Polylactic Acid

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Introduction

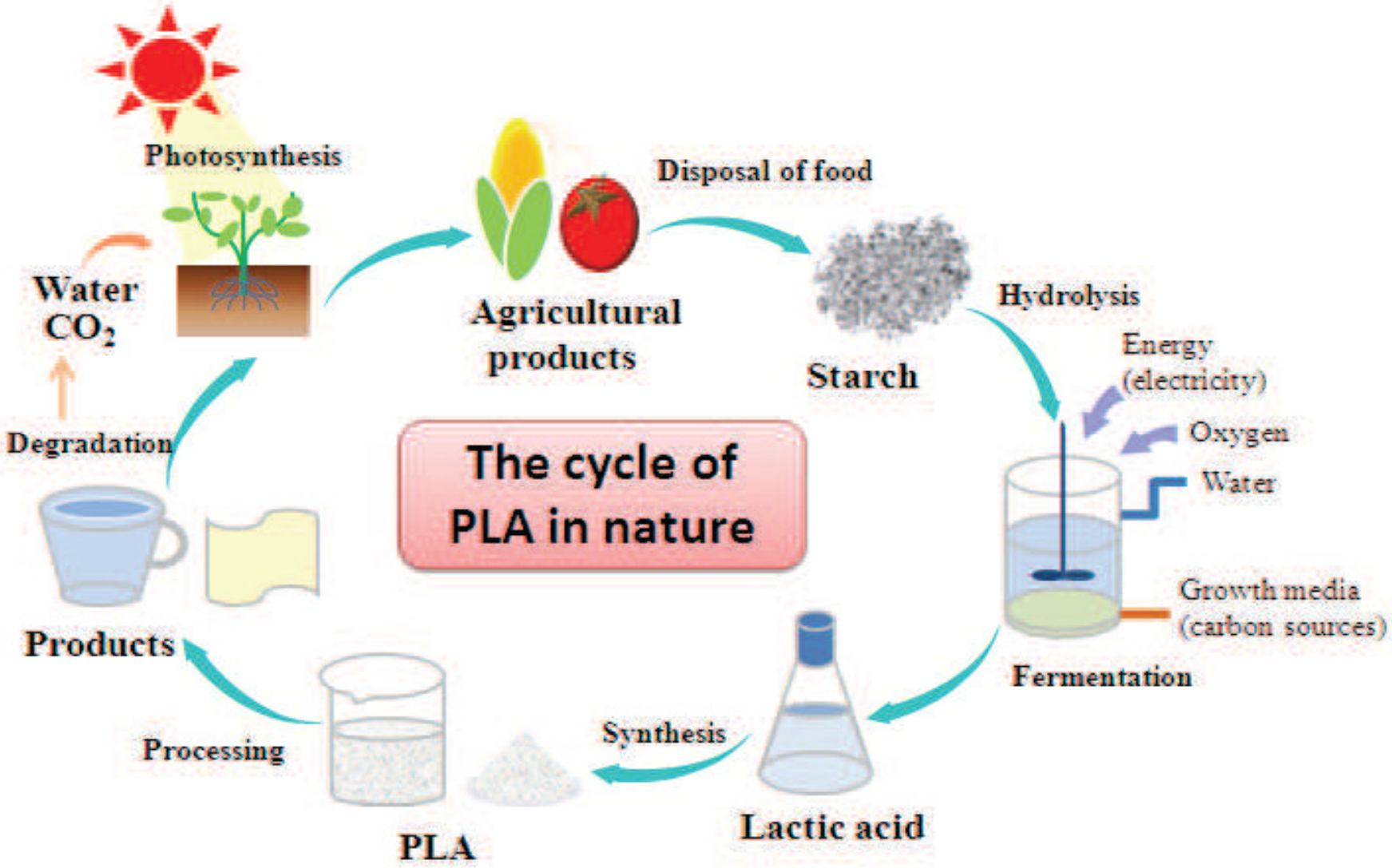
Poly(lactic acid) (PLA) is an aliphatic polyester

Advantages

- Renewability
- Biocompatibility
- Processability
- Energy Saving

- PLA is derived from renewable and degradable resources such as corn and rice.
- PLA and its degradation products, namely H_2O and CO_2, are neither toxic nor carcinogenic to the human body.
- PLA can be processed by film casting, extrusion, blow molding, and fiber spinning.

PLA Life Cycle



Synthesis of PLA

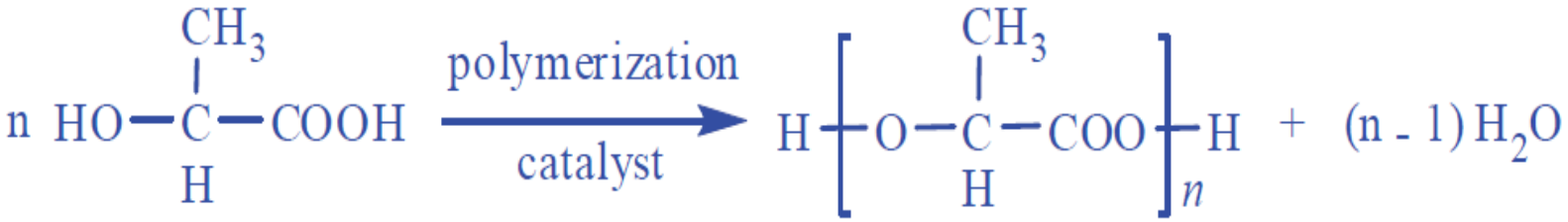
1. **Direct polycondensation**

   Solution polycondensation

   Melt polycondensation

2. **Ring-opening polymerization**

Direct polymerization



Lactic acid Poly(lactic acid)

Solution Polycondensation

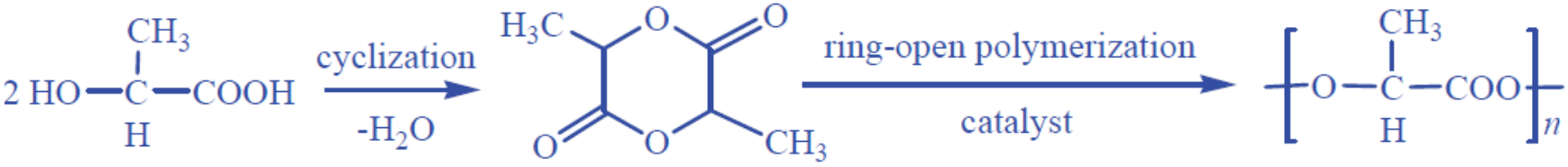
- Organic solvent capable of dissolving the PLA without interfering with the reaction is added.
- The mixture is refluxed with removal of the water generated in the polycondensation process, which is beneficial to achieve a high molecular weight.
- Many procedures yield PLA with a weight-average molecular weight (*Mw) of over 200,000.*
- The resultant polymer can be coupled with isocyanates, epoxides or peroxides to produce a range of molecular weights

Melt Polycondensation

- In the melt polycondensation of monomers can mproceed without any organic solvent

- One-step polymerization processes are relatively economical and easy to control

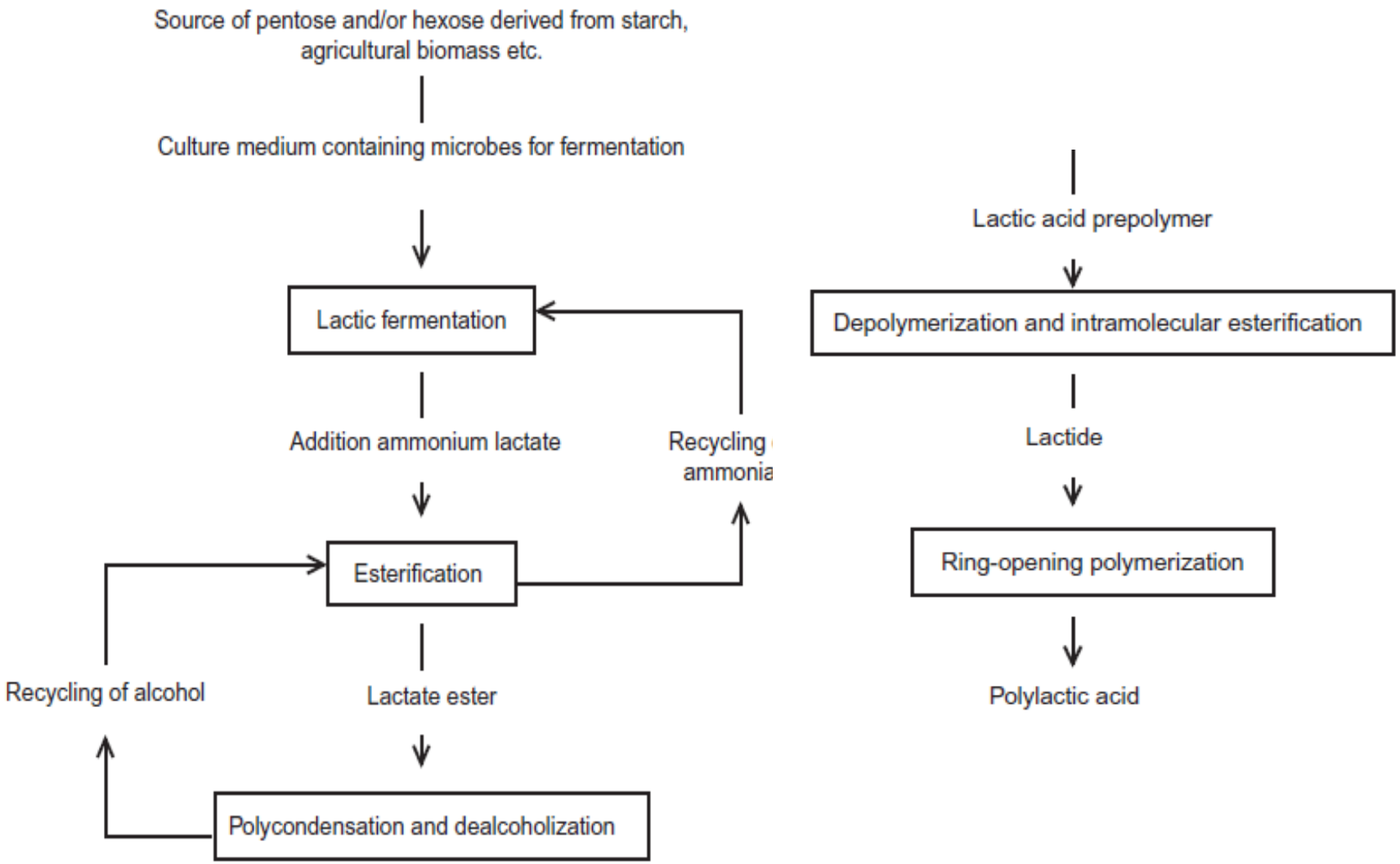
Ring-opening Polymerization



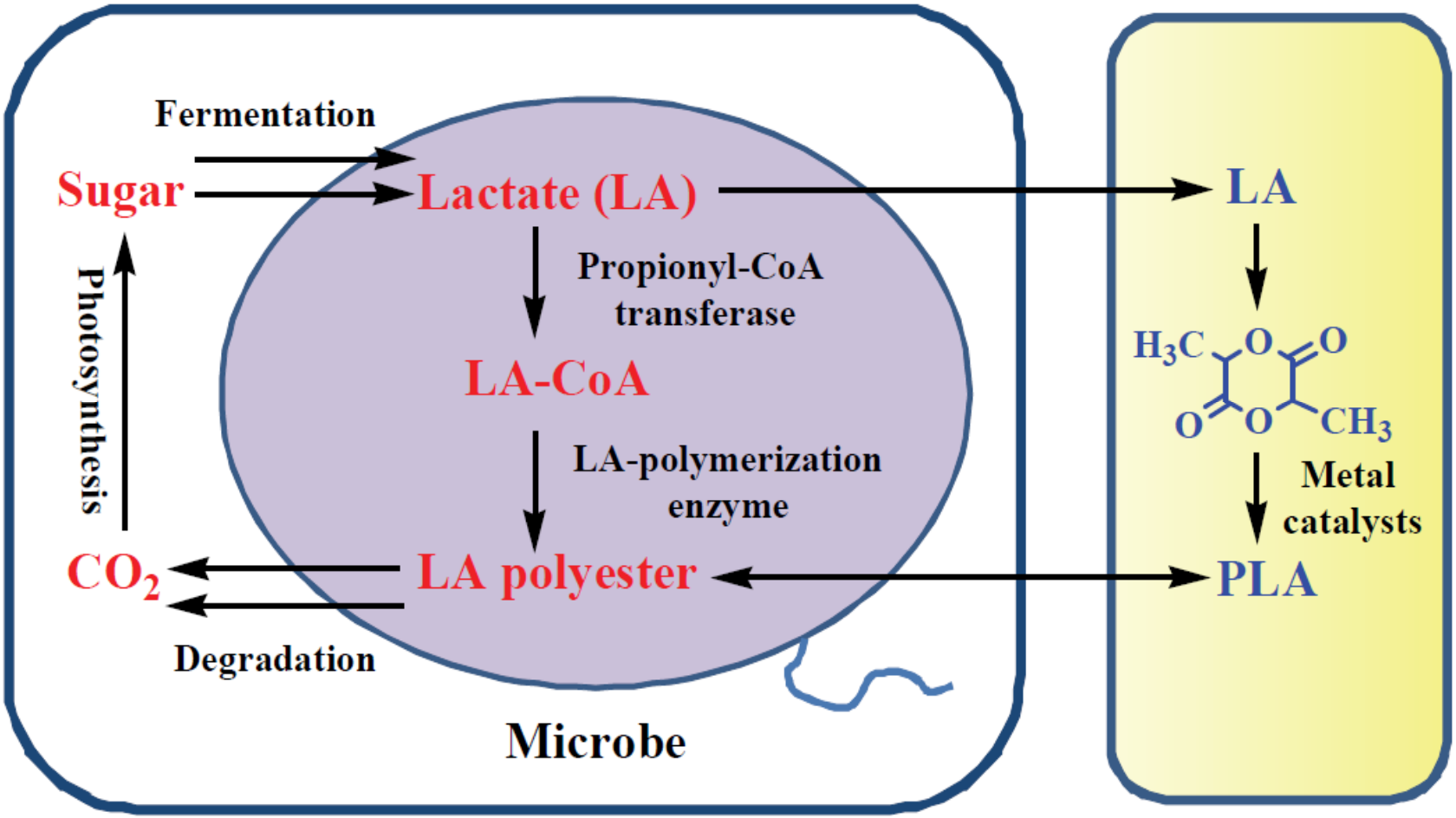
Lactic acid Lactide Poly(lactic acid)

The polymerization mechanism involved can be ionic, coordination, or free-radical, depending on type of catalyst employed

Production of PLA



Bio-synthesis of Lactic Acid



Advantageous Properties

- Property ranges depending on the ratio of isomers used and variable molecular weight
- High modulus of elasticity
- High scratch resistance
- High transparency (low degree of cristallinity), low haze, and high gloss
- Good dyeability
- High surface energy, i. e., very good printability and easy to metallize
- Good odor and flavor barrier properties
- Good oil, fat, water, and alcohol resistance
- UV resistance
- Good contour accuracy
- Hot sealability
- Certified compostability
- Approved for applications with food contact

Disadvantages

- Relatively strong hydrophilic and water vapor permeability
- Poor carbon dioxide barrier
- Moderate oxygen barrier
- Requires sophisticated engineering for injection molding processing
    - Slow crystallization when injection molded (relatively long cycle times)
    - Hot-runner advisable
    - Purging is required
    - Tends to hydrolyze during processing
    - Pre drying is required
- Brittle without additives (glass transition temperature above 50 – 55 °C)
- Low heat resistance, i. e., low softening temperature
- Poor resistance to solvents, acids and bases
- Only degradable at elevated temperatures (above 60 °C)
- Not home compostable

Degradation

Abiotic Degradation

- Thermal Degradation
- Hydrolytic Degradation

Biotic Degradation

- PLA fiber is used as a material for making garments
- Suitable for making bottles
- Light weight and transparent food packaging containers
- Bakery goods, confectionery, salads, shrink wrap, envelope windows, laminated coatings, multi-layer performance packaging, etc.
- Widely used as the casing for electronic devices, cosmetics and stationary.
- Rigid and soft toys for children
- carpet, laminated flooring materials and wallpapers
- PLA mulch film can provide soil protection, weed management, fertilizer retention, etc.
- PLA IS used to fabricate screws, pins, scaffolds, etc., to provide a temporary structure for the growth of tissue
- Used as drug carrier