

# Environmental Life Cycle Assessment of Poly(3-hydroxybutyrate) (PHB): A Comparative Study with Petrochemical and Bio-Based Polymers.

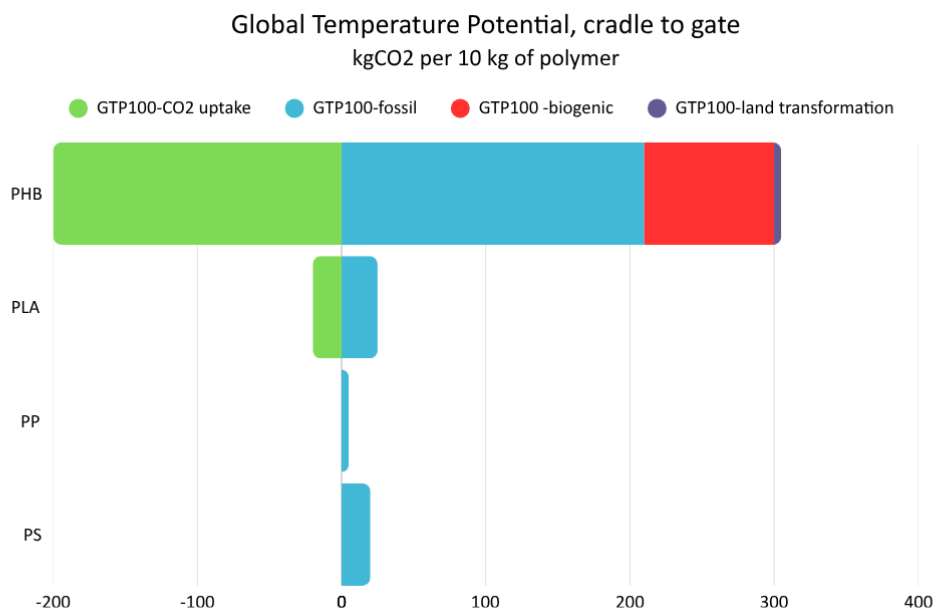
This study analysed the life cycle of PHB polymer, measuring emissions from experimental and small-scale production and focusing on energy and raw material consumption. It was compared with calculations for PLA, PS, and PP based on Ecoinvent data.

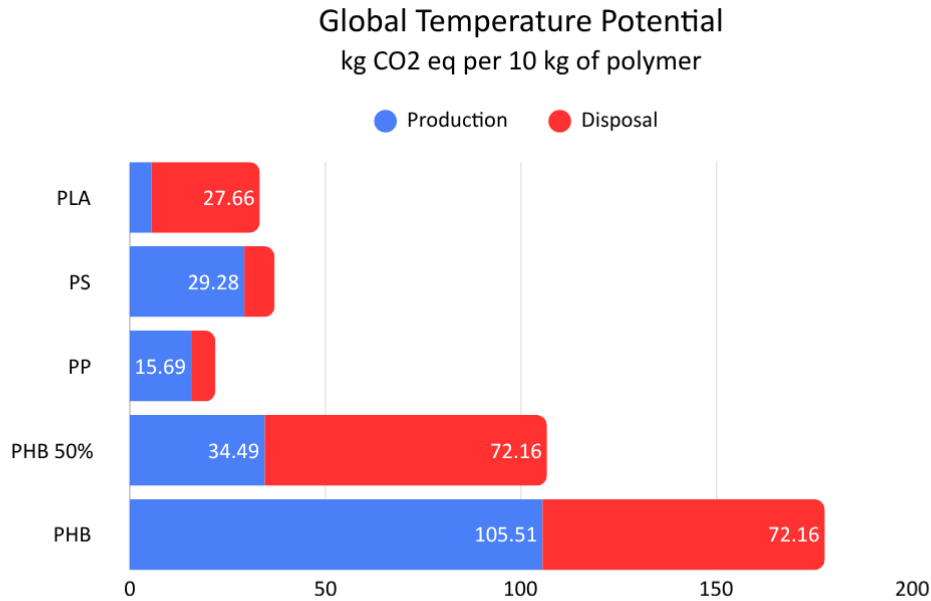
PHB is biodegradable and derived from renewable feedstocks. Its environmental potential is maximised when it is composted via industrial composting facilities or at home. There is also an option for PHB to be chemically and mechanically recycled.

The production of polyhydroxybutyrate (PHB) through bacterial fermentation is a multi-step biotechnological process that begins with the cultivation of specific microorganisms and ends with the recovery and purification of the biopolymer. This process currently has a high energy demand. In PHB production processes, the largest share of the carbon footprint (77.8%) is associated with energy use by equipment.

There reduction of production emissions (-22.3%) due to the use of glycerin produced from extruded rapeseed oil (biobased content). Total CO<sub>2</sub> emissions from PHB production are 105.6 kg CO<sub>2</sub>-eq, and disposal via the municipal solid waste system is 72.2 kg CO<sub>2</sub>-eq.

By using 50% of energy from renewable sources such as photovoltaic panels, fossil carbon dioxide emissions from production processes were reduced by 67.31% (PHB 50% in the graph).





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The study illustrates the challenges of fairly comparing novel materials with established ones, as novel alternatives haven't reached the same scale of production and infrastructure.

- 1) Comparing different scales of production. The main contributor to CO<sub>2</sub> emissions in the PHB case is the energy demand to produce 10 kg of PHB. However, this is compared to established large-scale processes that benefit from higher efficiencies for PS and PP.
- 2) Composability, biodegradability and low toxicity benefits are not reflected in standardised municipal waste treatments. While this is an accurate reflection of the current split in available treatments, it is useful to consider a future perspective in which additional treatments, such as composting, become available.
- 3) GHG emissions focus. The benefits of alternative materials might lie beyond the carbon reduction, and it is valuable to consider other indicators for a fair comparison.

Overall, the study confirms that a bio-based or biodegradable origin alone does not mean lower GHG emissions by default. Polyhydroxybutyrate, being derived from renewable resources such as glycerol or waste plant oils, reduces dependence on fossil fuels. The combination of renewable sourcing (using agricultural or industrial by-products as raw materials), optimised processing, a switch to renewable energy sources, and tailored waste management infrastructure plays an important role in maximising the environmental benefits of PHB materials. The comparison with well-established materials such as PP, PS, and PLA also clearly demonstrates that environmental impacts are system-dependent and that the full picture needs to be considered when comparing different materials.

<sup>2</sup> GWP (Global Warming Potential): Measures the total energy integrated over a set time horizon (e.g., 100 years).

GTP (Global Temperature Change Potential): Measures the change in surface temperature at a specific point in time (e.g., the temperature rise exactly 100 years after an emission).

This study is part of our five-part Bio-based LCA Blog series. We will explore other topics in the upcoming blog posts. If you have any particular topic, you would like us to cover, please reach out at [lca@recoup.org](mailto:lca@recoup.org)

*Disclaimer: The summary reflects the article's findings, which apply only to the products or systems studied and are based on the data and assumptions used by the research team. A single LCA study's results do not represent a comprehensive comparison of materials or processes and are specific to the scenario analysed. For questions about these findings, consult the article and contact the research team directly. Always cite the original study when referencing it. BPF and RECOUP support independent research and recommend reading the full study.*

Link: [Environmental Life Cycle Assessment of Poly\(3-hydroxybutyrate\) \(PHB\): A Comparative Study with Petrochemical and Bio-Based Polymers | MDPI](#)