Role of AI Towards Climate Resilient Polymer Sustainability

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Geographical Location of IIT Guwahati

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- Biotechnology
- Chemical Engineering
- Chemistry
- Civil Engineering
- Computer Science & Engg.
- Design
- Electronics & Electrical Engg.
- Humanities & Social Sc.
- Mathematics
- Mechanical Engineering
- Physics
- Centres
- Central Instruments Facility
- Centre for Edu. Technology
- Centre for Energy
- Centre for Nanotechnology
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Indian Institute of Technology Guwahati
Guwahati - 781039, INDIA

IIT G Area: ~ 9 Square Kilometer

Artificial Intelligence (AI) & Carbon Footprint

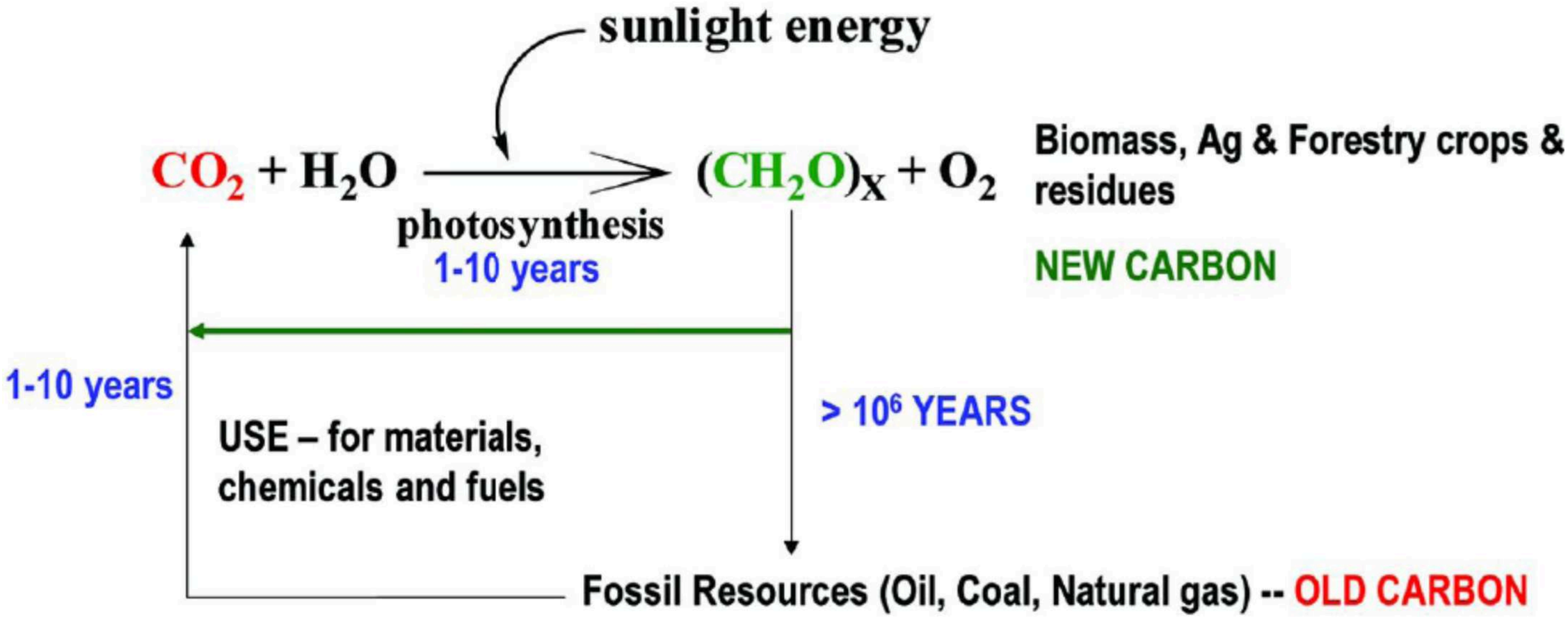
- **Artificial Intelligence (AI)** addresses the simulation of human intelligence in machines that are programmed to think, learn, and solve problems autonomously.
- AI leverages machine learning and neural networks to streamline the design, synthesis, and recycling and end of life behaviour of polymers and composites.
- The **Carbon Footprint** is the total greenhouse gas emissions into the atmosphere, measured in terms of carbon dioxide equivalents.
- The carbon footprint of polymers spans their entire lifecycle, from raw material extraction and manufacturing to final disposal.

Day-to-Day Lifestyle with Plastics

Where does our Fossil based Plastic go?

CO2 Value Proposition: Bio vs Petro-based

Preserve and enhance natural capital by controlling finite stock



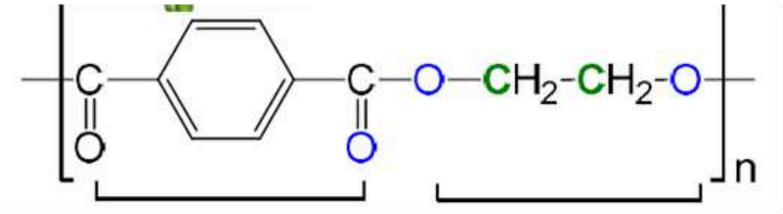
Rate and time scales of CO_2 utilization is in balance using bio/renewable feedstocks (1-10 years) as opposed to using fossil feedstocks

Importance of BioPlastics Towards Carbon Footprint

plantbottle™

up to 30% plant-based
100% recyclable bottle

redesigned plastic,
recyclable as ever.

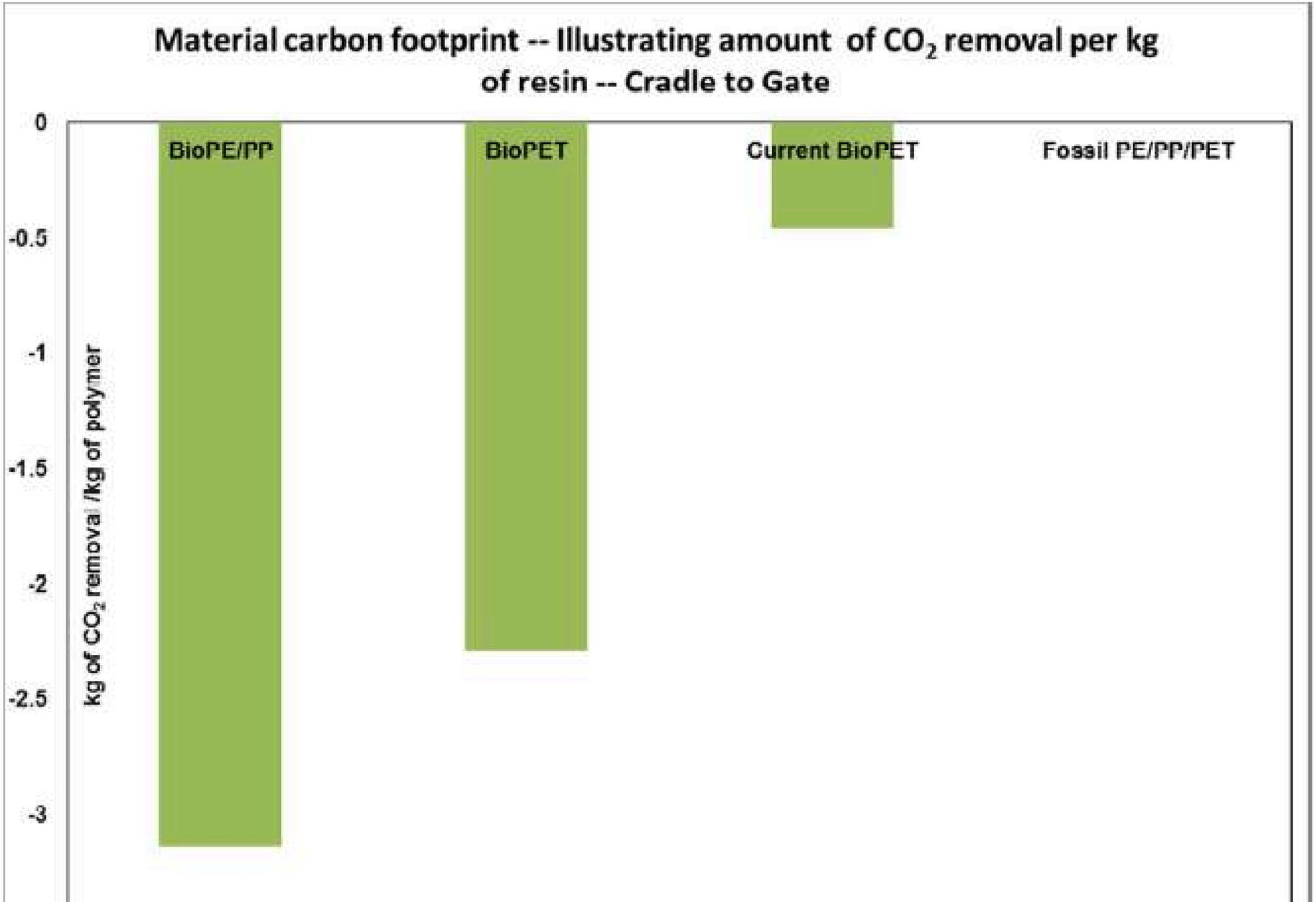


Fossil based Acid Carbon (8); 68.75% by mass	Bio-based glycol Carbon (2); 31.25% by mass

For bottles:
37.5 MM tons PET used
17.2 MM tons CO_2 savings
40 million barrels of oil/yr savings

ASTM D6866: 20% BCC equivalent to 31.25 by wt of plant biomass

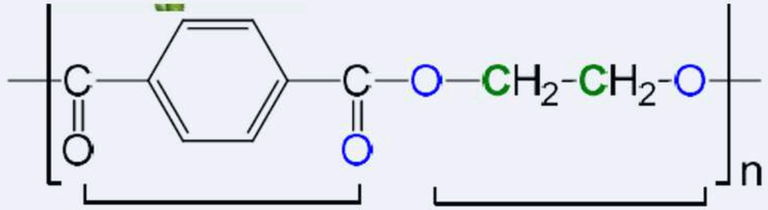
Bio vs Petro-based Carbon Footprint



❖ Bioplastic refers to the "beginning of life"- Plant/biomass

plantbottle™

PET Bottle

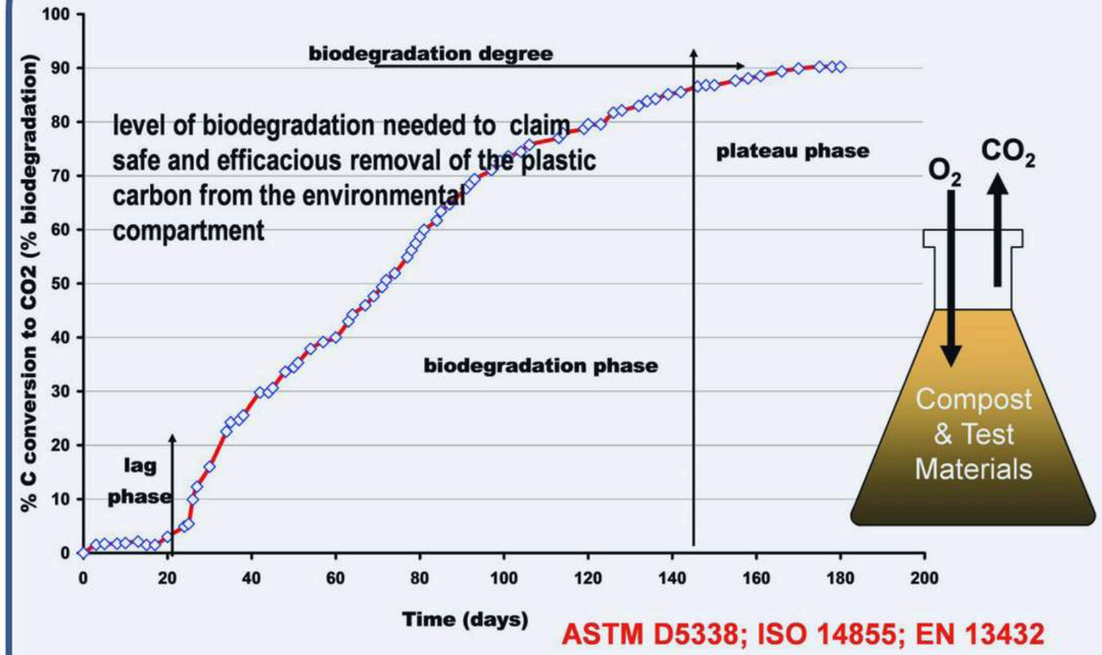


Fossil based Acid Carbon (8); 68.75% by mass

Bio-based glycol Carbon (2); 31.25% by mass

Help towards Sustainable Carbon Cycle

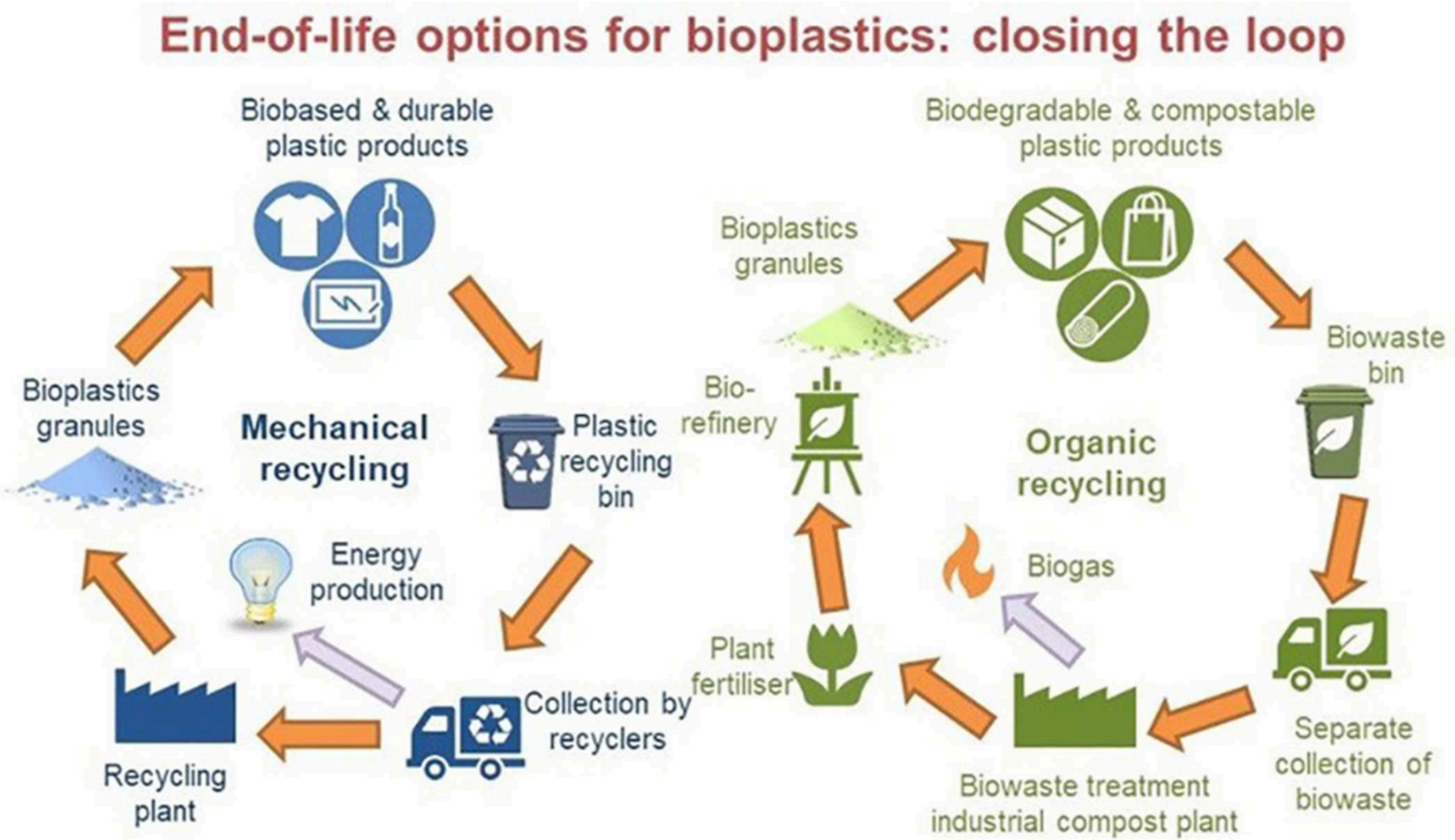
• Biodegradable refers to the "End of life"- Compostable Plastics

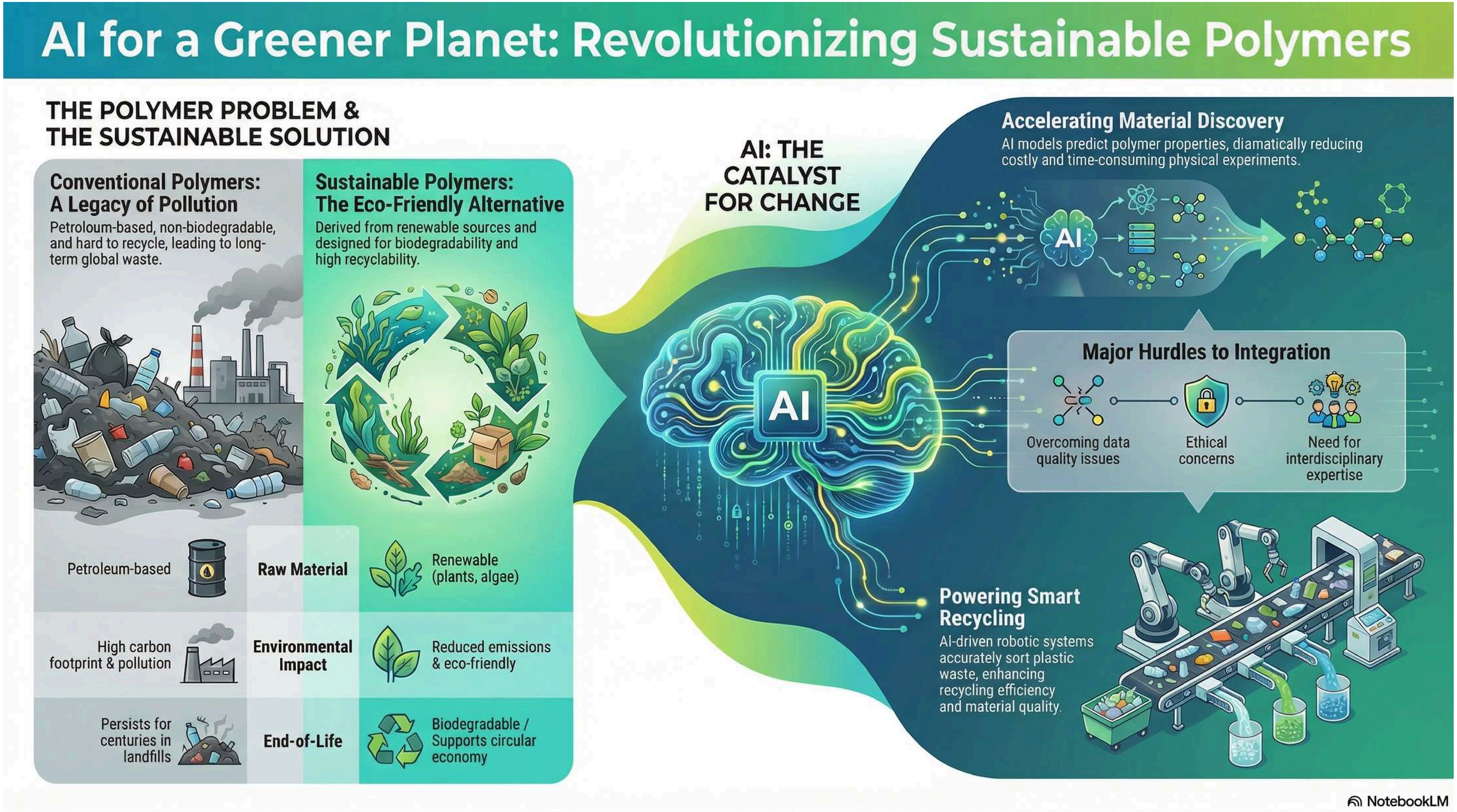


Measuring extent of biodegradability of test plastic as the sole carbon source

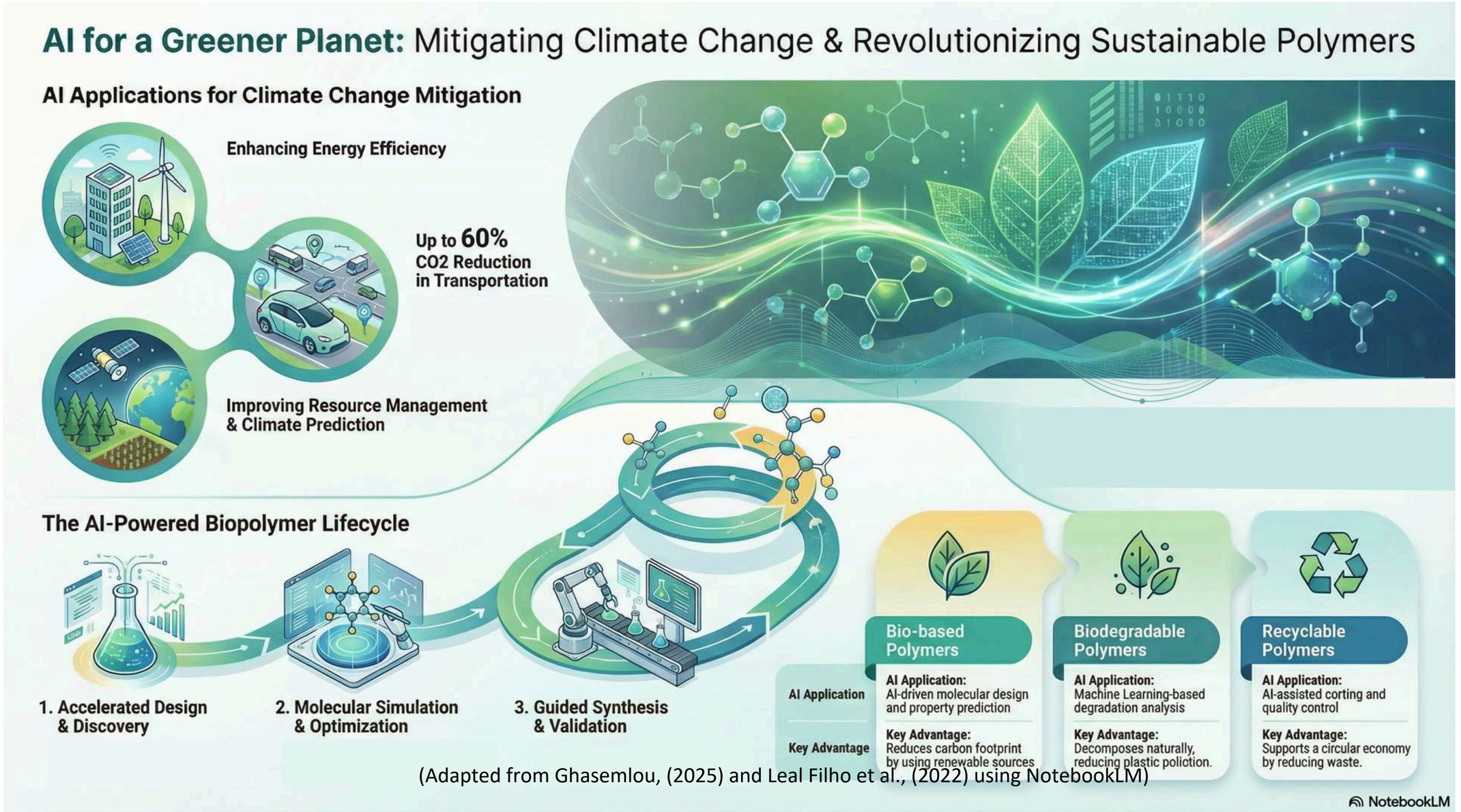
Help towards Safe removal of Carbon from EC

Bioplastics: the sustainable alternative




AI for a Greener Planet: Revolutionizing Sustainable Polymers
THE POLYMER PROBLEM & THE SUSTAINABLE SOLUTION
Conventional Polymers: A Legacy of Pollution
Petroloum-based, non-biodegradable, and hard to recycle, leading to long-term global waste.
Sustainable Polymers: The Eco-Friendly Alternative
Derived from renewable sources and designed for biodegradability and high recyclability.
Petroleum-based
Raw Material
Renewable (plants, algae)
High carbon footprint & pollution
Environmental Impact
Reduced emissions & eco-friendly
Persists for centuries in landfills
End-of-Life
Biodegradable / Supports circular economy
AI: THE CATALYST FOR CHANGE
AI
Accelerating Material Discovery
AI models predict polymer properties, diamatically reducing costly and time-consuming physical experiments.
AI
Major Hurdles to Integration
Overcoming data quality issues
Ethical concerns
Need for interdisciplinary expertise
Powering Smart Recycling
AI-driven robotic systems accurately sort plastic waste, enhancing recycling efficiency and material quality.
NotebookLM

Climate change and integration of AI for its mitigation



(Adapted from Ghasemlou, (2025) and Leal Filho et al., (2022) using NotebookLM)

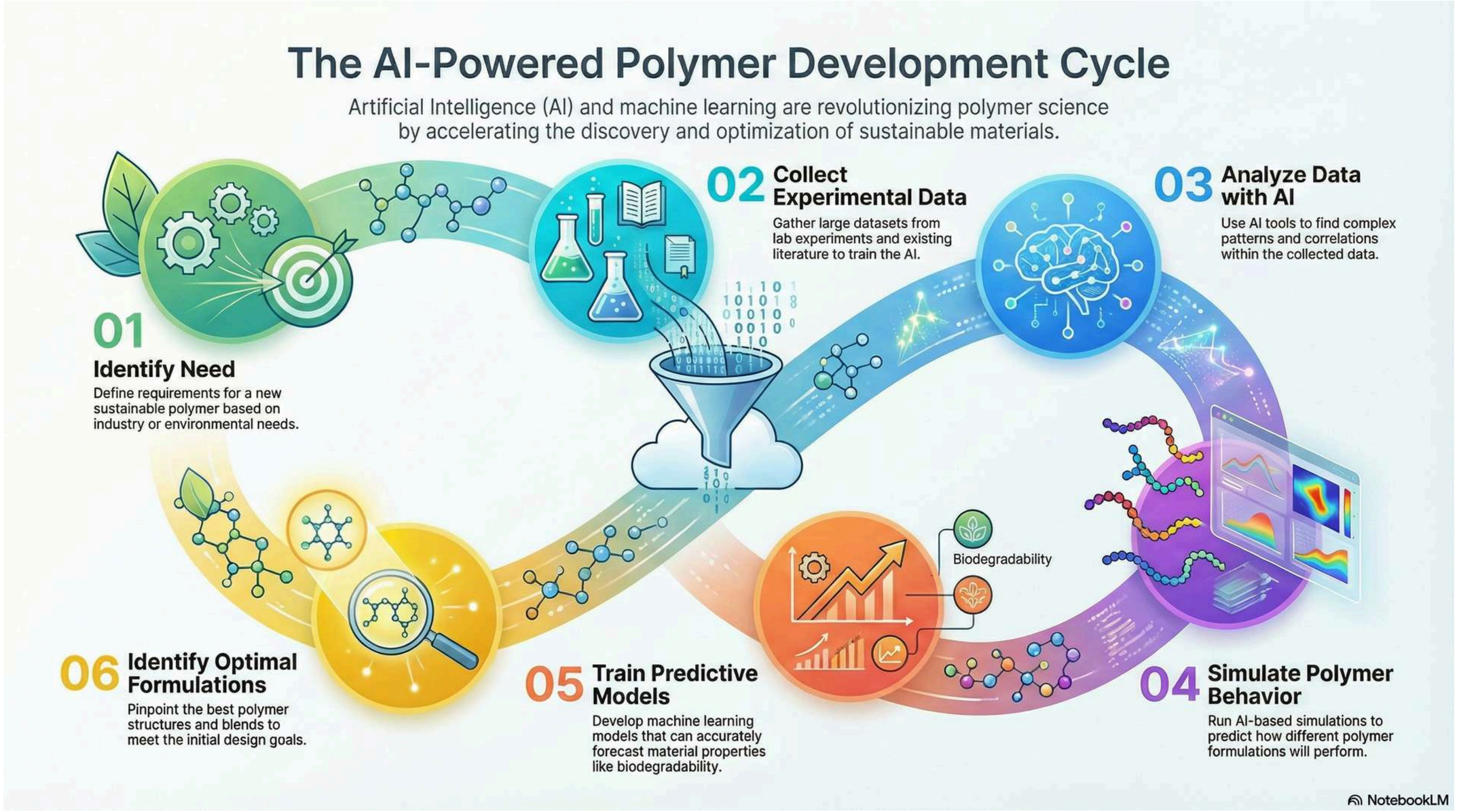
Need of AI in Climate change

The Linear Trap: Why We Need a Material Revolution

The Problem: The world relies on a ‘take-make-waste’ model. Conventional polymers persist for centuries, degrade arable land, and generate massive emissions.

The Bottleneck: Traditional material discovery relies on physical trial-and-error, a slow process incompatible with the urgency of climate change.

AI-driven polymer development process



(Adapted from Hashmi et al.,(2025)

Advantages of AI in polymer processing

From Trial-and-Error to Digital Precision

AI compresses decades of research into months through predictive modeling.

Physical Experimentation

AI Integration

High-Throughput Screening

Predictive Modeling

Automated Synthesis

High-Throughput Screening

Rapidly testing thousands of theoretical combinations *in silico*.

Predictive Modeling

Simulating stress, heat, and biodegradation behavior before synthesis.

Machine Learning & Deep Learning

Identifying non-obvious correlations between molecular structure and performance.

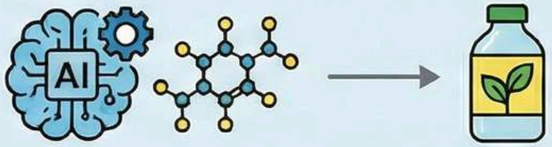
Circular economy for plastics driven by the use of AI

AI: Closing the Loop on Plastic Waste

How Artificial Intelligence is a key tool for creating a **circular economy** for plastics.

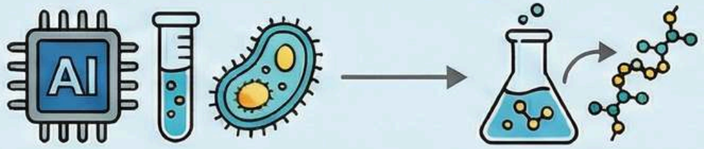
DESIGNING SUSTAINABLE PLASTICS

Inventing New Bioplastics



AI analyzes vast datasets of chemical structures to discover and design new, fully biodegradable replacements for petroleum-based plastics.

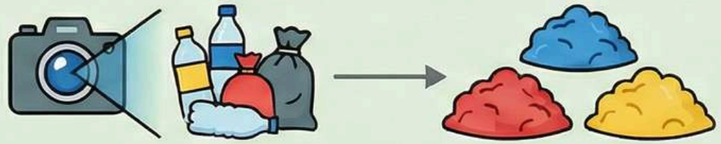
Optimizing Microorganisms



AI models metabolic networks to discover or genetically engineer microbes that can efficiently produce and accumulate biopolymers

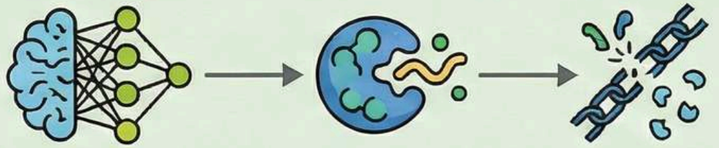
REVOLUTIONIZING RECYCLING

Automated Smart Sorting



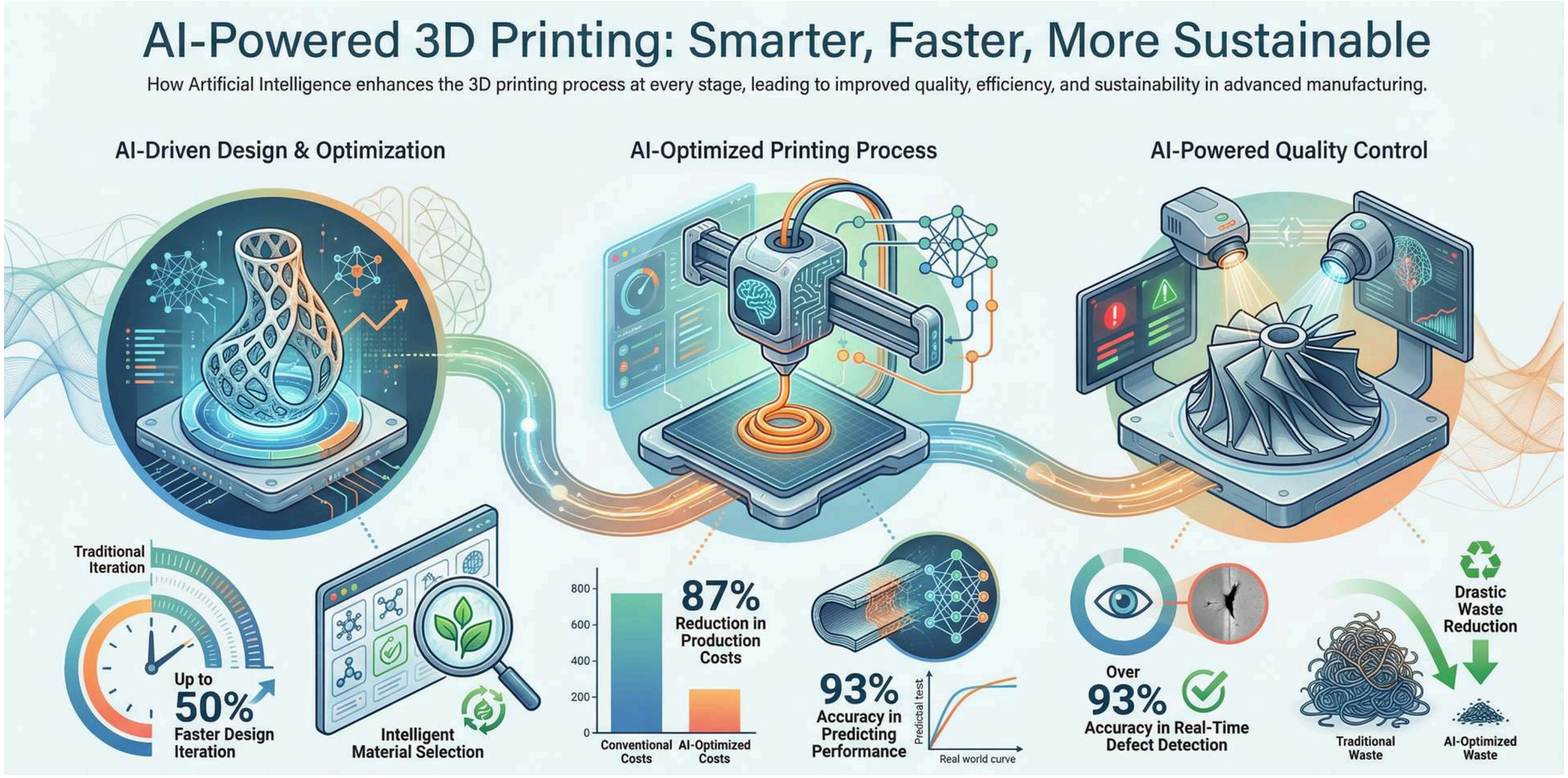
AI-driven computer vision identifies and classifies mixed plastics by composition and color, boosting sorting accuracy and the quality of recycled materials.

Finding Plastic-Eating Enzymes



By simulating millions of interactions, AI accelerates the discovery of new enzymes capable of breaking down hard-to-recycle plastics like PE and PP.

Use of AI in 3D printing using biopolymers

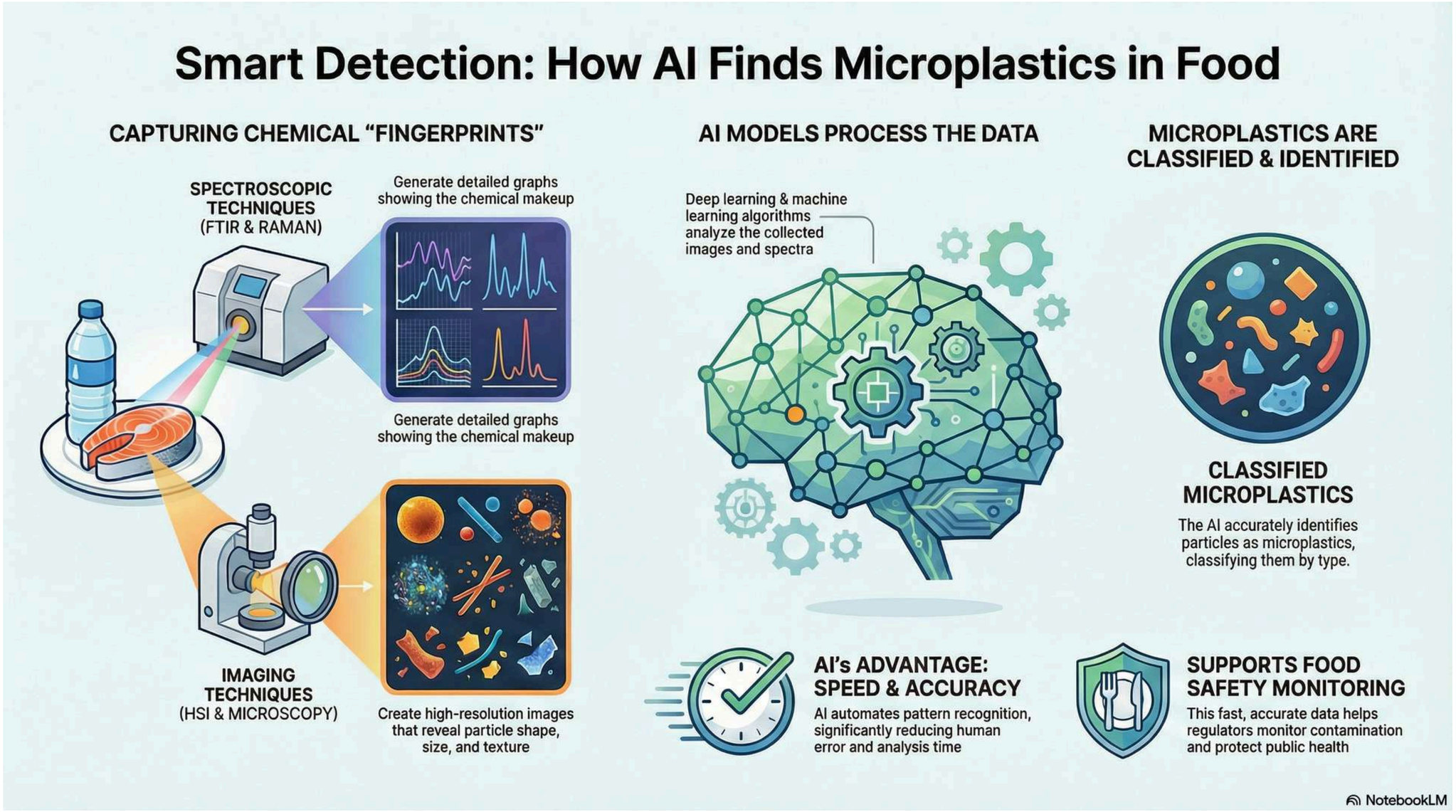


Used in the development of-

1. AI- driven design optimization
2. Intelligent process control

(Adapted from Hassan et al.,(2025) using NotebookLM)

Microplastics in Food Supply chain



Bioplastics: IIT Guwahati Status

- **Centre of Excellence for Sustainable Polymers funded by DCPC, Govt. of India.**
- **Joint DBT-TERI Centre of Excellence for Biofuels and Bio-commodities, DBT.**
- **NRL-Centre of Excellence for Sustainable Materials at IIT Guwahati.**
- **CRTDH HUB for MSME by DSIR**
- **Biodegradable Toy Centre Funded by DST for rural livelihood through Industry 4.O**
- **North Eastern Science & Technology Cluster: Sustainable Plastics as one vertical**
- **Total Project Executed so Far > 30**
- **Sustainable Polymers Journal Researchh Articles/book chapters > 300**
- **PhD Graduated in Sustainable Polymers area >30**
- **PhD Graduated working in Sustainable Polymers area >20**
- **Patents (Granted/Filed) in Sustainable Polymers domain>40**
- **Book Published in Sustainable Polymers domain: 8**
- **Indigenous PLA Technology developed for Industries**
- **Developing PBAT/PCL/ PEF Polymer Based Technologies**
- **Multiple Downstream product based technologies has been developed so far..**

Thank You for Your Attention