Emirates Biotech

The Carbon Footprint of PLA biopolymer compared to traditional plastics.

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Executive Summary

PLA (Polylactic Acid), a plant-based polymer, offers notable environmental benefits, including over 75% reduction in carbon footprint as compared to conventional fossil-based plastics like Polyethylene Terephthalate (PET), Polystyrene (PS), Polyethylene (PE) and Polypropylene (PP). In this paper the publicly available cradle-to-gate Life Cycle Assessments (LCA) for PLA are compared to the cradle to gate LCA's for traditional polymers. The UAE green Agenda 2030, UAE circular Economy 2031, and UAE Energy Strategy 2050 all emphasize the need for materials with a reduced carbon footprint.

Key Findings

- **PLA biopolymer has a Global Warming Potential (GWP) of:** ~0.5 kg CO_2 eq/kg polymer (this is cradle to gate and including the biogenic CO_2)
- **Compared to the average of 4 traditional polymers (PET, PS, PE, PP) the GWP of PLA is more than 75% lower.**
- **Continuous improvement**: Whereas production optimization and reduction of GWP for traditional polymers is limited, research shows that process improvements in the production of PLA are still abundantly available and will continue to lead to reductions in GWP for PLA polymers.

This paper will also detail the LCA methodology used, will provide references to LCA publications and will present comparative data on carbon footprint.

1. Assessing the Carbon Footprint of Sustainable Materials

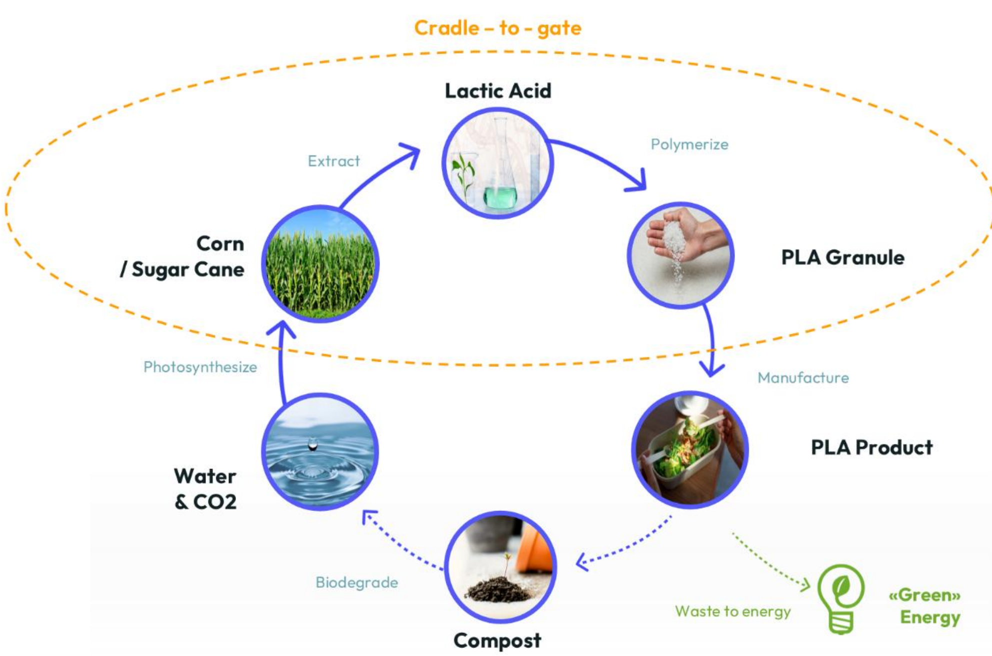
PLA has emerged as a leading plant-based and biodegradable polymer. Derived from renewable resources like corn or sugarcane, PLA offers functional properties comparable to many conventional plastics, making it suitable for a wide range of applications from food packaging to 3D printing. To objectively assess its environmental benefits, we turn to the globally recognized methodology of LCA using ISO 14040 and 14044 standards. Rather than conducting a single LCA, we perform a meta-study of multiple credible, and publicly available LCAs, allowing us to capture a broader, more reliable picture. Within this scope, we focus specifically on global warming potential, the most relevant indicator for the carbon footprint and the fight against climate change.

Scope

This paper focuses on a **"cradle-to-gate"** analysis which is a common approach for plastics and polymers. This scope includes all activities from the extraction of raw materials from the earth (the "cradle") to the point where the finished polymer pellets leave the manufacturer's factory gate. This includes:

- Plant-based polymers: Farming the feedstock (e.g., sugarcane, corn), fertilizer use, energy, transport, converting sugar to lactic acid, and polymerizing lactic acid into PLA pellets[1,2].
- Fossil-based plastics: Extraction of fossil resources from wells, downstream processing, transport, and polymerization to plastic granules.

A crucial distinction in the LCA of plant-based materials is the accounting of biogenic carbon. This uptake naturally removes greenhouse gases. Biogenic carbon is the carbon from CO_2 which is captured from the atmosphere by the plants. Due to the large number of possible end uses and end-of-life treatments for finished products, the assessments do not include the use phase of PLA resins or the end-of-life of the final products.



Picture 1: A simplified flow diagram for the manufacture of PLA. The yellow dotted line represents the cradle to gate boundary.

Literature review:

PLA Biopolymer LCA's

The environmental performance of PLA has been extensively documented through third-party reviewed LCAs carried out by leading global producers operating world-scale facilities. Notably, both TotalEnergies Corbion and NatureWorks have published rigorous cradle-to-gate LCAs for their respective production systems. The TotalEnergies Corbion study reports a global warming potential (GWP) of 0.29 kg CO_2 eq/kg of PLA pellets in 2025[1], while the NatureWorks LCA reported 0.62 kg CO_2 eq/kg polymer in 2015[2] depending on process configuration. These values reflect significant improvements compared to earlier PLA LCAs from the early 2000s, such as those reported by NatureWorks (2.0 kg CO_2 eq/kg polymer in 2005[3] and 1.3 kg CO_2 eq/kg polymer in 2010[4]). The credibility of these LCAs is reinforced by the fact that they adhere to ISO 14040 and 14044 standards, undergo critical third-party review, and represent industrial-scale operations rather than pilot or lab data.

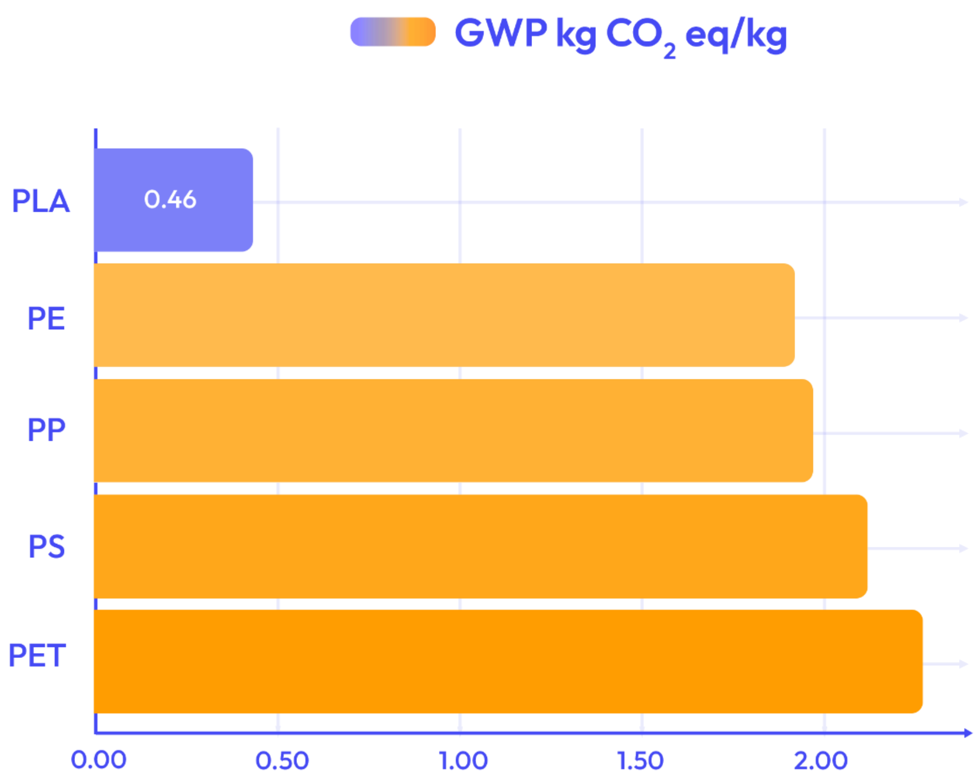
PLA biopolymer is a relatively new and emerging material, and significant opportunities for further decarbonization remain. Both TotalEnergies Corbion (2025) and NatureWorks (2015) emphasize in their LCA publications that improvements are ongoing throughout the value chain: technology optimization, yield increases, process intensification, waste reduction, and scale-up to larger production units all contribute to efficiency gains. Additionally, increasing the use of renewable energy and recycled feedstocks offers further carbon savings. Both companies project that in the foreseeable future, PLA's carbon footprint could approach zero or even negative emissions, effectively making PLA a carbon sink. Together, these results provide a robust evidence base confirming PLA's substantial environmental advantages.

Traditional Plastic LCA's

To ensure a fair and relevant comparison, this study relies exclusively on credible, industry-accepted, and regionally specific data for conventional plastics. The environmental data for materials like PET[5], PE[6], PP[6] and PS[7] are sourced from rigorous, long-term studies by industry associations such as PlasticsEurope[5] and the Institute for Energy and Environmental Research (ifeu). These sources are also built on ISO 14040 and 14044 compliant methodologies and represent comprehensive cradle-to-gate datasets derived from full-scale commercial production facilities across Europe and the Gulf Cooperation Council (GCC). By doing this, we ensure that the GWP values for the mentioned conventional plastics are transparent, reproducible, and reflective of real-world operations.

3. Carbon Footprint of PLA and traditional polymers compared

The chart below summarizes the latest cradle-to-gate GWP values. The PLA value is an average of the latest data from the world's two largest producers, TotalEnergies Corbion[1] and NatureWorks[2], reflecting the current state of the industry.



The results are striking. Virgin PLA offers a carbon footprint reduction of over 75% compared to the average of **four** key conventional plastics, **PET** (2.19 kgCO_2 eq/kg)[5], **PS** (2.16 kgCO_2 eq/kg)[7], **PP** (1.95 kgCO_2 eq/kg)[6], and **PE** (1.70 kgCO_2 eq/kg)[6]**.** This is a direct consequence of PLA's renewable origins and the benefit of biogenic carbon uptake.

4. The Path Forward: PLA's Role in a Low-Carbon UAE

The UAE's Net Zero by 2050 strategic initiative is an ambitious commitment that requires transformative action across all sectors. For the nation's thriving industrial and manufacturing base, material selection is a powerful lever for change. The data clearly shows that adopting PLA is not an incremental improvement but a significant step-change in reducing the carbon footprint of plastic goods. Recognizing this opportunity, Emirates Biotech is building a state-of-the-art PLA manufacturing facility within the UAE. This facility is a direct answer to the nation's strategic goals using state-of-the-art technology that is set to achieve a similar or better GWP than 0.46 kgCO_2 eq/kg of PLA.

5. Conclusion

Based on scientifically accurate, standardized, and publicly available cradle-to-gate Life Cycle Assessment data, PLA demonstrates a compelling and scientifically validated environmental advantage over virgin conventional plastics, with a carbon footprint reduction of over 75%. As a plant-based polymer, PLA provides a clear pathway to lowering the environmental impact of everyday applications, particularly in food packaging, food service ware, and 3D printing.

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