P4SB

From Plastic waste to Plastic value using Pseudomonas putida Synthetic Biology

Microbes — the mighty helpers revalourising plastic waste

Research and innovation goals

The main objective of the P4SB project is the biotransformation of plastic waste into value-added alternative material. This project uses synthetic biology tools to engineer the bacterium *Pseudomonas putida* to a whole-cell biocatalyst. In a two-step process, first enzymes are used to decompose oil-based plastic and second, trained microbes re-compose the monomers back into fully biodegradable counterparts. Polyethylene terephthalate (PET) and ester bond containing polyurethane (PU) can be depolymerised by the engineered enzymes. The *P. putida* cell-factory can also be customised to synthesise from the decomposed plastics new environmentally friendly materials such as biodegradable bioplastics (polyhydroxyalkanoates, PHA).

What P4SB is for

P4SB aims at supporting the ambitious recycling targets for plastic waste set by the EU. These industry driven objectives will help to address the market need for novel routes to revalourise the gigantic plastic waste streams, and will create direct opportunities spanning the entire value chain for P4SB's SME partners. Advancements in biobased processing toward cost savings and a novel bulk, plastic waste to become a novel substrate and a second generation carbon source for the industrial biotechnology have been established.

Technological approach

The microbes underwent deep metabolic surgeries to efficiently channel the diverse substrates into the production of polyhydroxyalkanoates (PHA) and other derivatives. Laboratory evolution revealed the metabolic and regulatory basis of ethylene glycol metabolism by *P. putida* KT2440. The programmed lytic secretion of PHA facilitates a simple harvesting of the bioplastic.
The project has developed six different technologies at different readiness levels. Molecular, metabolic and process-level modelling for the design and optimisation of PET/PU hydrolysing enzymes, *P. putida* PHA biocatalysts and the envisioned P4SB fermentation process have been provided. Synthetic biology based downstream process (DSP) to unlock the cost-efficient production of PHAs are under development.

More smooth surface-enzymes are at **TRL 7**

During the project, PU degradation enzyme group went from **TRL 1** to **TRL 3**

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Main markets and main clients

The maximum market growth rate expected is in double-digit millions of euros within five years. It may be even higher, given the prospect of the plastic market doubling by 2050. Main clients: bio-chemical intermediate markets, producers of polymers and advanced materials, PHA markets, enzyme businesses, synbio/bio-conversion technologies, recyclers, environmental technology applications.

Commercialisation steps

As bio-plastic costs are still higher than conventional plastics, new standards and enhanced EU legislation to push increased recycling are still required.

Patents for PET and PU degradation are available. Several new patent applications: production of PHA; monomer of PU degradation; PET degradation, novel enzymes (amidase, protease).

PET degradation has been patented for washing machines.

Patentability and feasibility studies have been completed, value chains have been revised, a customer needs analysis was performed, and six business exploitation plans have been developed. Academic and industry partners have the motivation needed to exploit and commercialise the results.

Rich scientific and popular literature is available on the project website.

Estimated cost for technology converting plastic waste to plastic value on an industrial scale: double digit millions of euros for a facility that can process 5 000 tonnes of PHA.

P4SB is looking for

- New knowledge sharing opportunities with SMEs/investors/start-ups
- Networking and matchmaking
- Marketing opportunities

Partners

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KETBIO Biotech transfer

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