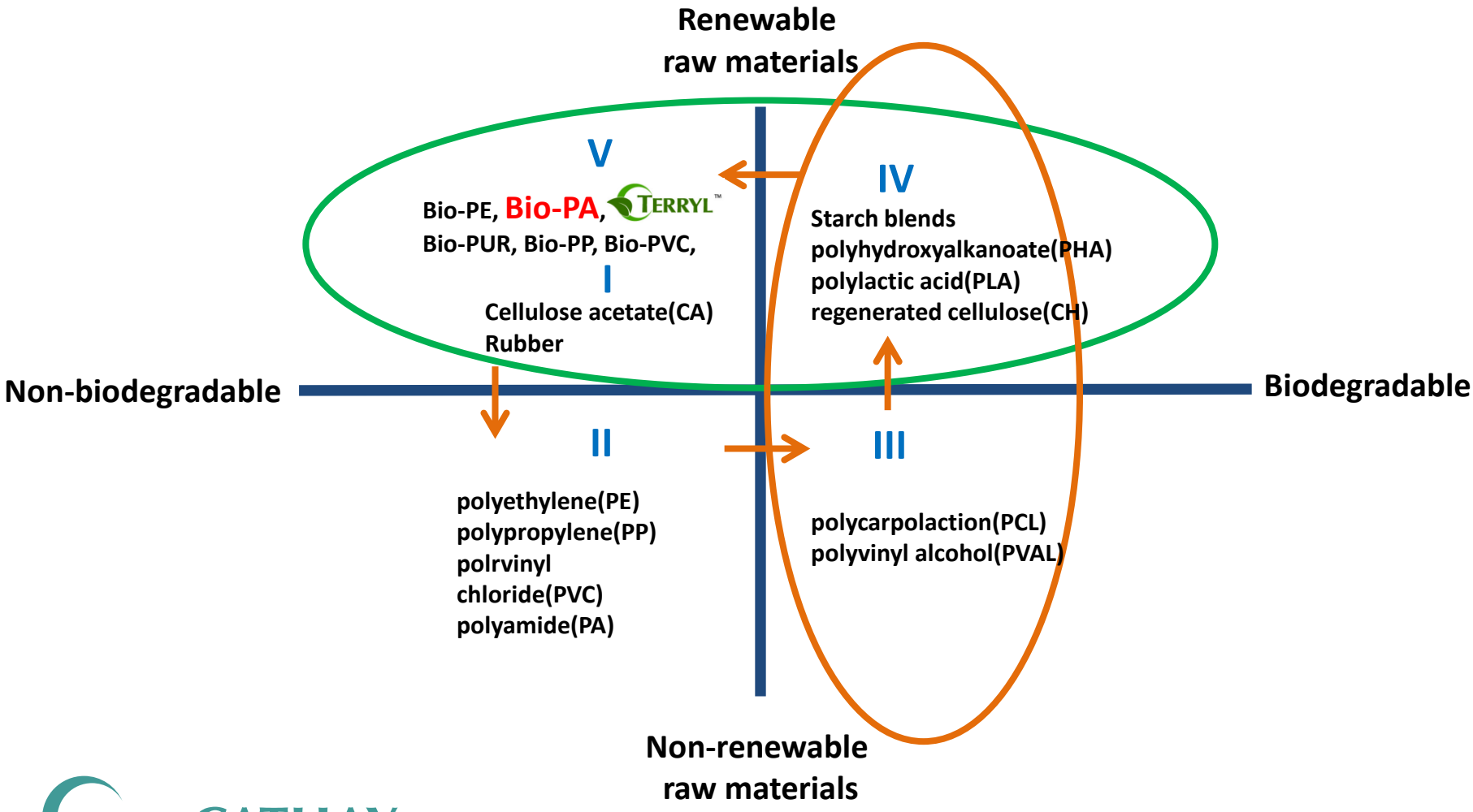
Bio-plastics Classification & History



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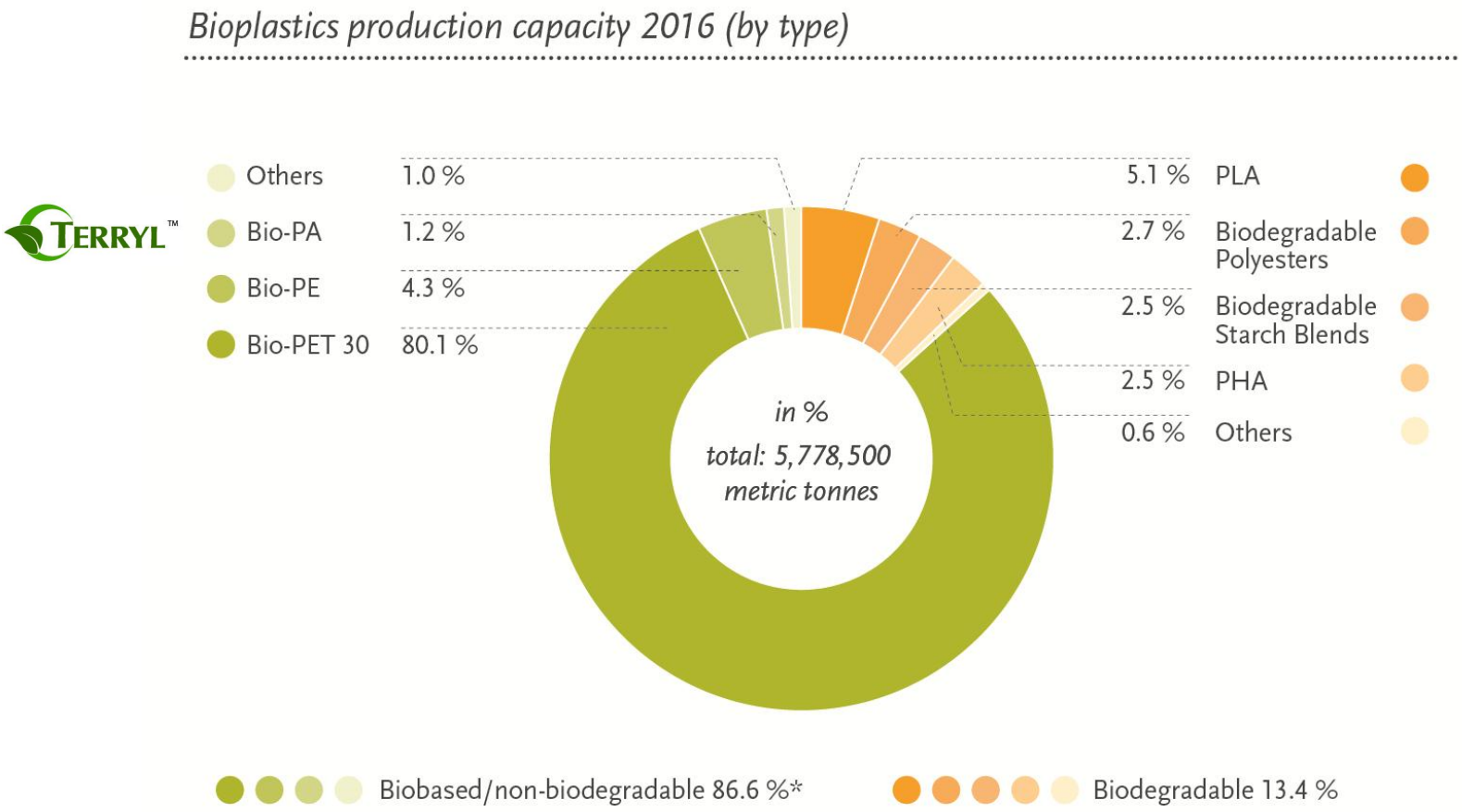
Bio-plastics Production Capacity 2016 (by type)



- ***Bio-plastics——drive the evolution of plastics***
- ***A broad range of renewable nylons & monomers***
- ***Cathay Industrial Biotech Introduction***

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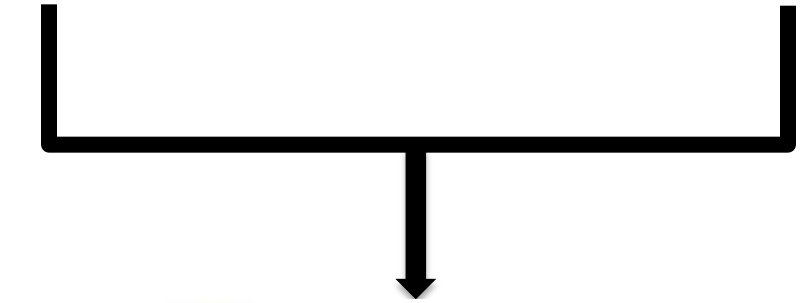
Cathay green nylon project

- ***Bioprocess long chain diacids (LCDAs)***
- ***Green Diamine (DN5)***
- ***DN5-based Green nylon (PA5X)***

$H_2N\text{-}(CH_2)_5\text{-}NH_2$
Green/Petro Diamine

HOOC-(CH2)n-COOH
Green/Petro Diacid



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Diacid Bioprocess Alternative to Chemical Synthesis

Process Comparison | **Competitive Landscape**

Bio-Based Process

Petro/Plant Paraffin — CH3-(CH2)n-CH3

Or

Fatty Acids — CH3-(CH2)n- COOH (Renewable Source)

→ *Micro-organism* →

LCDAs

Or

Green LCDAs

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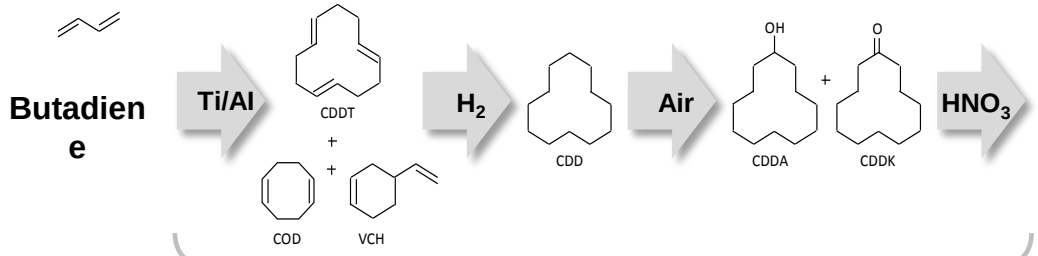
Standard Chemical Based Process



Multiple Chemical Steps

- **INVISTA**
- **Ube(1)**
- **Evonik Industries AG**

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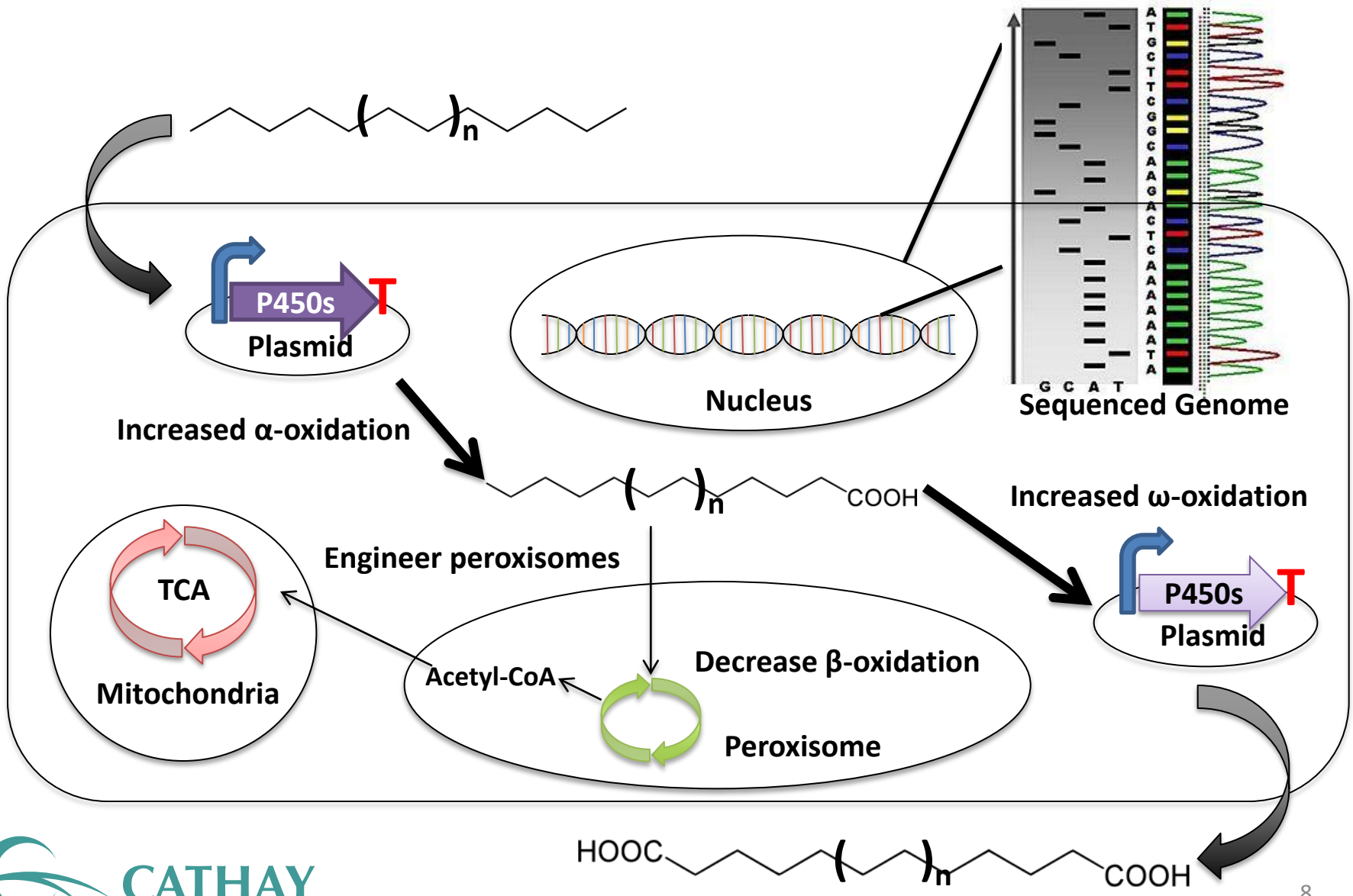
(1) Ube uses a similar chemical-based benzene process

7

Cathay Diacid Factory



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Broad Innovative Product Range

1,11-Undecanedioic Acid	$HOOC(CH_2)_9COOH$
1,12-Dodecanedioic Acid	$HOOC(CH_2)_{10}COOH$
1,13-Brassylic Acid	$HOOC(CH_2)_{11}COOH$
1,14-Tetradecanedioic Acid	$HOOC(CH_2)_{12}COOH$
1,15-Pentadecanedioic Acid	$HOOC(CH_2)_{13}COOH$
1,16-Hexadecanedioic Acid	$HOOC(CH_2)_{14}COOH$
1,18-Octadecanedioic Acid	$HOOC(CH_2)_{16}COOH$
1,5 Pentane Diamine	$H_2N(CH_2)_5NH_2$

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Cathay Major Markets

Engineering Plastics

Polyamide 5-6, 5-X, 6-12 & 6-14

Adhesives & Performance Coatings

Co-polyamide adhesives

Polyester adhesives and paints

Coatings GMA Powder Coat Cross-linker

Wheels

Anti Corrosion

Metal working fluids/Industrial cooling systems

Synthetic Lubricants (Dibasic Esters)

High Performance/Automobiles

Personal Care-Synthetic Musk & Ketone Fragrances

Household cleaners

Pharmaceutical Intermediates

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Diamine Bioprocess Alternative to Chemical Synthesis

Process Comparison | **Competitive Landscape**

Bio Process

1,5-pentane diamine
C-BIO N5 (DN5)

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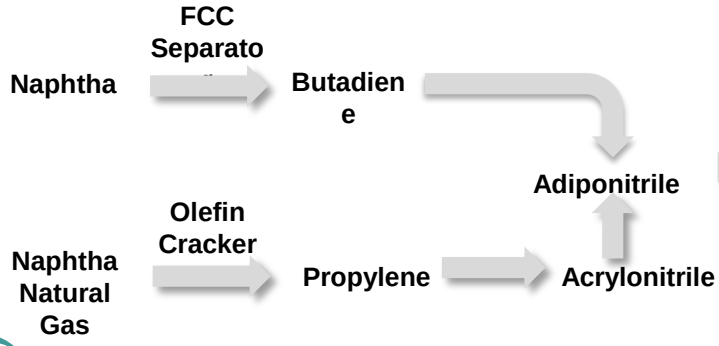
Standard Chemical Process



1,6-hexamethylenediamine
HMDA (DN6)

- **Invista**
- **Ascend**

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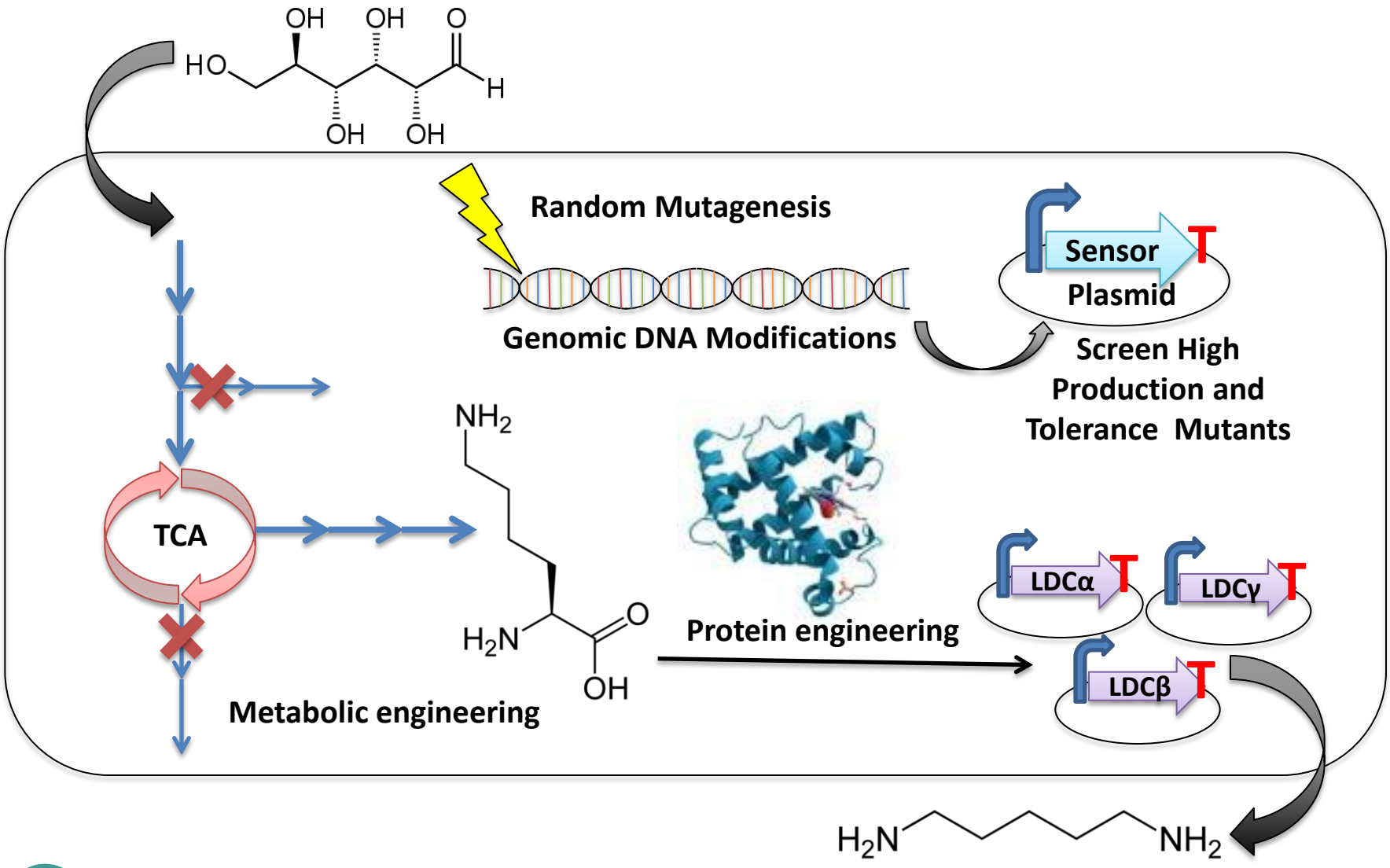
Cathay Diamine Factory



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Cathay C-Bio N5 Technical Data

	C-BIO N5	HMDA
CAS No.	462-94-2	124-09-4
% Renewable (ASTM D6866)	**100%**	0%
Molecular weight	102	116
Formula	$H_2N-(CH_2)_5-NH_2$	$H_2N-(CH_2)_6-NH_2$
% NH2	31%	28%
Appearance	**clear liquid**	clear solid
Melting point (°C)	9	41
pKa1	10.05	10.24
pKa2	10.93	11.02
pH 5% solution	12.6	12.4

8% less diamine needed with C-Bio N5

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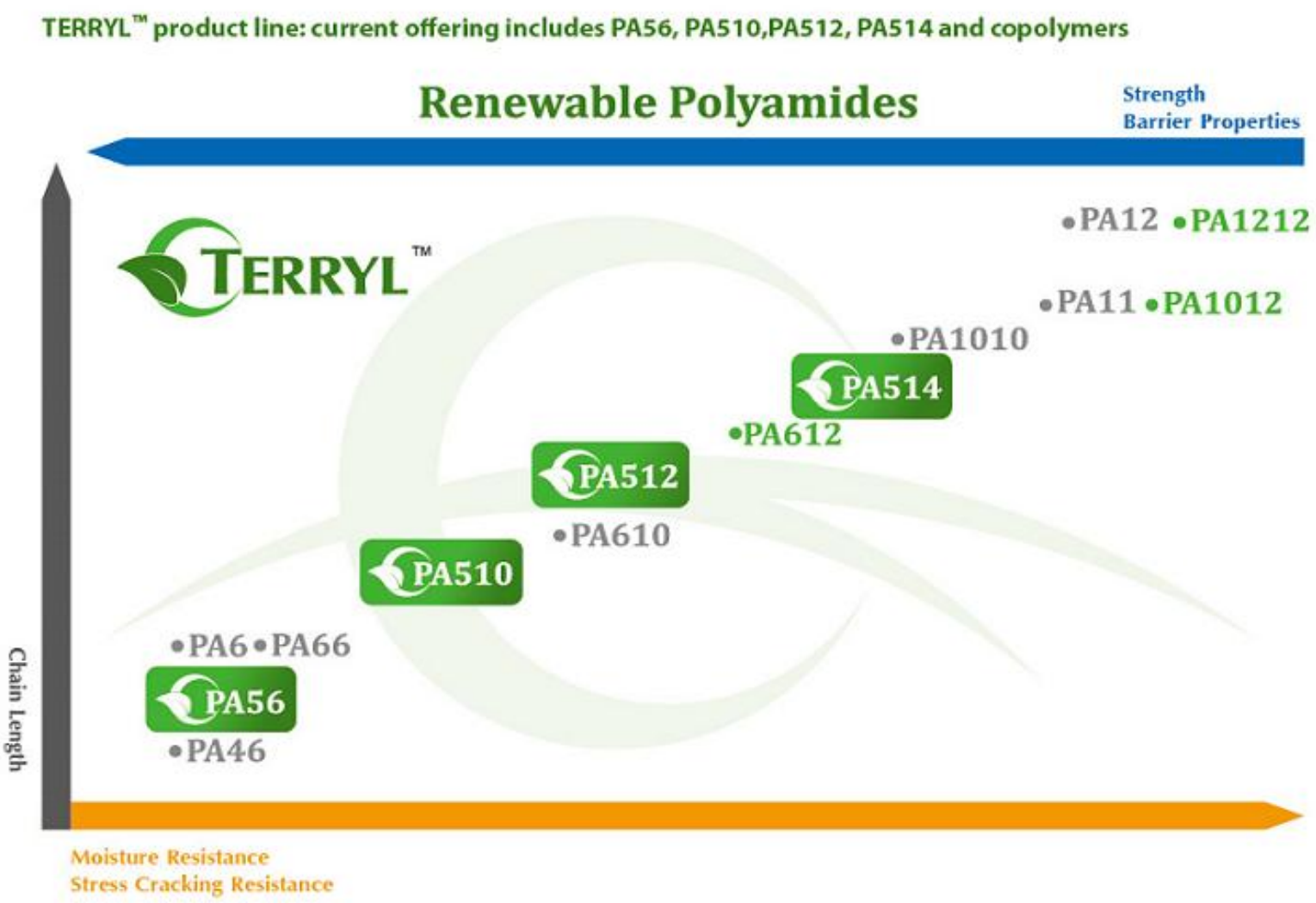
Cathay Terryl™ PA5X



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Nylons and Monomers

Terryl™	Renewable %	Diamine	Diacid
PA56	47%	5	6
PA510	100%	5	10
PA511	36%	5	11
PA512	34-100%	5	12
PA513	32-100%	5	13
PA612	up to 63%	6	12
PA514	31-100%	5	14
PA1012	46-100%	10	12
PA1212	up to 100%	12	12

Cathay Terryl™ PA56 Properties

	Test Method	Unit	PA66	PA6	Terryl™ PA56
Decomposition temperature	TGA	° C	424.7	426.3	424.3
Melting point	TGA	° C	261.1	217.9	254.0
Crystallization temperature	DSC	° C	222.3	193.7	213.5
Notched Izod Impact	ASTM D256	J/m	42.4	41.8	35.3
Tensile Modulus	ASTM D638	Mpa	3087.2	3010.2	2940.1
Tensile Strength at Break	ASTM D638	Mpa	75.4	72.4	69.8
Elongation at Break	ASTM D638	%	17.4	8.0	15.7
Flexural Modulus	ASTM D790	Mpa	2851.8	2600.0	2870.1
Flexural Strength	ASTM D790	Mpa	124.3	118.0	125.6
Density	ASTM D792	g/cm^3	1.14	1.13	1.13
% Renewable	ASTM D6866	%	0	0	47%

PA56 seems more similar to PA66 than PA6

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Samples

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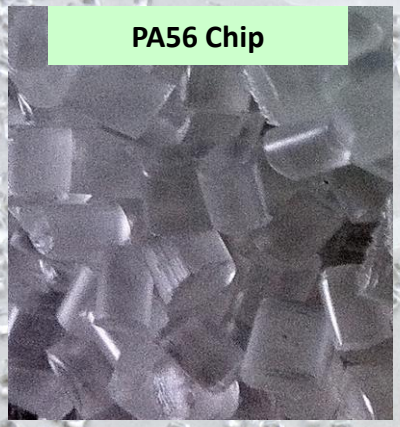
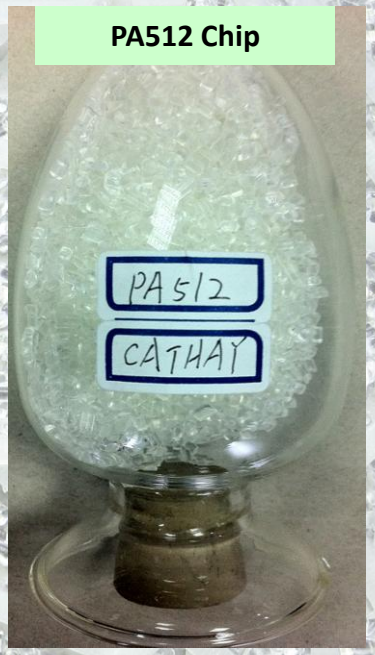
PA56 Chip

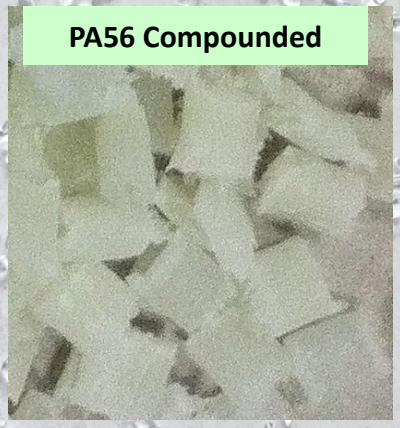


PA510 Chip

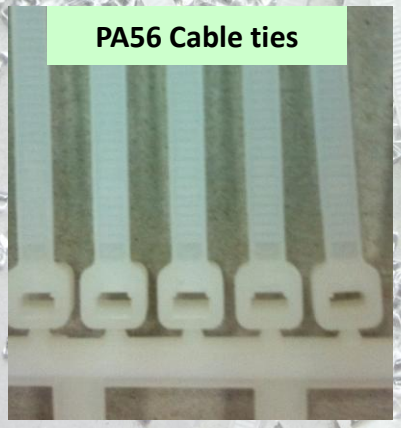
PA512 Chip



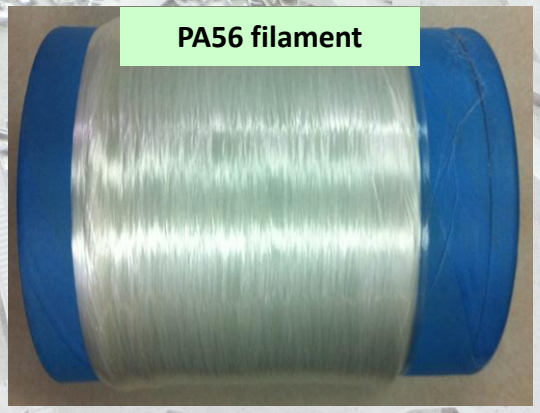
PA56 Compounded



PA56 Cable ties



PA56 filament



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Green Nylon in Test Products

Heated Bug Repellent
Pure PA56

Electric part
PA56 + 30% glass fiber

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- ***Bio-plastics——drive the evolution of plastics***
- ***World's broadest range of renewable nylons***
- ***Cathay Industrial Biotech Introduction***

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Company History

1997 2001 2003 2005 2007 2009 2011 2013 2015

Corporate

- Company founded
- built first plant
- Series A & B Financing
- Series C Financing
- Achieved revenue of >US$150 mn

Long Chain Diacid

- began R&D
- began commercial production
- expansions
- major DC12 supplier globally
- developed next generation process

Bio-butanol

- board approves bio-butanol project
- 100,000 MT plant built
- cellulosic biomass tech breakthroughs

Green Diamine

- began R&D
- technology breakthroughs
- pilot production
- Annual production 20,000 MT

Green Nylon

- began R&D
- pilot production
- Annual production 40,000 MT

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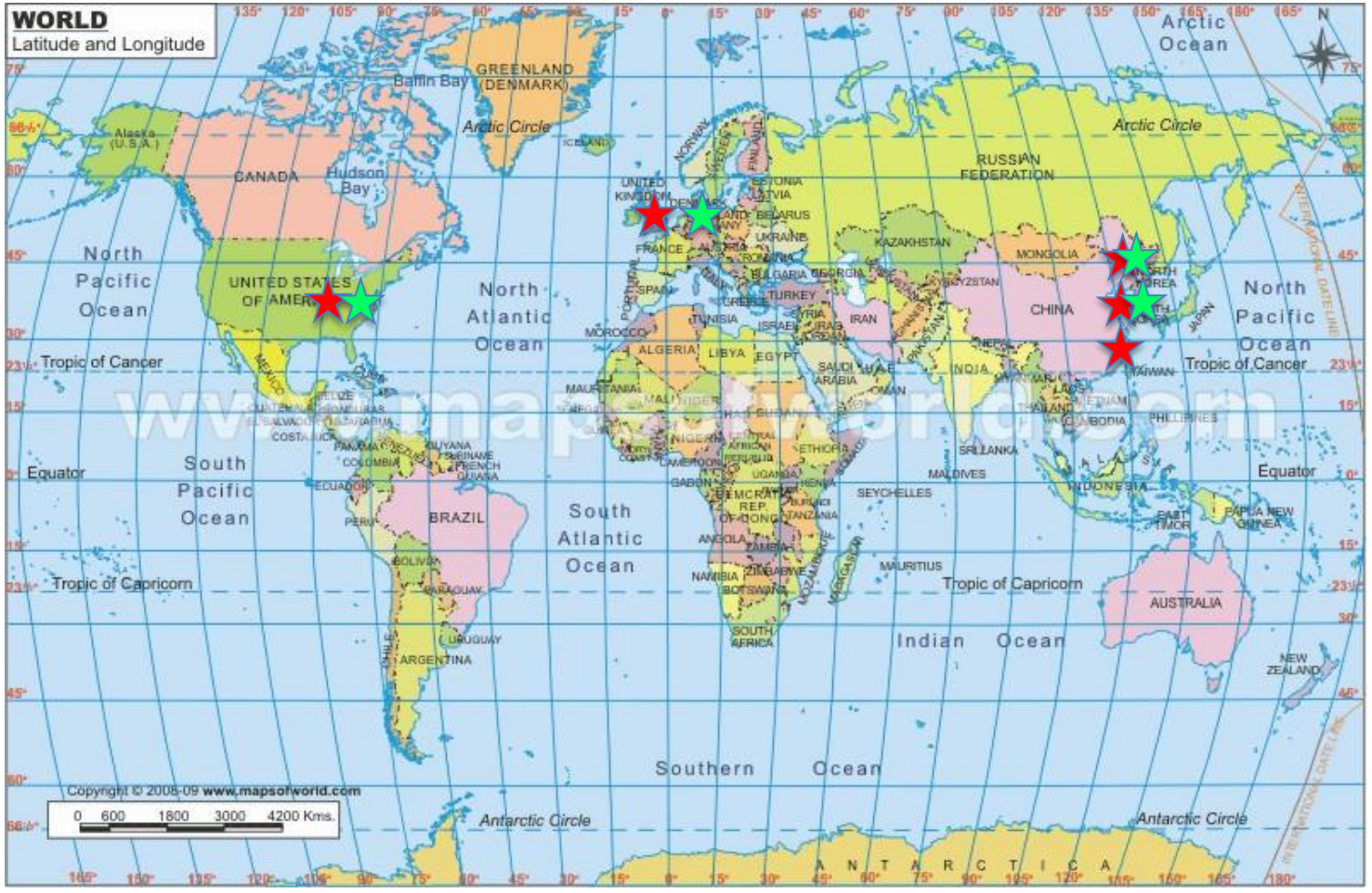
Our World Footprint



★ **Sales Office** ★ **Warehouse**

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Cathay Shandong Province Production Facility (LCDA, DN5, GREEN NYLON)

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Cathay Shandong Province Production Facility (bio-butanol, bio-acetone)

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Summary

- Biopolymers are the fastest growing segment of the polymer industry
- Cathay's fermentation of long chain diacids has already replaced the chemical process as market leader by providing a "drop in" chemicals.
- New competitive biobased C5 diamine , CBIO N5 is available for new polyamides and adhesives.
- Terryl™ PA5,6 has comparable performance properties to PA6,6.
- Terryl™ PA5XX provides unique new performance properties for high performance polyamides.

Contact Cathay for a sample of TERRYL™

www.cathaybiotech.com

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Thank You

Also Available Biobutanol and Bioacetone

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