

# Additives to Adjust Lifetime of Biopolymers

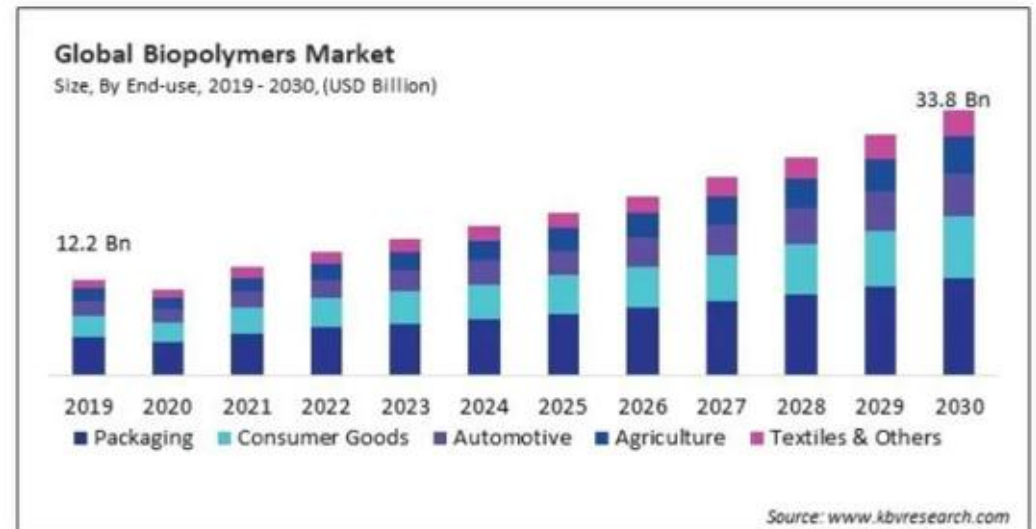
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**Prof. Dr. Rudolf Pfaendner**  
Fraunhofer Institute for Structural Durability and System Reliability LBF

# Biopolymers based on polyester structures

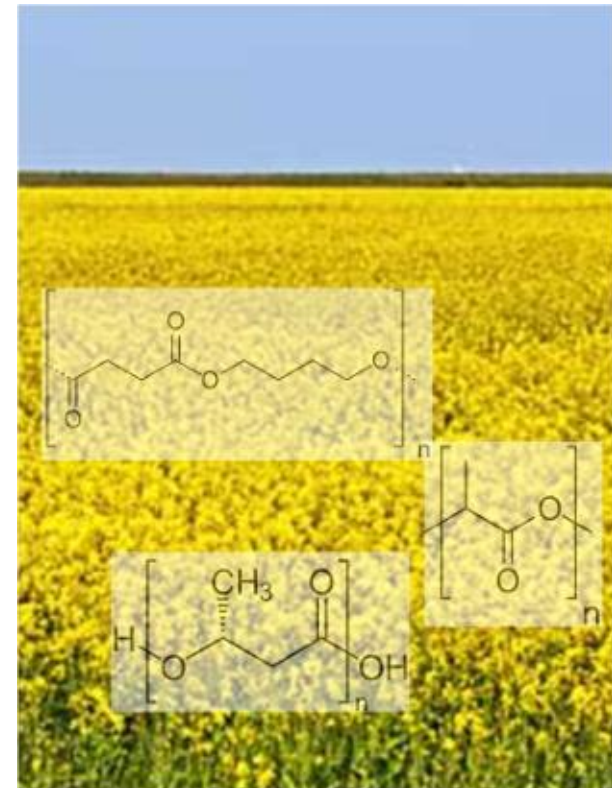
- Biopolymers from renewable resources show substantial growth rates in the years to come (>10 % annually).
- Polyester based biopolymers are among the most promising materials.
- Examples include Polylactic acid (PLA), Polybutylene succinate (PBS), PBAT, .....



Source: [www.kbvresearch.com/biopolymers-market/](http://www.kbvresearch.com/biopolymers-market/)

# Biopolymers based on polyester structures

- Polyester based biopolymers are (bio)degradable through hydrolytic cleavage of ester bonds.
  - > However, degradation rate is slow, often too slow e.g. for composting, in soil or at ambient temperature.
  - > Hydrolytic degradation prevents long-term use in technical applications.
- Both drawbacks can be overcome through suitable additives



# Additives for biopolymers

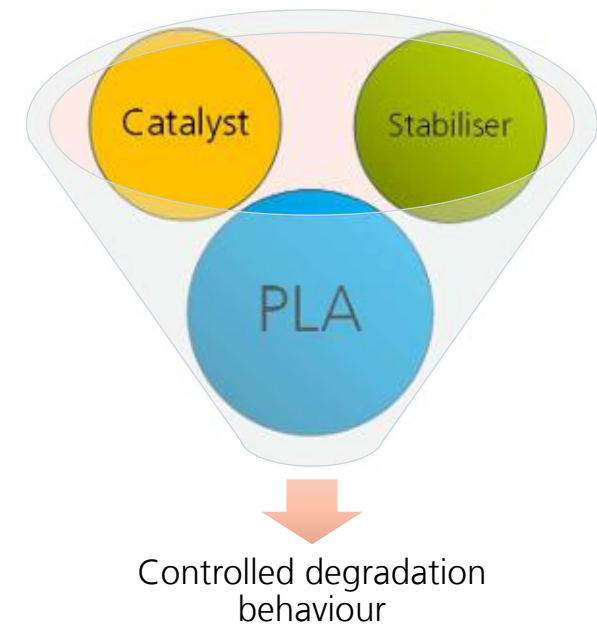
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- In general additives are used to adjust polymer properties, to guarantee smooth processing and long-term properties.
- Examples of additives common in biopolymers comprise e.g. impact modifiers, plasticizers, antioxidants, UV-stabilizers, nucleating agents a.o.



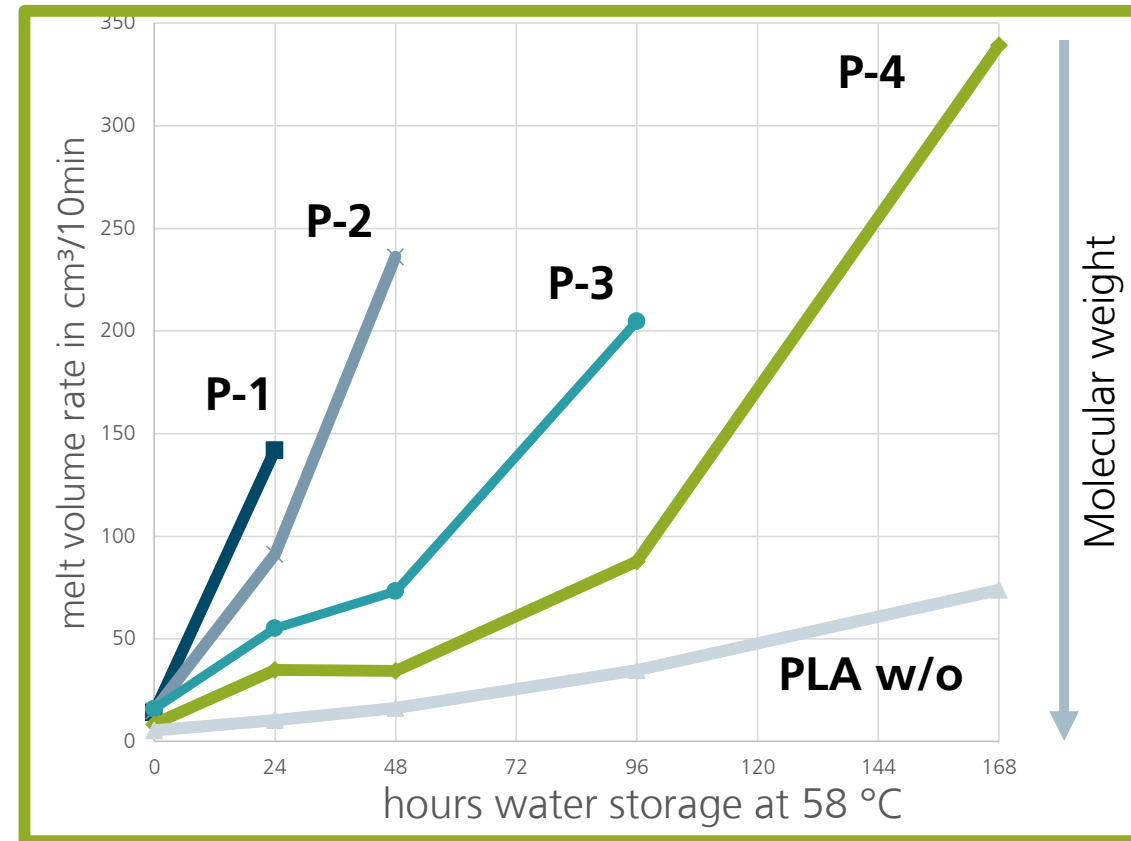
# PLA-target 1: acceleration of hydrolytic degradation

- Acceleration of hydrolytic degradation is achieved through the combination of a catalyst and a stabilizer.
- The catalyst is activated in the presence of water/humidity, accelerates hydrolysis and subsequent faster metabolism by microorganisms.
- The stabilizer maintains the molecular weight during processing and avoids premature degradation.
- By adjusting the ratio catalyst/stabilizer tailored lifetime is accessible.



## PLA results: water storage at 58 °C

- Compounding of commercial PLA via twin-screw extrusion: processing stability of PLA is maintained.
- Acceleration of hydrolytic degradation up to a factor of 10 is feasible.
- Degradation rate and stability is tunable through different catalyst structures, catalyst concentration and ratio catalyst/stabilizer.

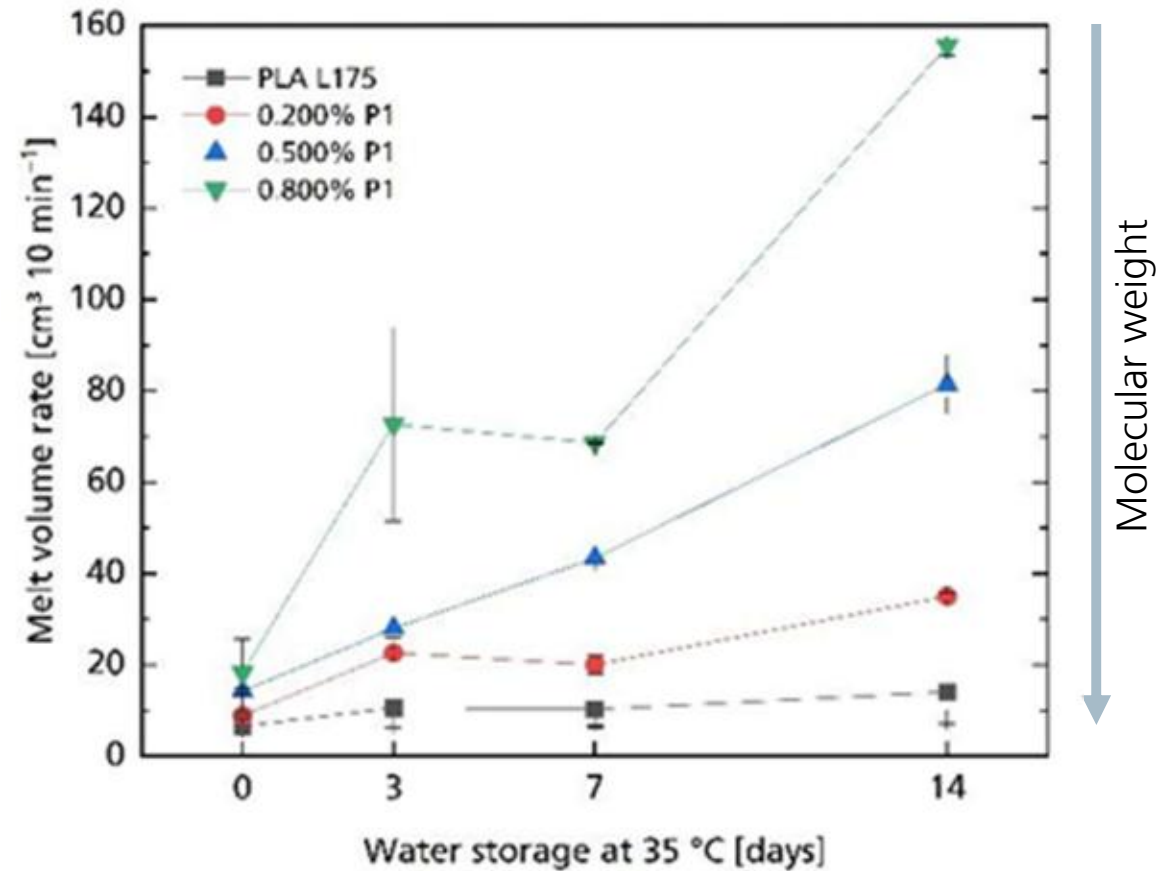


Additive concentration: 0.5 %

Source: M. Polidar et al. Polymers 2022, 14, 4237

## PLA results: water storage at 35 °C

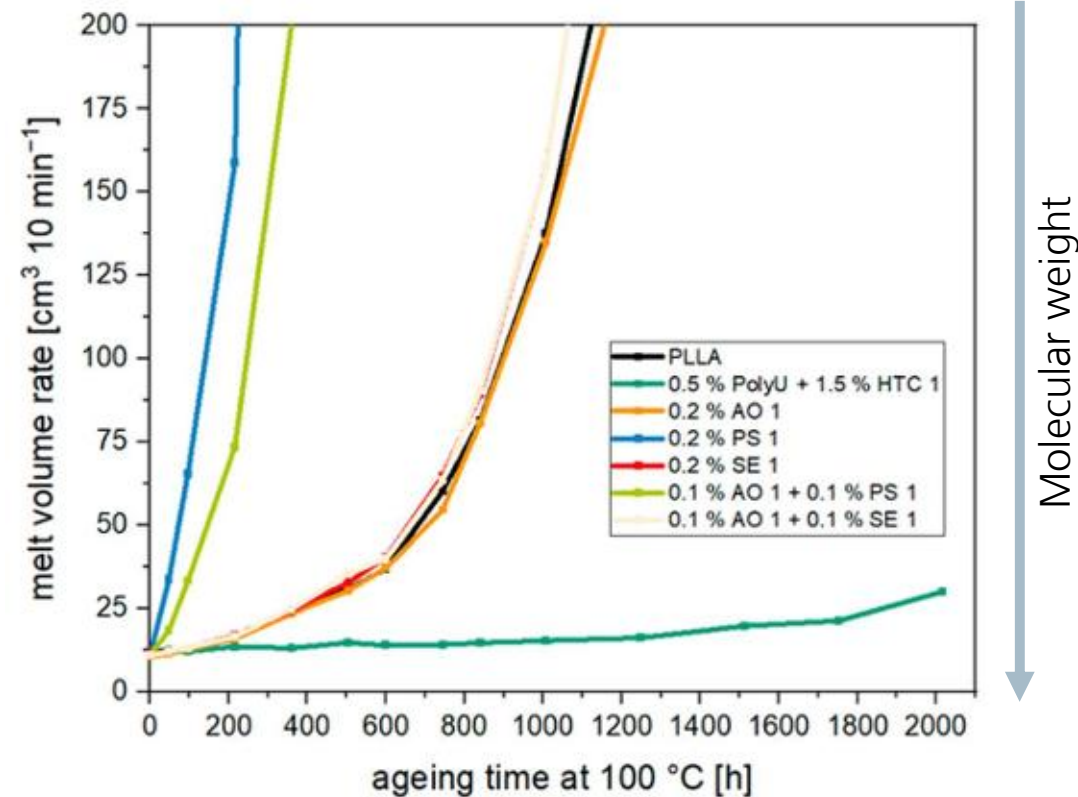
- Accelerated and controlled degradation takes place even at low temperatures („home composting“).
- Increased catalyst concentration boosts degradation rate.
- Weight average molecular weight was reduced by 40 % after 14 days.



Source: M. Polidar et al. Polymers 2022, 14, 4237

## PLA target 2: enabling long-term applications

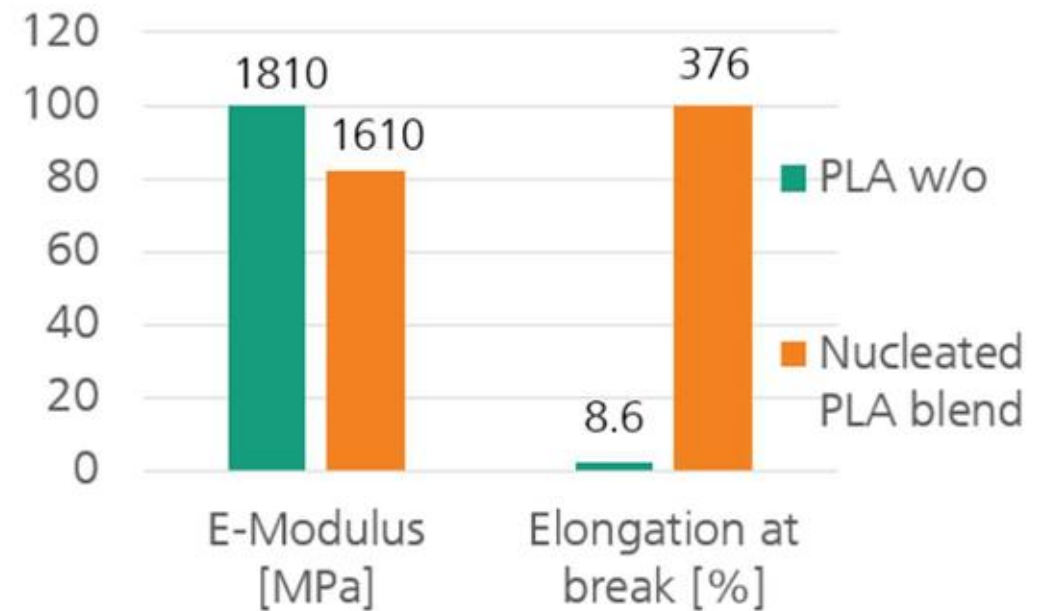
- Sensitivity to hydrolysis is the main reason to prevent the use of PLA (and other polyester biopolymers) in long-term technical applications.
- Selected additives can extend substantially lifetime of PLA.
- A combination of reactive components (PolyU Aziridine) and acid scavengers (HTC 1 Hydrotalcit) is the additive system of choice.



Source: J. Hallstein et al. Materials 2024, 17, 2761

# PLA formulation development

- Inferior toughness and low elongation at break is a drawback of PLA to extend application fields.
- A composition of nucleating agents, metallocene polyethylene and a compatibilizer can increase toughness while keeping stiffness.



Source: DE 102018201018, Fraunhofer Ges

## Additives to adjust lifetime of biopolymers: conclusion

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- Additives are essential key elements in formulation development of biopolymers to adjust and to maintain polymer properties during processing and use.
- Biodegradation of polyester biopolymers such as PLA can be accelerated and tailored through suitable catalyst/stabilizer combinations.
- Long-term stability of polyester biopolymers can be achieved through suitable additive systems comprising selected hydrolysis stabilizers.
- Fraunhofer LBF is seeking partners for exploitation of the identified technologies.

Thank you very much for your  
attention!



Contact:

Prof. Dr. Rudolf Pfaendner

Senior Consultant

Fraunhofer Institute for Structural Durability and  
System Reliability LBF

Research and Development

Schlossgartenstr. 6, 64289 Darmstadt

[rudolf.pfaendner@lbf.fraunhofer.de](mailto:rudolf.pfaendner@lbf.fraunhofer.de)