POLYLACTIC ACID 3D PRINTED PROSTHETICS: REVOLUTIONIZING PATIENT CARE

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CREATE → APPLY → SUSTAIN

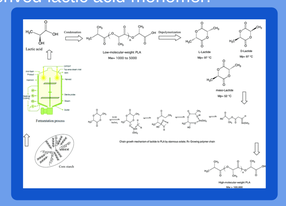
Polylactic Acid (PLA)

Polylactic Acid is a commonly used substitute for petrochemical plastics derived via the polymerization of the bio-derived lactic acid monomer.

Discovered in 1932 by heating lactic acid under vacuum while removing condensed water.

Industrial-scale lactic acid is produced through **lactic fermentation**:

- The lactic acid bacteria metabolize the glucose sugars of agricultural substrates forming the lactic acid product.



The lactic acid monomer is then purified and polymerized into the PLA polymer.

Due to PLA's **thermoplastic qualities** it may easily be melted and reformed to create 3D printed structures.

PLA exhibits **thermoplastic qualities**:

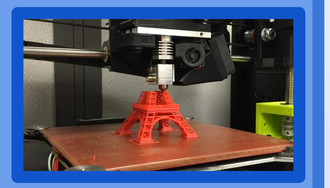
- Low melting point
- May be heated to its melting point, cooled, and then reheated again without significant degradation

3D Printing and CAD

The Process

1. First, a digital blueprint is created using a **Computer Aided Design** software (CAD).

1. Melted filaments are loaded into the 3D printer to be squeezed from a nozzle controlled by the computer
   - Filaments typactly made of metal filaments, carbon fiber mixes, or thermoplastics (such as PLA)



3. Finally, the printer uses the blueprint to create the object layer by layer by placing thousands of thin horizontal cross sections of material on top of each other

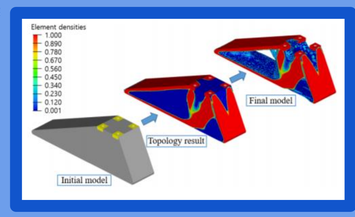
Topology Optimization

A team of graduate engineering students at Inha University design prosthetic feet manufactured out of polylactic acid using a design optimization process known as **Topology Optimization.**

Topology Optimization: A process of design optimization using CAD and 3D printed PLA to maximize a prosthetic foot's ability to take on stress, yet still reducing weight and amount of materials used.

The team could identify the best design concept that not only improves design performance but also reduces the design development time and overall cost.

Thermoplastics like polylactic acid allow the optimized design to be brought to life through precise dispensing from the 3D printer in complex structures which require tensile, structurally sound materials.



This optimization of prosthetic production and design is possible only through the continued development of 3D printed technology and materials such as PLA.

Tracheobronchial Splint

Medical professionals and researchers at the University of Michigan C.S. Mott Children's Hospital are employing 3D printed prosthetic technology to treat **pediatric tracheobronchomalacia (TBM).**

Tracheobronchomalacia: Condition exhibiting excessive collapse of airways during respiration. Only lasts from birth to 24-36 months.

All patients are successfully treated using a personalized, 3D-printed, bioresorbable splint which is designed to facilitate the growth and development of each infant's airways.

- Prosthetic created to fit anatomy of the patient flawlessly, using medical imaging and CAD software.
- Designed their product using the PCL polymer, which has the same bio-compatible qualities as PLA with a longer lifespan
- The splint successfully resolved all pulmonary and extrapulmonary complications rooted in tracheobronchomalacia and is absorbed at the point which the condition no longer presents problems.

The application of 3D printing towards the creation of prosthetic devices made to fit each patient's needs allows for higher levels of personalization and effectivity in the medical field.

Global Impacts

Economical Impact	• Studies show that the cost of 3D printing with polylactic acid is 56% cheaper than using traditional polymers. • Cost reduction comes from the highly efficient use of materials through 3D printing as well as a distinct reduction in time to remake devices which already have a digital scan uploaded and ready to print. • The low cost of production of means that this technology is more accessible to people of low income compared to other types of prosthetics.

Social Impact	• The polymer is solely produced from renewable, easy to produce, agricultural sources such as corn, corn waste, and sugar beets.
	  ○ Because PLA is produced mainly of organic materials it makes the polymer **biocompatible.**
	  ○ This characteristic of PLA makes it useful for developing internal prosthetics because the material will not affect

Environmental Impact	• Polylactic acid is **biodegradable** which means that it can be decomposed by bacteria and other living organisms. ○ PLA also will decompose relatively quickly as opposed to other plastics that can take decades to decompose, releasing toxic gases into the surrounding environment.