

The brittleness of polylactic acid (PLA) can be improved using several strategies, as detailed in the retrieved documents:

1. **Plasticization:**

Adding plasticizers to PLA can increase its flexibility and ductility, reducing brittleness. Common plasticizers include polyethylene glycol, citrate esters, and oligomeric lactic acid.

2. **Copolymerization:**

Copolymerizing PLA with other monomers can introduce flexibility and improve toughness.

3. **Addition of Rigid Fillers:**

Incorporating rigid fillers can modify the mechanical properties and improve impact resistance.

4. **Blending with Flexible Polymers or Rubbers:**

Blending PLA with more flexible polymers or rubbers is a widely used method to enhance toughness. This is similar to how rubber-modified high-impact polystyrene (HIPS) and ABS copolymers were developed to address the brittleness of polystyrene.

5. **Reactive Blending:**

Reactive blending, where chemical reactions occur during melt blending, has been shown to be especially effective in achieving high impact strength.

6. **Variation in Stereochemistry, Molecular Weight, and Crystallinity:**

Adjusting these intrinsic factors can improve ductility and impact resistance to some extent, though the effects are usually marginal and may not be sufficient for many practical applications.

Summary:

Many strategies have been developed to improve the toughness of PLA, including plasticization, copolymerization, addition of rigid fillers, and blending with flexible polymers or rubbers. Reactive blending is particularly effective for increasing impact strength. Adjustments to stereochemistry, molecular weight, and crystallinity can also help, but their effects are typically limited ([reference_156.pdf, p. 1051](#)).

If you need more details on specific toughening agents or blending partners, please let me know!