The use of biotechnology to upcycle plastic wastes into new bioplastics

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upPE-T

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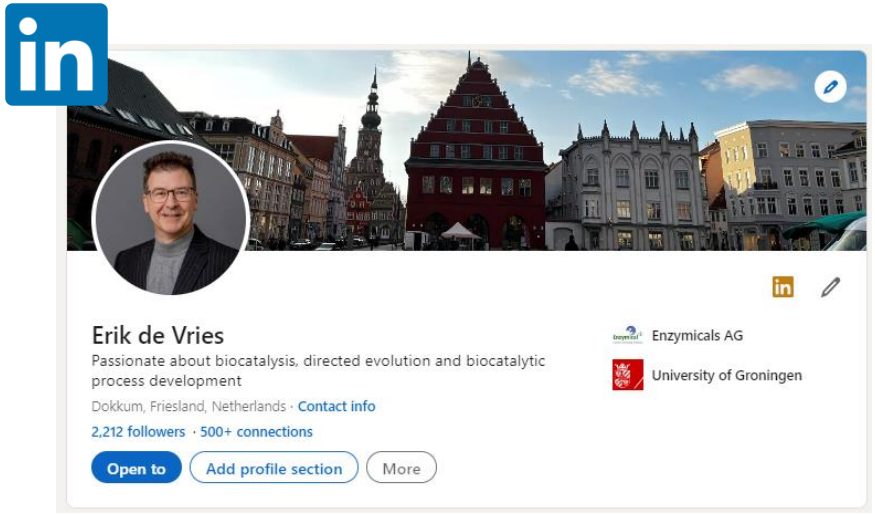
Introduction



www.linkedin.com/in/erik-de-vries/

- CEO of Enzymicals AG, Greifswald, Germany
- Career in Biotech >20 years
- Alumnus of Codexis, Purolite, Amyris, Dottikon

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- Biotech firm that develops biocatalytic processes for pharma and fine chemicals
- Enzyme discovery and optimization

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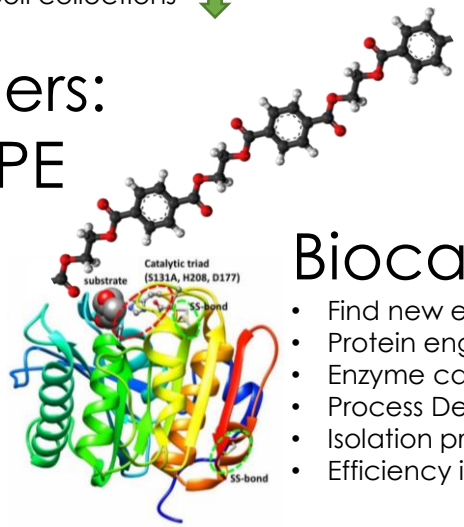
upPE-T - Our approach

Diversity

- DNA databases
- Metagenome
- Cell collections

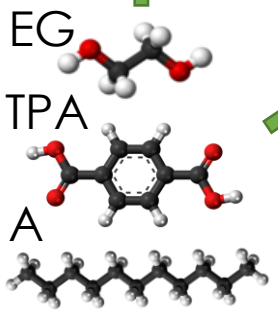
Polymers:

PET, PE shown



Biocatalysis

- Find new enzymes
- Protein engineering
- Enzyme cascades
- Process Development
- Isolation procedures
- Efficiency improvements



Polymerize EG to green solvent PEG

- Process development
- Optimal chain length distribution
- Commercial applications
- Solvent for upPE-T bioplastic extraction

Modify A and TPA using biocatalysis

- Develop into nutrients for fermentations to PHBV bioplastic
- Other value-added compounds

PHBV Bioplastic development

Monomers from PET: EG, TPA
Fragments from PE: A

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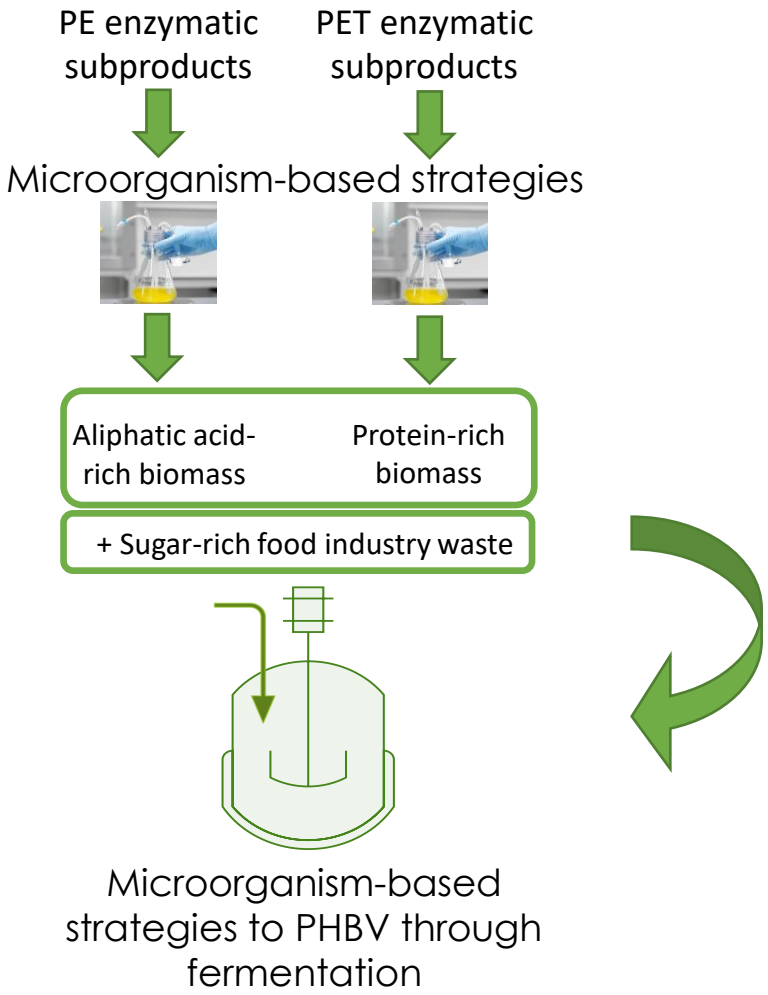
upPE-T - Our approach



Conditioning of enzymatic degradation products to obtain nutrients for microorganisms producing PHBV and a 'green' solvent for PHBV extraction

Modulation of PHBV chemical content and properties using different feed strategies in the bioprocess

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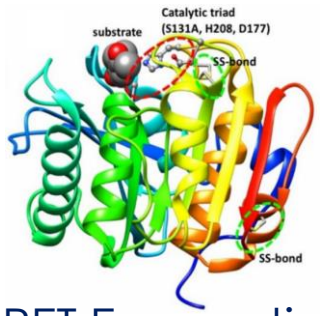
upPE-T - Results

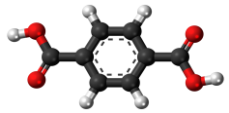
PET bottles

Pretreatment (heat, quench, cryo-milling)



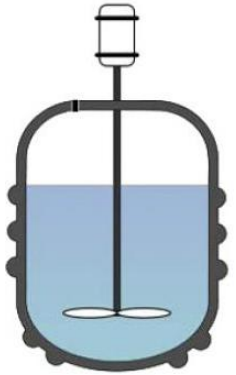
PET Enzymatic degradation

150 gr PET

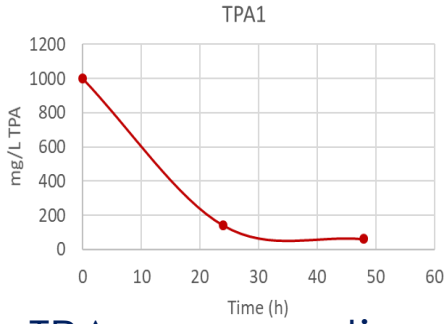


TPA

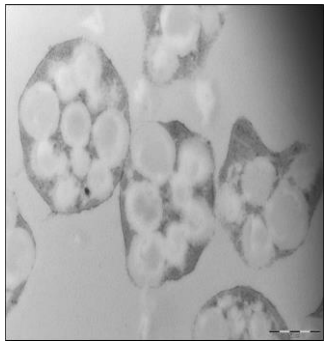
Bacteria growing on TPA carbon source



Fermen-tation



TPA consumption during bacterial growth



Bioplastic (PHAs)

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Nature saves Nature

Polyethylene:

PET:

- *Ideonella sakaiensis* PETase found in soil sample from PET recycling facility
- LCC PETase ("Carbios enzyme") was identified in Leaf and branch compost

Angewandte Chemie — GDCh — Eine Zeitschrift der Gesellschaft Deutscher Chemiker

Forschungsartikel

Discovery and Genetic Code Expansion of a Polyethylene Terephthalate (PET) Hydrolase from the Human Saliva Metagenome for the Degradation and Bio-Functionalization of PET

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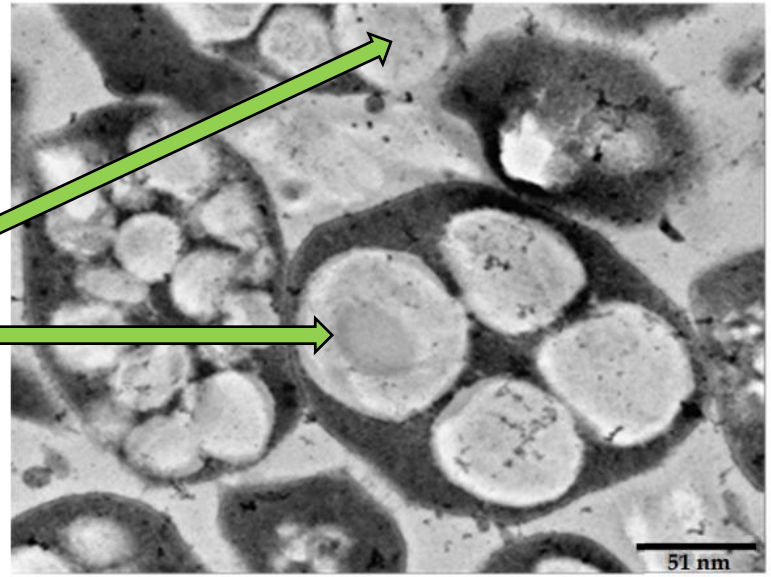
Nature saves Nature

Haloferax mediterranei, previously isolated from saltern ponds located in Santa Pola, Alicante, Spain produces microscopic plastic particles simply by growing on the right carbon source.

PHA



Ratio Hydroxybutyrate/hydroxyvalerate can be modulated, giving bioplastics with different properties.

Strain	Carbon Source	Type of PHA (mol %)	Cultivation Mode	DCW (g L^{-1})	PHA (g L^{-1})	PHA/CDW (%)
Haloferax mediterranei DSM 1411	25% pretreated vinasse	PHBV (12.4%3HV)	Flask		19.7	70.0
Haloferax mediterranei DSM 1411	50% pretreated vinasse	PHBV (14.1%3HV)	Flask		17.4	66.0
Haloferax mediterranei DSM 1411	Hydrolyzed whey	PHBV (6.0% 3HV)	Batch-42L Bioreac-tor		12.2	72.8

upPE-T

Simó-Cabrera, L.; García-Chumillas, S.; Hagagy, N.; Saddiq, A.; Tag, H.; Selim, S.; AbdElgawad, H.; Arribas Agüero, A.; Monzó Sánchez, F.; Cánovas, V.; et al. Haloarchaea as Cell Factories to Produce Bioplastics. Mar. Drugs 2021, 19, 159

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Conclusions

- Enzymatic degradation of plastic waste is certainly possible
- There are different ways to upcycle the degradation products
  - upPE-T uses fermentation-based processes
- Bio-based plastics like PHBV offer good properties but remain too expensive
  - Using plastic waste as input may give the required cost advantage

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THANK YOU

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