Plasticiser Degradation Using Bacterial Enzymes

Source: TH

IIT Roorkee has successfully **used the esterase enzyme,** produced by the **soil bacterium *Sulfobacillus acidophilus*,** to break down the **plasticizer Diethyl Hexyl Phthalate (DEHP).**

- This advancement addresses the growing environmental and health concerns posed by plasticisers.

Note: Plasticisers (chemicals added to **plastics and personal care products** to improve flexibility and shine) like DEHP, found in **baby toys, food containers,** etc are harmful pollutants.

- **Plasticisers are additives** used to make **rigid plastics like PVC (polyvinyl chloride) more flexible and softer** by reducing intermolecular forces within the polymer chains. This is particularly relevant to plastic products **requiring durability and flexibility, such as cables, hoses, and films.**
- They are **carcinogens**, posing health risks through **skin absorption or ingestion.** As **persistent organic pollutants**, they contaminate water and soil, harming ecosystems and aquatic life.

How Do Bacterial Enzymes Work in Degrading Plasticisers?

- **Mechanism of Action:** The esterase enzyme breaks down DEHP plasticizer into two products- **modified phthalate** (affect biological system) and **alcohol compound (impact the environment).**
  - These are further broken down by other enzymes into harmless substances like **Water and Carbon Dioxide.**
- **Structural Insights:** X-ray crystallography (technique that uses **X-rays to determine the atomic and molecular structure of a crystal**) identified active sites on the esterase enzyme, elucidating the mechanism by which DEHP is targeted and broken down.
- **Sustainability:** The integration of these enzymes into bacteria ensures prolonged activity and continuous degradation without requiring frequent enzyme replacement.
- **Efficiency:** Lab experiments show significant efficiency in **degrading high molecular weight plasticisers**, **providing an edge** over previously reported methods.

What is Plastic?

- **About: Plastic** is a **lightweight, durable, and hygienic material** that is easy to mold into various forms and **is cost-effective to produce**.
  - Most plastics **do not decompose naturally**. Instead, they slowly break down into smaller pieces called **microplastics.**
- **Status of Plastic Production: In 2023,** the world produced **413.8 million metric tons (mt)** of plastic. This is a sharp increase from 1950, when the world produced only two million tons.

    - **India** leads the world in generating plastic waste, **producing 10.2 million tonnes a year**.
- **Types of Plastics:**
    - **Biodegradable Plastic**: This type of plastic **degrades through biological or microbial processes** and are derived from **fossil fuels** or renewable sources but are designed to break down more quickly under specific conditions.
        - Not all plastics are biodegradable, and some conventional plastics persist in the environment for long periods.
    - **Bioplastics**: These are both **biodegradable and bio-based**, made from natural materials like corn, etc.
    - **Compostable Plastic**: These plastics are a subset of biodegradable plastics, made from renewable materials such as **corn, starch, etc.** They are **non-toxic and decompose naturally** into carbon dioxide, water, and biomass through composting.

Which plastics are recyclable?

Summary of plastic polymer groups, their common uses, properties and recyclability.
Numerical coding (from 1-7) is typically provided on plastic items and gives information of their polymer grouping below. Recyclability is based on common recycling schemes but can vary between countries as well as regionally within countries; check local recycling guidelines for further clarification.

Symbol	Polymer	Common Uses	Properties	Recyclable?
1 PETE	Polyethylene terephthalate	 Plastic bottles (water, soft drinks, cooking oil)	Clear, strong and lightweight	Yes; widely recycled
2 HDPE	High-density polyethylene	 Milk containers, cleaning agents, shampoo bottles, bleach bottles	Stiff and hardwearing; hard to breakdown in sunlight	Yes; widely recycled
3 PVC	Polyvinyl chloride	 Plastic piping, vinyl flooring, cabling insulation, roof sheeting	Can be rigid or soft via plasticizers; used in construction, healthcare, electronics	Often not recyclable due to chemical properties; check local recycling
4 LDPE	Low-density polyethylene	 Plastic bags, food wrapping (e.g. bread, fruit, vegetables)	Lightweight, low-cost, versatile; fails under mechanical and thermal stress	No; failure under stress makes it hard to recycle
5 PP	Polypropylene	 Bottle lids, food tubs, furniture, houseware, medical, rope, automobile parts	Tough and resistant; effective barrier against water and chemicals	Often not recyclable; available in some locations; check local recycling
6 PS	Polystyrene	 Food takeway containers, plastic cutlery, egg tray	Lightweight; structurally weak; easily dispersed	No; rarely recycled but check local recycling
7 OTHER	Other plastics (e.g. acrylic, polycarbonate, polyactic fibres)	 Water cooler bottles, baby cups, fiberglass	Diverse in nature with various properties	No; diversity of materials risks contamination of recycling

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Prelims

Q.1 In India, 'extend producer responsibility' was introduced as an important feature in which of the following? (2019)

(a) The Bio-medical Waste (Management and Handling) Rules, 1998

(b) The Recycled Plastic (Manufacturing and Usage) Rules, 1999

(c) The e-Waste (Management and Handling) Rules, 2011

(d) The Food Safety and Standard Regulations, 2011

Ans: (c)

Q2. Why is there a great concern about the 'microbeads' that are released into environment? (2019)

(a) They are considered harmful to marine ecosystems.

(b) They are considered to cause skin cancer in children.

(c) They are small enough to be absorbed by crop plants in irrigated fields.

(d) They are often found to be used as food adulterants.

Ans: (a)