CORN STARCH BLEND COMPOSTABLE PLASTIC FILM

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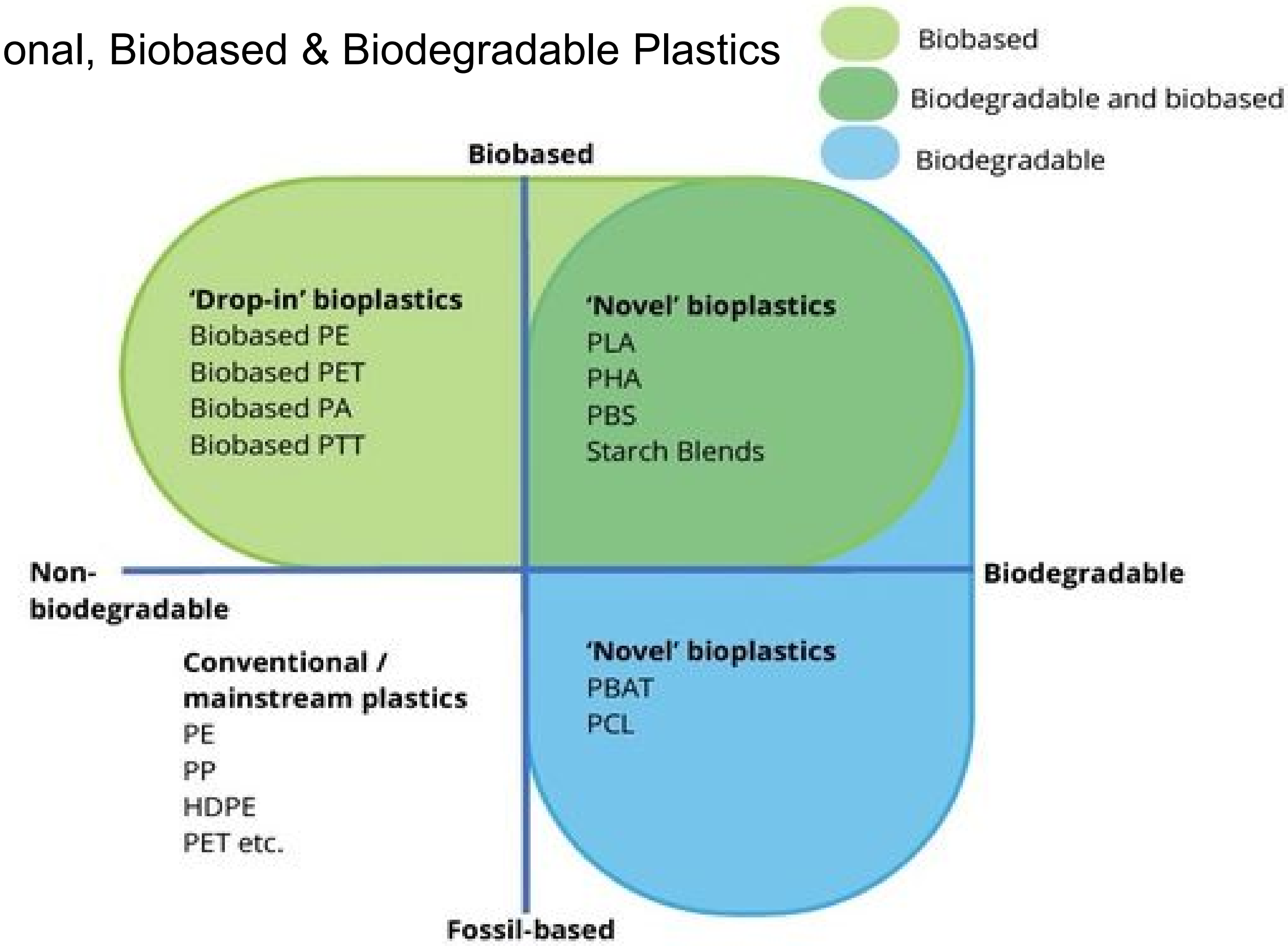
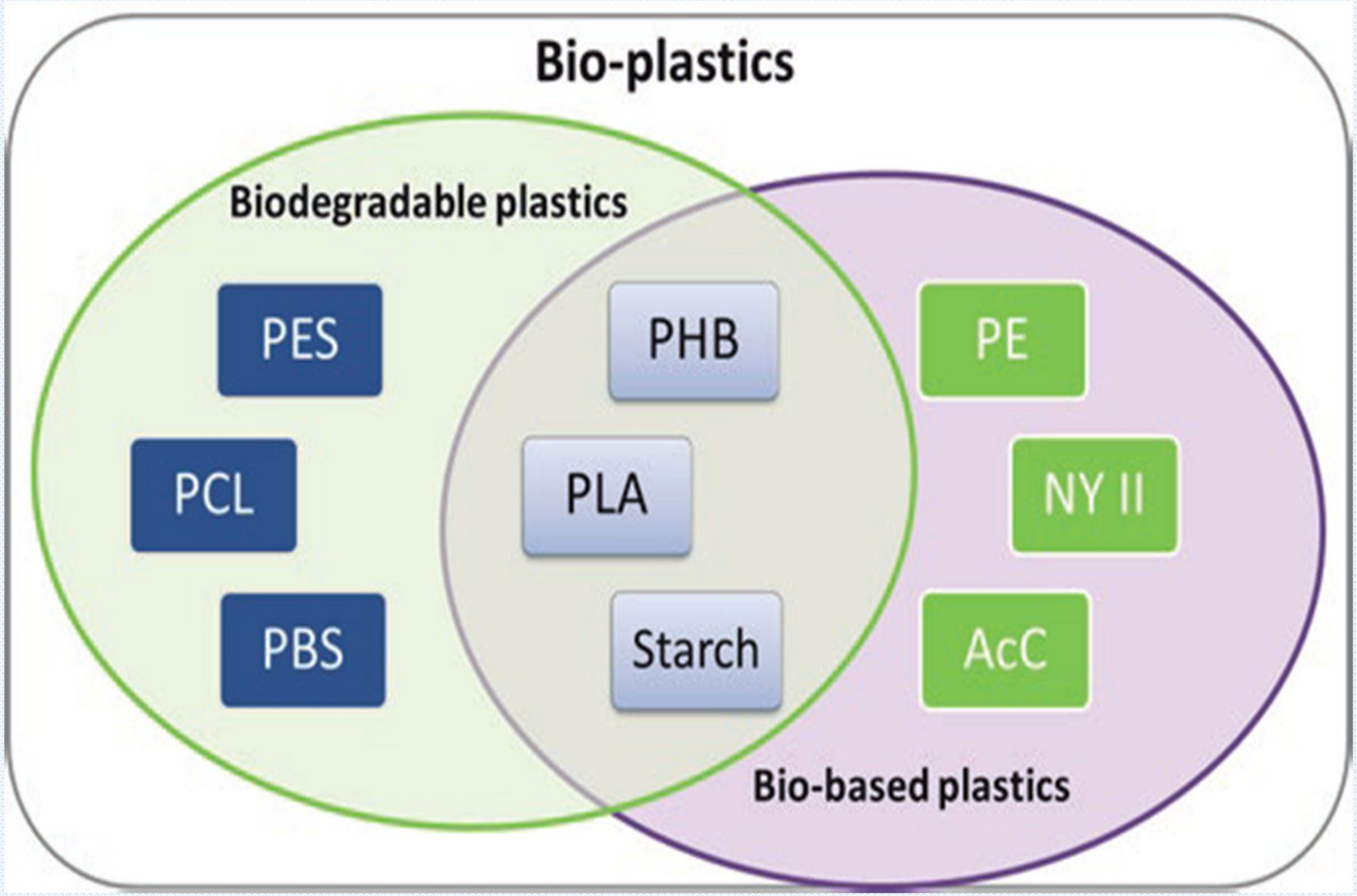
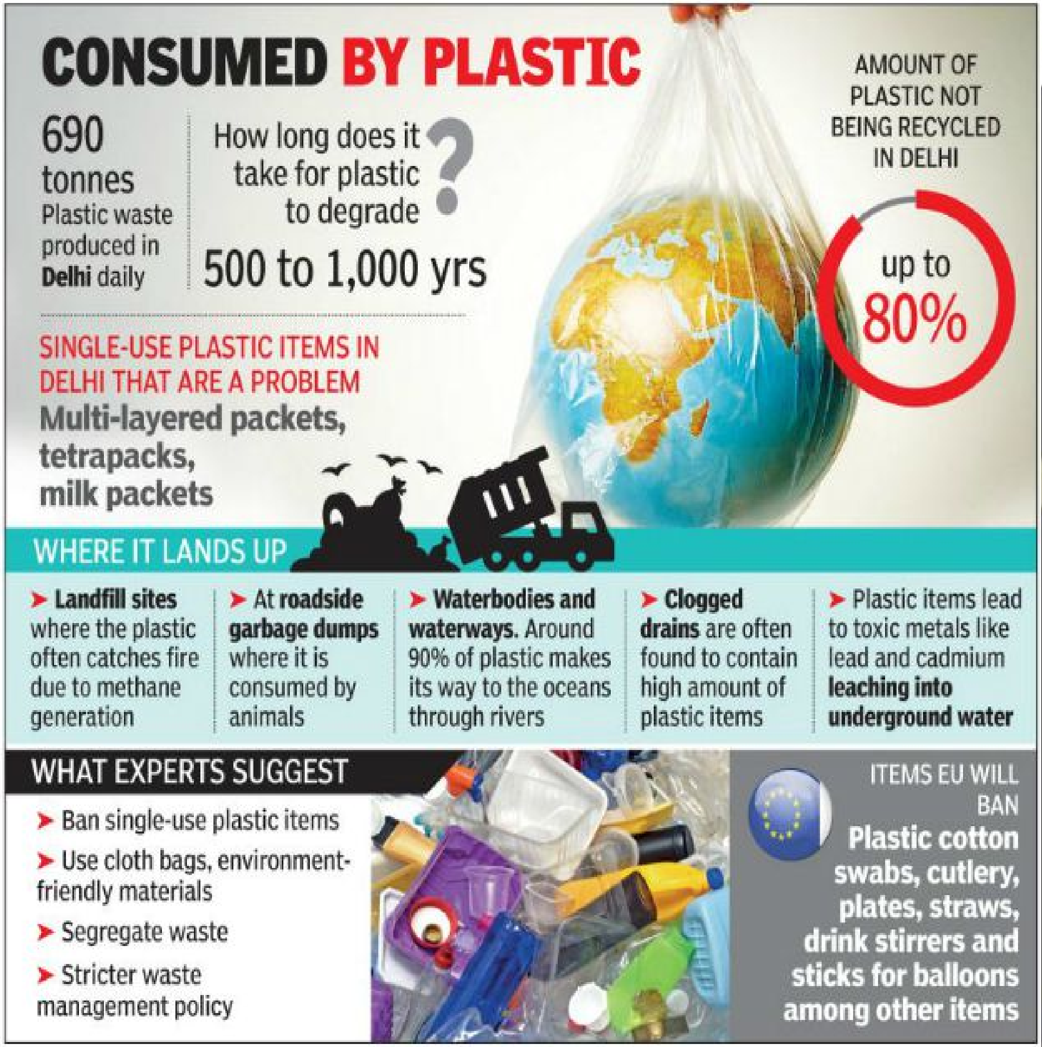
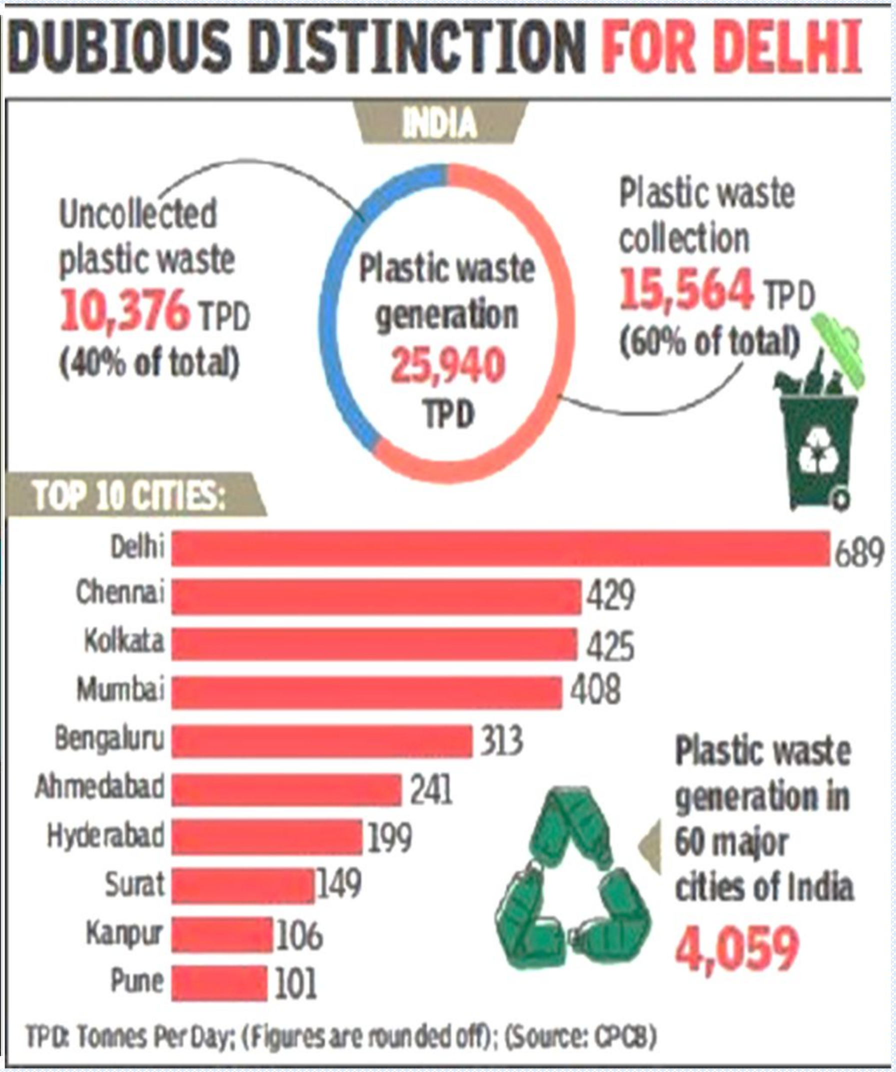
Conventional, Biobased & Biodegradable Plastics




Bio-plastics
Biodegradable plastics
PES
PCL
PBS
PHB
PLA
Starch
PE
NY II
AcC
Bio-based plastics

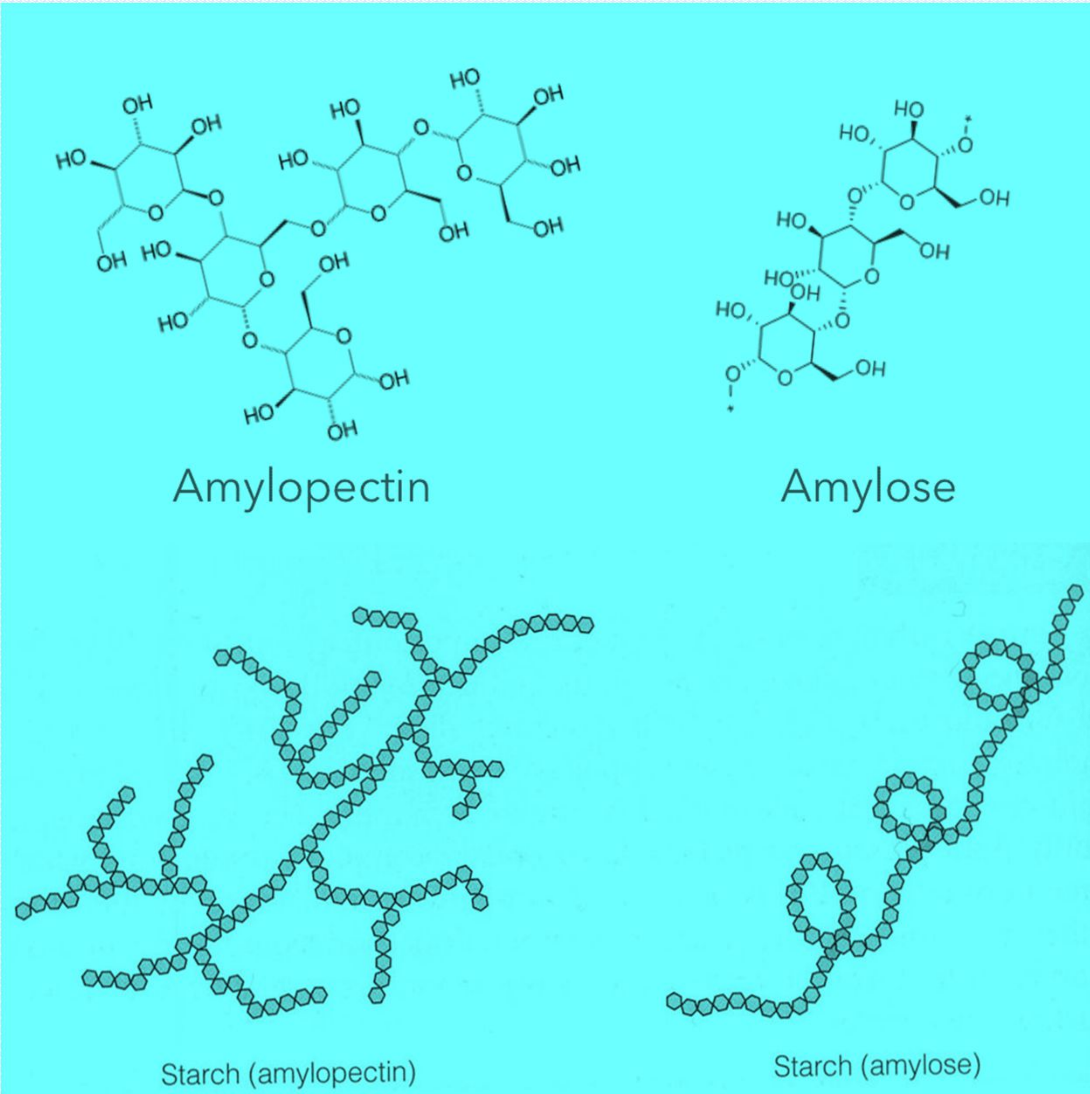

CONSUMED BY PLASTIC
690 tonnes Plastic waste produced in Delhi daily
How long does it take for plastic to degrade?
500 to 1,000 yrs
AMOUNT OF PLASTIC NOT BEING RECYCLED IN DELHI
up to 80%
SINGLE-USE PLASTIC ITEMS IN DELHI THAT ARE A PROBLEM
Multi-layered packets, tetrapacks, milk packets
WHERE IT LANDS UP
Landfill sites where the plastic often catches fire due to methane generation
At roadside garbage dumps where it is consumed by animals
Waterbodies and waterways. Around 90% of plastic makes its way to the oceans through rivers
Clogged drains are often found to contain high amount of plastic items
Plastic items lead to toxic metals like lead and cadmium leaching into underground water
WHAT EXPERTS SUGGEST
Ban single-use plastic items
Use cloth bags, environment-friendly materials
Segregate waste
Stricter waste management policy
ITEMS EU WILL BAN
Plastic cotton swabs, cutlery, plates, straws, drink stirrers and sticks for balloons among other items


DUBIOUS DISTINCTION FOR DELHI
INDIA
Uncollected plastic waste 10,376 TPD (40% of total)
Plastic waste generation 25,940 TPD
Plastic waste collection 15,564 TPD (60% of total)
TOP 10 CITIES:
Delhi 689
Chennai 429
Kolkata 425
Mumbai 408
Bengaluru 313
Ahmedabad 241
Hyderabad 199
Surat 149
Kanpur 106
Pune 101
Plastic waste generation in 60 major cities of India
4,059
TPD: Tonnes Per Day; (Figures are rounded off); (Source: CPCB)

OUT Plastic thalis, spoons, straws

IN Natural and biodegradable options like corn starch thalis, wooden spoons, paper straws, carry bags made from sugarcane pulp, paper cups, kulhads, clay handis and glass bottles

Composition of Corn Starch



Thermoplastic Starch (TPS)

Tg of pure, dry starch is above its decomposition point, so it does not soften and flow on heating. However, starch can be plasticized (destructurized) by low levels organic plasticizers and shear force.

This “thermoplastic starch” (TPS) flows at elevated temperature and pressure and can be extruded to produce pellets, sheets, films and solid moulded articles.

Unfortunately properties of TPS tend to be disappointing hence it has to be blended with other bio-degradable polymers like PVA, PBAT, PLA, PBS, PCL, PBSA, PHAs etc.

Polyvinyl Alcohol

Polyvinyl alcohol (PVOH or PVA) is a water-soluble synthetic polymer.

PVA has excellent film forming, emulsifying and adhesive properties.

PVA is also resistant to oil, grease and solvents.

PVA has high tensile strength and flexibility, as well as high oxygen and aroma barrier properties.

However, these properties are dependent on humidity

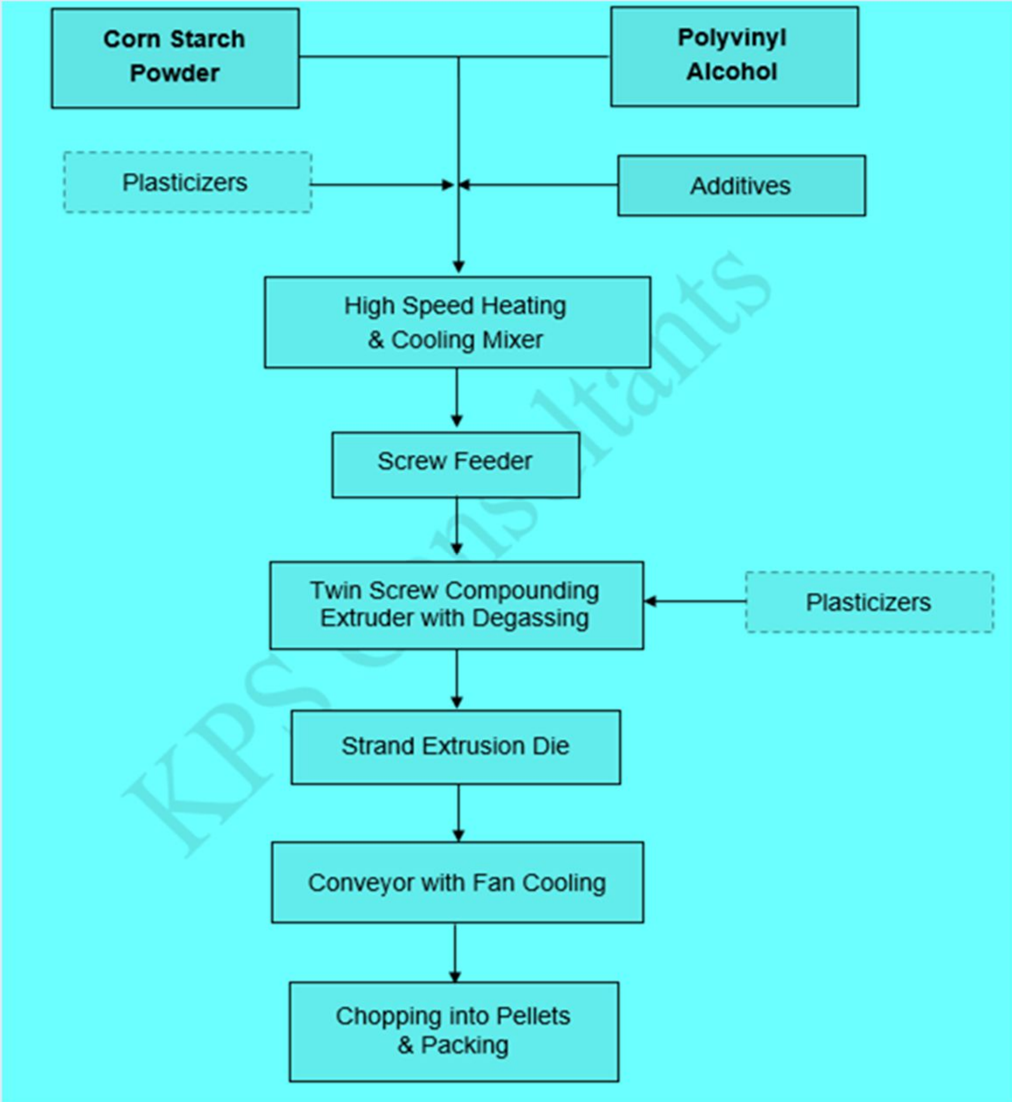
PVA has a melting point of 230°C and 180 – 190°C for the fully hydrolyzed and partially hydrolyzed grades respectively and decomposes rapidly above 200°C.

Typical Compound Composition

- Corn Starch Powder (higher amylose content)
- Polyvinyl Alcohol (DH 88%, medium MW or Viscosity)
- Plasticizers
- Nucleating agent
- Lubricants
- Cross-linking agent
- Fillers

CORN STARCH – PVA BLEND PLASTIC

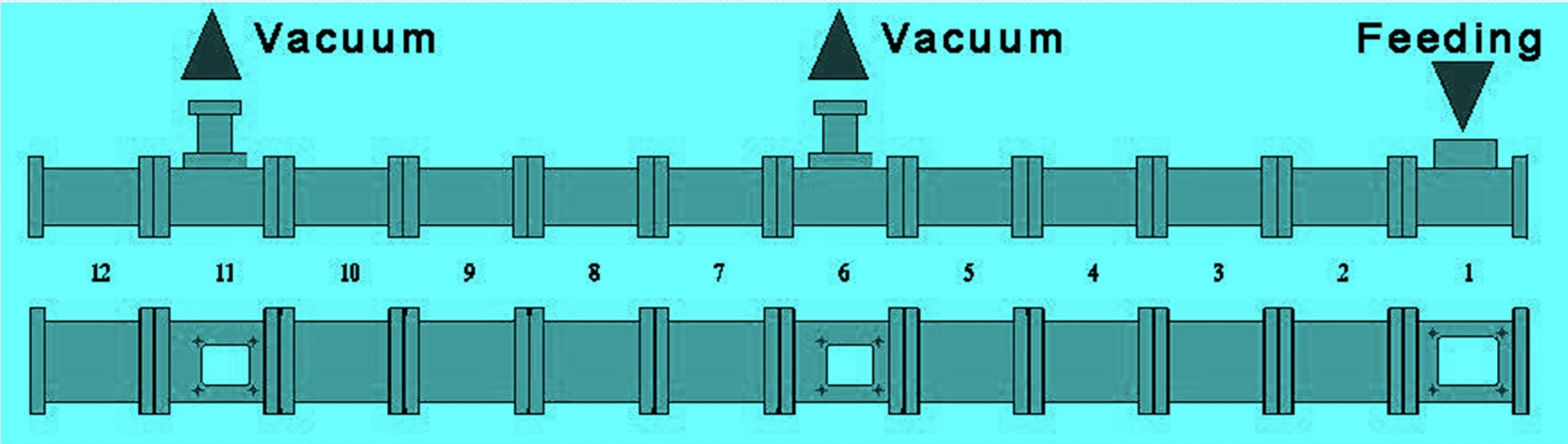
Manufacturing Process



High Speed Heating & Cooling Mixer

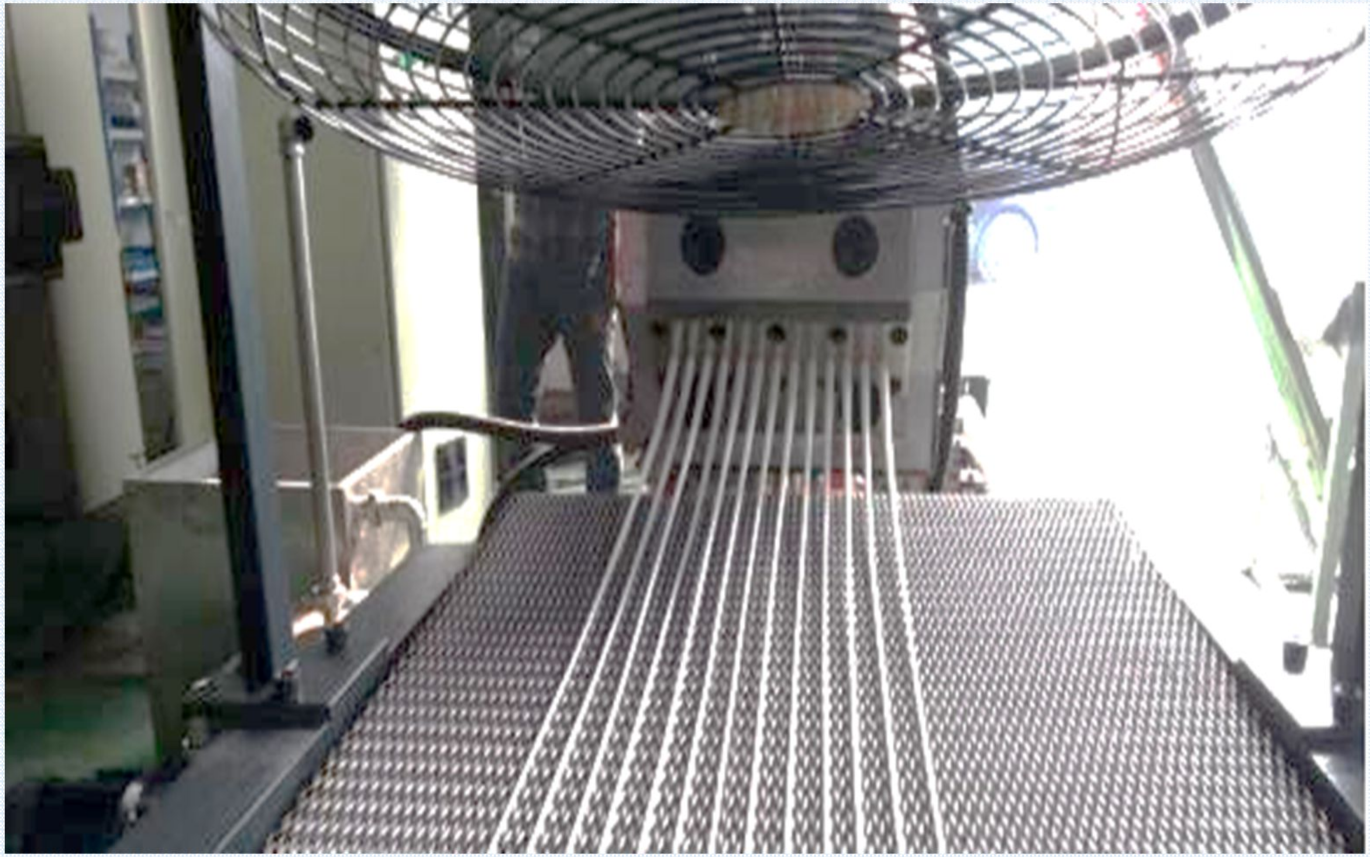
Parallel Twin Screw Co-rotating Extruder

Vacuum Degassing System

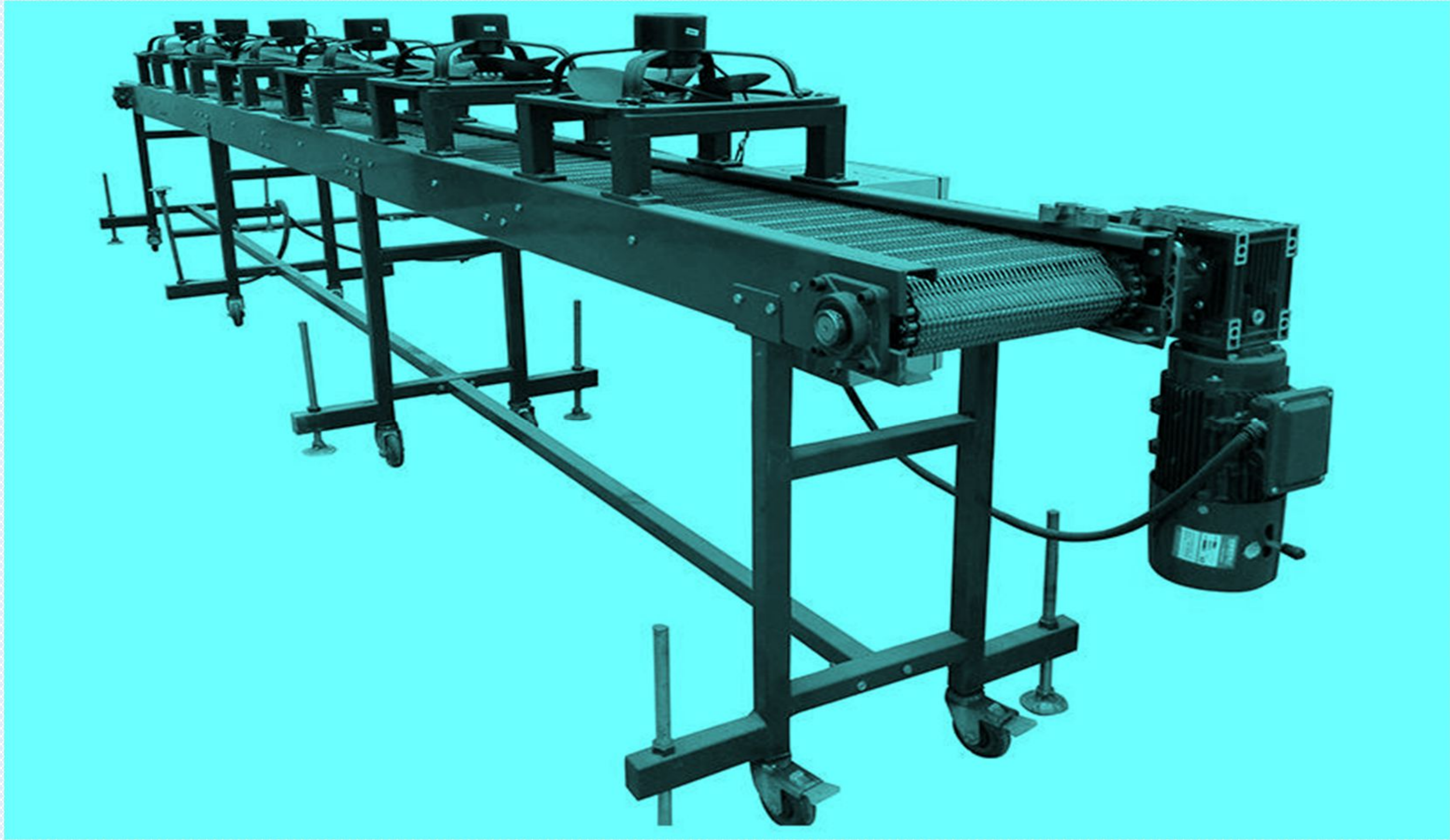


Plasticizer Injection

Hydraulic Screen Changer and Strand Extruder Die



Air Cooling Conveyor Belt

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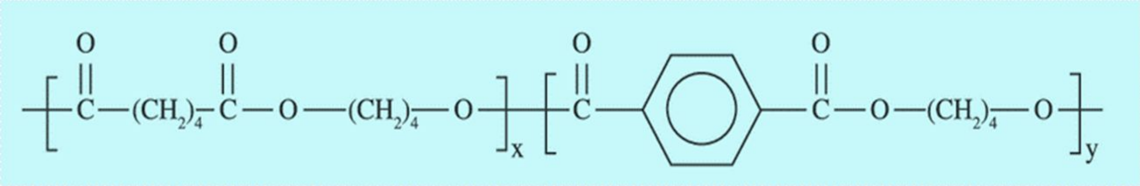
Poly (butylene adipate co-terephthalate)

PBAT is a bio-degradable random co-polymer

Co-polyester of adipic acid, 1,4 butanediol and terephthalic acid from dimethyl terephthalate

Produced by random co-polymerization of 1,4-butanediol, adipic acid, and dimethyl terephthalate (DMT) monomers.

Main advantage of PBAT is that it is a fully biodegradable alternative to LDPE, having similar properties including high flexibility and toughness, allowing it to be used for various packaging applications. Biobased content in the polymer can be as high as 50% if 1,4 butanediol (BDO) from renewable sources is used.



Typical Compound Composition

- Corn Starch Powder (higher amylose content)
- PBAT
- Plasticizers
- Nucleating agent
- Lubricants
- Compatibilizer
- Peroxide initiator

Polylactic Acid - PLA

Lactic acid (LA or 2-hydroxypropionic acid) is the most widely occurring hydroxycarboxylic optical active acid. This chiral molecule exists as two enantiomers L and D-Lactic Acid. Polylactide is based on lactic acid monomers obtained from the fermentation of sugars, beet-sugar, cane-sugar etc. obtained from renewable sources such as sugar cane or corn starch. Poly-lactic acid is an aliphatic polyester and produced by two main routes:

Direct polycondensation reaction

This usually leads to low molecular weight polymers which then can be converted to higher molecular weight polymers by addition of chain coupling agents.

Ring opening polymerization

PLA is produced by formation of lactide monomer first and formed lactide is then put through ROP using metal alkoxides as catalysts resulting in high molecular weight polyester – PLA.

Most of the commercial L-PLA products are semi crystalline polymers with a high melting point 180°C and having their Tg in the range of 55 – 60°C

- PLA is a high strength and high modulus thermoplastic with good appearance
- It has high stiffness and strength, comparable to polystyrene (PS) at room temperature

However, there are still some disadvantages associated with the polymer:

- Its glass transition temperature is low (Tg ~ 55°C)
- Its poor ductility, low impact strength and brittleness limits its use as compared to other thermoplastics
- It has low crystallization rate and processing results mainly in amorphous products
- PLA is much more susceptible to chemical and biological hydrolysis
- It is thermally unstable and has poor gas barrier performance
- It has low flexibility and requires longer moulding cycle
- It is relatively hydrophobic
- It has slow degradation rate

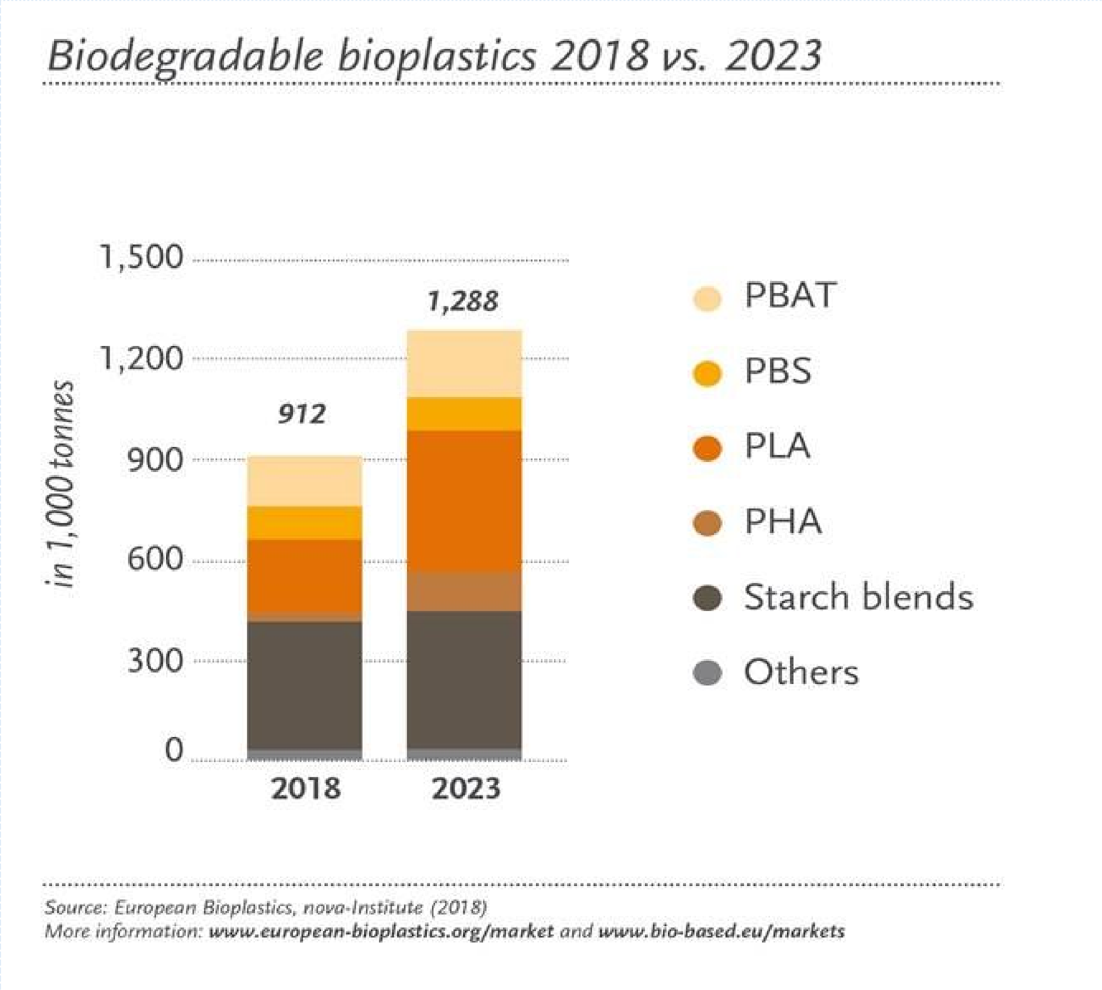
Compounds & End Applications

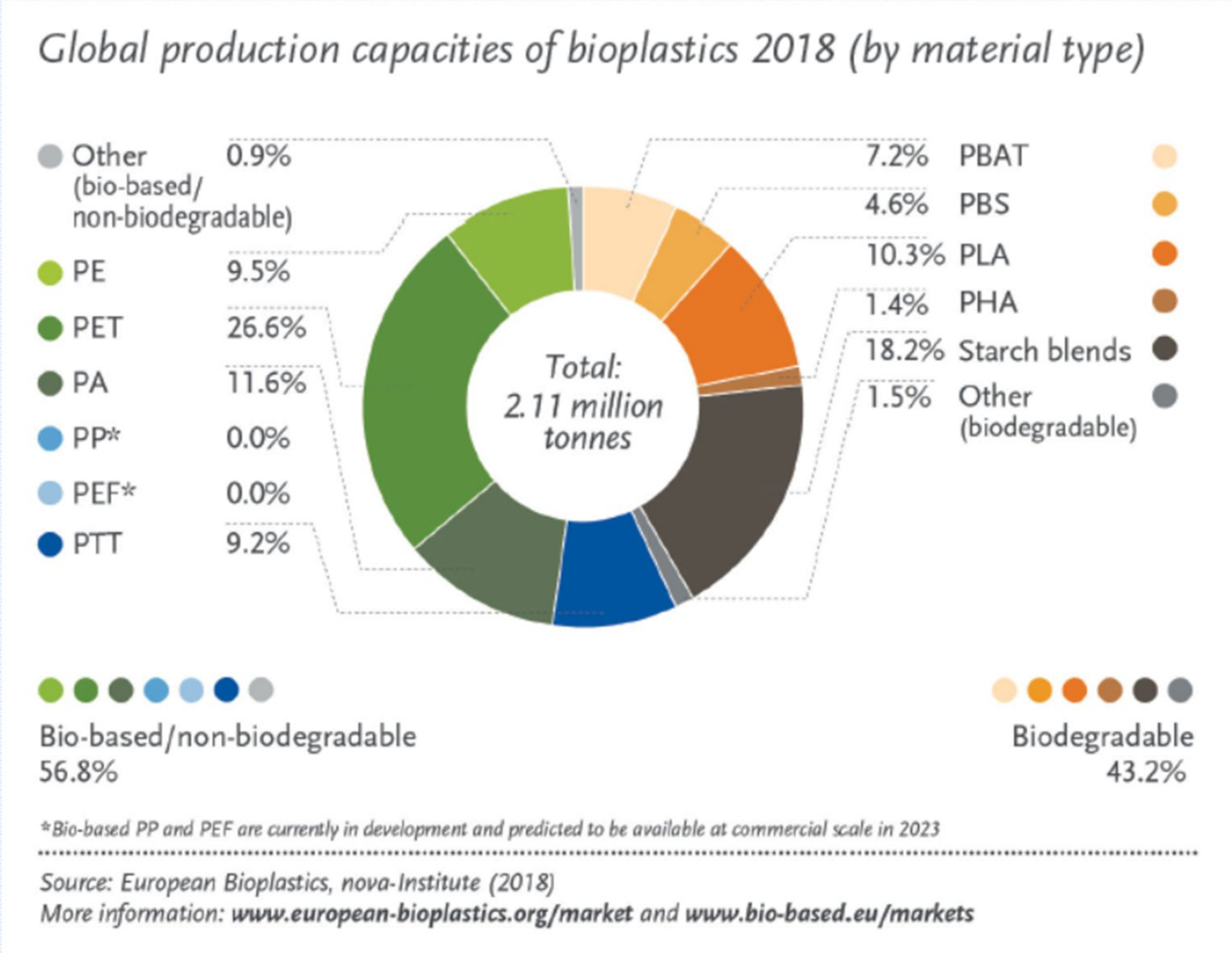
Compound Type	Remarks	End Application
Thermoplastic Corn Starch + PVA	Suitable for extrusion blowing of films Acceptable mechanical properties Competitive cost Very good compostability Soluble in hot water However, properties deteriorate on prolonged contact with hot water / moisture	Blown film – single use carry bags, shopping bags, garbage bags, agricultural mulch films, food wrapping films etc.
Thermoplastic Corn Starch + PVA	Suitable for extrusion of sheet Acceptable mechanical properties Competitive cost Very good compostability	Extruded sheet for thermoforming – plates, thalis, trays, bowls, cups clam shells etc.
Thermoplastic Corn Starch modified PBAT	Good tensile, tear & puncture strength Good melt flow rate for extrusion blowing of film Fair to good level of compostability	Blown film – carry bags, shopping bags, apparel packing bags, fruit & vegetable packing, food wrapping, agricultural films etc.
Thermoplastic Corn Starch modified PBAT and PLA	Good tensile, tear & puncture strength Good melt flow rate for extrusion blowing of film Fair level of compostability	Same as above

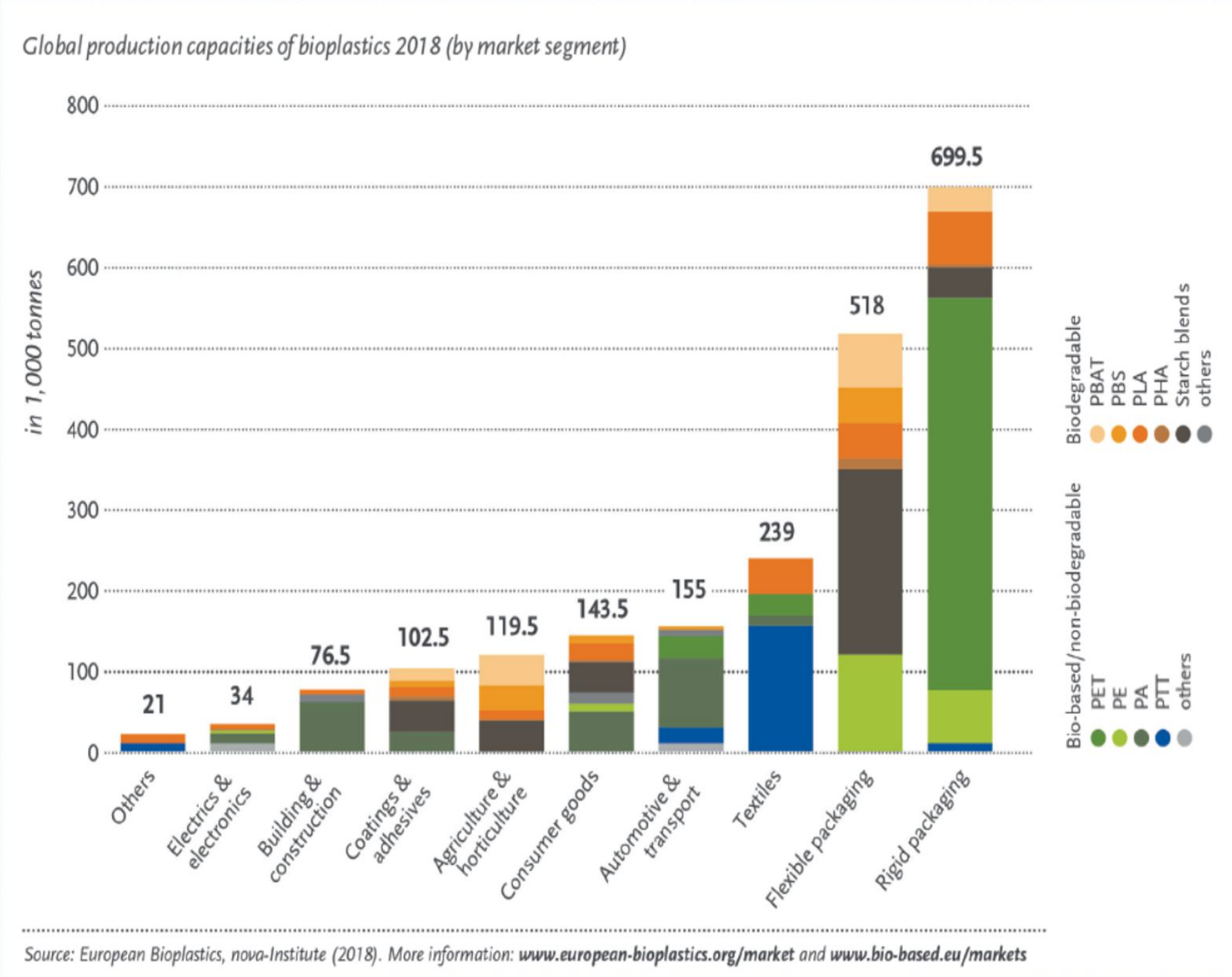
Market Potential

No reliable statistics are available for the production or consumption of plastic bags in India. Hence, we have used a proxy to estimate total consumption of plastic bags in India. Plastic bags are mainly based on LDPE or low density polyethylene. According to PlastIndia Foundation, domestic LDPE consumption in 2016 - 17 was around 700,000 metric tons. Assuming 60% of total LDPE consumption was for the manufacture of plastic bags, the LDPE polymer consumption will be around 420,000 metric tons. Based on this figure, the consumption of LDPE compound for plastic bags will be around 600,000 metric tons. Even a 5% market share for bio-degradable material plastic bags represents a consumption figure of 30,000 metric tons per year growing at 20 to 25% year on year.

Global Scenario

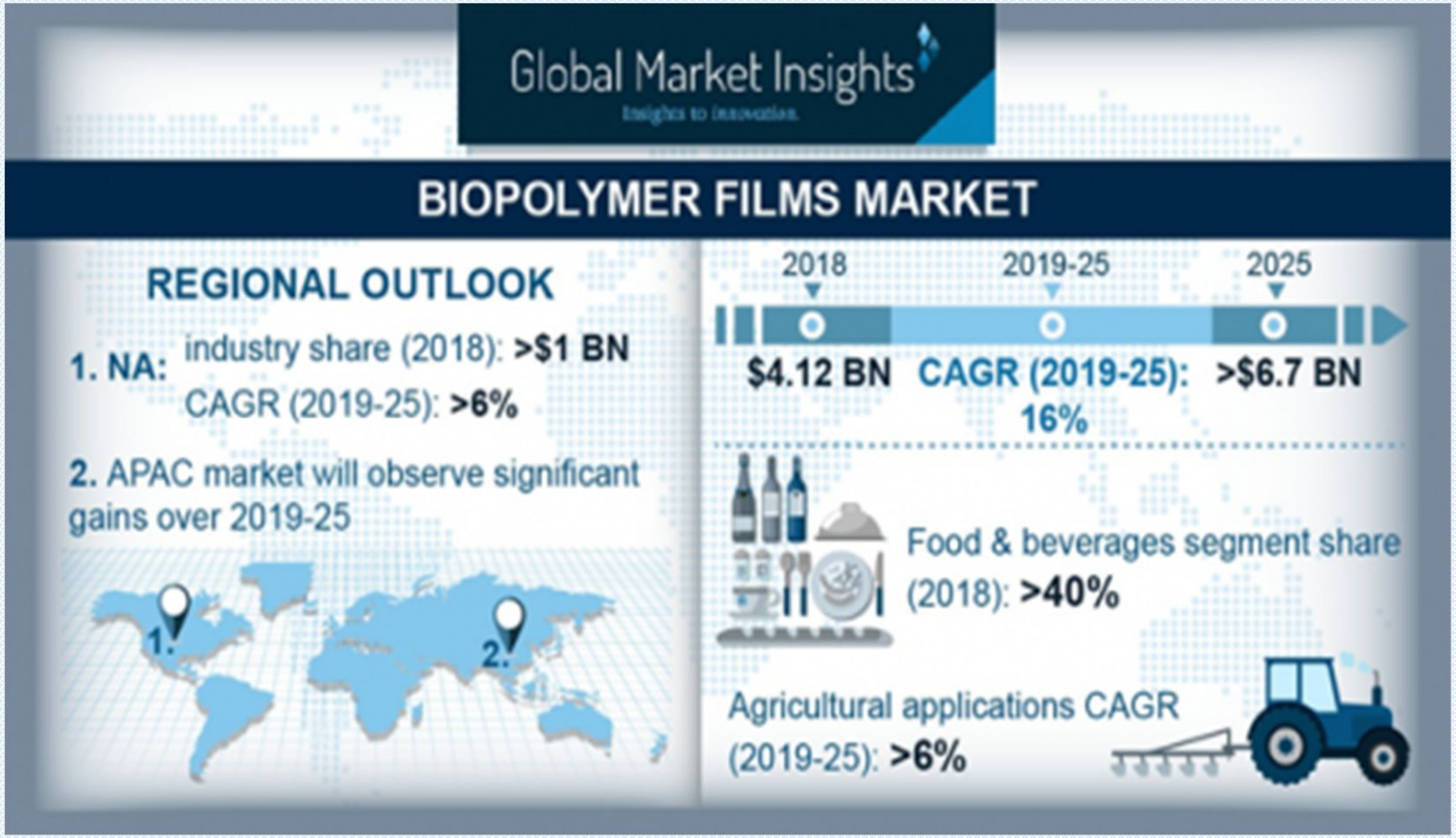



Global production capacities of bioplastics 2018 (by material type)
Other (bio-based/ non-biodegradable) 0.9%
PE 9.5%
PET 26.6%
PA 11.6%
PP* 0.0%
PEF* 0.0%
PTT 9.2%
7.2% PBAT
4.6% PBS
10.3% PLA
1.4% PHA
18.2% Starch blends
1.5% Other (biodegradable)
Total: 2.11 million tonnes
Bio-based/non-biodegradable 56.8%
Biodegradable 43.2%
*Bio-based PP and PEF are currently in development and predicted to be available at commercial scale in 2023
Source: European Bioplastics, nova-Institute (2018)
More information: www.european-bioplastics.org/market and www.bio-based.eu/markets



Global production capacities of bioplastics 2018 (by market segment)
in 1,000 tonnes
800
700
600
500
400
300
200
100
0
21
34
76.5
102.5
119.5
143.5
155
239
518
699.5
Others
Electrics & electronics
Building & construction
Coatings & adhesives
Agriculture & horticulture
Consumer goods
Automotive & transport
Textiles
Flexible packaging
Rigid packaging
Biodegradable
PBAT
PBS
PLA
PHA
Starch blends
others
Bio-based/non-biodegradable
PET
PE
PA
PTT
others
Source: European Bioplastics, nova-Institute (2018). More information: www.european-bioplastics.org/market and www.bio-based.eu/markets

Biopolymer films market value to surpass $6.7 billion by 2025



Global TPS blend compound manufacturers and their brands

Company	Brand	Remarks
Biograde Limited	Biograde (various grades)	Blend of thermoplastic starch (TPS), aliphatic polyesters (AP) or synthetic bio-degradable co-polyesters with natural plasticizers & additives
Biop	Biopar (various grades)	Blend of thermoplastic starch (TPS) with synthetic bio-degradable co-polyesters plasticizers & additives
Biotec	Bioplast (various grades)	Thermoplastic starch with or without plasticizer and with additives
Cardia Bioplastics	Biohybrid (various grades)	Blend of thermoplastic starch (TPS), with polyolefins mainly LDPE and additives
Cerestech	Cereloy (various grades)	Blend of thermoplastic starch (TPS), with polyolefins like LDPE and octene LLDPE & additives

Contd.

Company	Brand	Remarks
ENSO Plastics	ENSO Renew	Thermoplastic starch with plasticizer and additives
Franplast	Chemiton (various grades)	Blend of thermoplastic starch (TPS), with co-polymers & additives
Grabio	Grabio (various grades)	Thermoplastic starch (TPS)with cellulose
Green Dot	Terratek (various grades)	Blend of thermoplastic starch (TPS), with polypropylene
Japan Corn Starch	Cornpole	Thermoplastic starch with plasticizer and additives

Contd.

Company	Brand	Remarks
Kingfa	Ecopond Flex	Thermoplastic starch with plasticizer and additives
Nexus Resin	Nexus Bio (various grades)	Blend of thermoplastic starch (TPS), with polyethylene grades
Resirene	Biorene (various grades)	Blend of polystyrene with thermoplastic starch (TPS)
Showa Denko	Bionelle (various grades)	Blend of thermoplastic starch (TPS), with PLA
Teknor Apex	Terraloy (various grades)	Blend of thermoplastic starch (TPS), with various materials like LLDPE / HIPS / Co-polyester etc.

THANK YOU

THE FUTURE BELONGS TO THOSE WHO SEE

POSSIBILITIES BEFORE THEY BECOME OBVIOUS

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