

NatureWorks LLC Is Committed to Zero Waste for Biopolymer Bottles  
**The company has engaged in years of research  
and collaborative effort toward this goal**

NatureWorks LLC believes it has a fundamental responsibility to all who make and use its products. This duty includes minimizing the impact on air, land, and water of its Ingeo™ plastic made from plants, rather than oil. NatureWorks has engaged in years of research and collaborative effort toward the goal of zero waste for all uses, including bottles.

**These milestones include:**

**2003**

NatureWorks LLC begins Ingeo industrial recycling at its Blair, Nebraska, processing facility.

- During any new polymer plant start-up, there is significant quantity of material that does not meet customer specifications, requirements, and expectations. In 2003, NatureWorks LLC began work to chemically recycle out-of-specification resin. In this process, clean, out-of-specification resin was broken down and converted back into its constituent monomer, lactic acid using heat and water. This reverse polymerization incorporated water back into the molecule as it broke down to lactic acid.
- From 2004 through 2007, NatureWorks LLC processed more than 21.5 million pounds of lactic acid recovered from roughly 17.5 million lbs of post-manufacturing waste PLA resin. The company's financial analyses demonstrated that post-industrial PLA chemical recycling to Ingeo resin is an economically viable means of recovering lactic acid suitable for a food-grade polymer

**2004**

Recycling equipment manufacturer TiTech Auto Sort tests the effectiveness of its technology on sorting Ingeo bottles.

- The test showed that Ingeo had a unique near infrared (NIR) spectrum, which meant it could be sorted by available recycling technology. The IR-based system was 97.5 percent effective in identifying and sorting Ingeo bottles. Even with an incoming level of one percent of Ingeo bottles, the residual biopolymer in the stream would be far below the threshold shown to impact clarity, IV, or the solid-stating performance of PET.

NatureWorks LLC presents test results to the Association of Post Consumer Recyclers.

- At Ingeo recycling stream concentrations of 1 and 2 percent respectively for PET and HDPE, there was no appreciable effect on the performance of these recycled plastics. For PET bottle-to-bottle recycling, this is based on the ability to separate down below 0.1%, which was found to be the threshold above which PLA can begin to have an impact on haze.

At the Telluride Bluegrass Festival, 41,000 meals are served with cups and service ware made from Ingeo.

- After the festival 49 percent of waste was either composted or recycled – a 20 percent increase compared to previous years.

Ingeo™ innovations are made uniquely from NatureWorks® biopolymer



## 2005

NatureWorks LLC presents the results of its research at the PET Container Recycling Technical Advisory Meeting in Europe.

- The company reiterated its commitment to continue researching ways to reach a zero-waste goal for Ingeo bottles.

NatureWorks LLC presents a one year update to the Association of Post Consumer Recyclers.

NatureWorks LLC announces a large-volume buy-back program at the National Recycling Convention in Minneapolis.

- The buy-back program was designed to encourage diversion of Ingeo bottles from landfills.

## 2006

NatureWorks LLC introduces a post-consumer bale specification at the National Recycling Coalition Congress in Atlanta.

- This new specification was foundational to the bottle buy-back program.

Cups, plates, and napkins used in the staff catering tent at the Winter X Games are made from Ingeo. The games organizers and hosts began a shift towards ongoing use of renewable and compostable food serviceware.

Seven concerned recyclers and environmental organizations in the U.S. request that NatureWorks LLC begin a moratorium on the use of Ingeo bottles.

- These organizations were concerned about the possible contamination of the PET recycling stream.
- Concerns were raised that not enough municipal recovery facilities (MRF's) had access to NIR sorting technology and commercial markets for separated product.
- Concerns also stemmed from the fact that many smaller recyclers still manually sort plastic beverage containers and would have a hard time distinguishing between PLA and PET.

## 2007

NatureWorks LLC places a hold on plans for a significant expansion of Ingeo bottles. It continues research into possible contamination of the PET recycling stream.

- NatureWorks committed to transparency of its intentions, actions, and research. The company worked closely with stakeholders — and continued to engage with recyclers, non-governmental organizations (NGOs), governments, brand owners, and retailers.
- NatureWorks releases its End-of-Life Vision. The strategic vision includes the growth of Ingeo in the marketplace in order to understand recycling concerns and the type of infrastructure required for a zero waste future.

Ingeo™ innovations are made uniquely from NatureWorks® biopolymer



NatureWorks LLC launches a five-month Ingeo bottle recycling study in two geographic regions of North America.

- The study involved more than 150 retail locations, approximately 2 million bottles, and a number of regional recycling centers. Brand owners, recyclers such as FCR Recycling, an independent division of Casella Waste Systems, FCR's PET customers, and members of the group that requested the moratorium are either involved in the study or are kept updated on its findings.

The Recycling Organization of New Zealand (RONZ) engages with NatureWorks and the Good Water Company to establish a first-of-its-kind product stewardship organization for Ingeo.

The goal was to educate and prepare for the introduction of biopolymer bottles. Subsequently, Good Water bottles were collected at large summer festivals and successfully recycled into wire sheathing for below ground cable installations. The work in North America and New Zealand found that given the limited volumes of PLA entering the recycling stream there was no appreciable contamination of PET, rPET, or HDPE.

A new study finds that over a complete life cycle from resin manufacture to end-of-life waste management, Ingeo bottles are superior to PET bottles in terms of lower greenhouse gas emissions, lower overall energy consumption, and lower use of finite resources for comparable end-of-life treatment.

- Building on practical experience and bottle production trials, The Coca-Cola Company and NatureWorks LLC underwrote the first life-cycle analysis comparing Ingeo to PET bottles. The research included a sensitivity analysis that evaluated a range of available disposal options and was presented at the 2007 NRC Congress in Denver, CO.
  - The life cycle analysis demonstrated that bottle-to-bottle recycling of Ingeo offers significant environmental and energy benefits and is the optimum end-of-life scenario for Ingeo bottles.
  - The study found that the optimum end-of-life scenarios for the plant-based plastic are mechanical bottle-to-bottle recycling directly followed by chemically recycling back into polymer which can be used to make new bottles. In the chemical recycling route, the used Ingeo bottles are hydrolyzed back into lactic acid, which is then purified and used again to make virgin PLA polymer. The PLA recovered via chemical recycling is exactly the same as the original, virgin polymer and therefore offers advantages in terms of package performance, ease of remanufacture, and less overall energy consumption and greenhouse gas emissions.
  - Recycling rather than municipal composting was shown to be the better option for Ingeo bottles. The research demonstrated that recycling conserves a high percentage of the energy that went into the manufacture of the resin. (Composting remains the optimum end-of-life option for food waste and Ingeo food containers and utensils because it diverts these materials from landfills.)

Laboratory tests on Naturally Iowa Milk bottles demonstrate that bottle-to-bottle chemical recycling is practical.

- Impurities such as TiO<sub>2</sub> colorant, as well as cap and label material were filtered down to a level that should allow chemical recycling back to bottle-grade resin.
- The company plans to pilot the process with simulated post-consumer material to further develop the process and economics of post-consumer recycling.

Ingeo™ innovations are made uniquely from NatureWorks® biopolymer



- Ultimately, this knowledge will be applied to true post-consumer collected Ingeo bottles, as market volumes have yet to reach levels for practical recovery required to confirm laboratory studies.

## 2008

The company maintains communication with NGOs and stakeholders in the recycling industry to ensure maximum transparency.

Programs are under way to investigate simple and practical identification techniques for manual sorting operations.

- Field projects compare recycling Ingeo at the municipal facilities to separation at dedicated plastics recycling operations.
- Projects evaluate a means to mark or identify Ingeo bottles in a way easily identified in a manual sorting municipal recovery facility

NatureWorks LLC continues with controlled market expansion and research.

- A controlled rollout of Primo water will test recycling effectiveness. This research provides deeper understanding of zero waste options.
- The go slow approach impacts a significant number of brand-owners and consumers interested in Ingeo. Smaller start-up companies without recycling experience or resources to manage recycling issues are the most affected.

NatureWorks LLC is a stakeholder in Future 500's pilot project to evaluate the optimum process and means to separate PLA and other plastics from the PET and HDPE recycling stream. The California Department of Conservation awarded \$1,047,000 to the 18-month pilot project and businesses are contributing an additional \$800,000 to the nearly \$2 million project. The findings of the project may eventually help to stimulate commercial separation and capture of PLA and help to create a PLA recycling value stream. This project will compare the effectiveness of automated sorting technologies at MRFs and plastics processor facilities, with the hope of showing where PLA can most efficiently and economically be sorted prior to being recycled into virgin resin.

NatureWorks LLC continues its long-term affiliations with industry organizations:

- American Fiber Manufacturers Association
- American Standard Test Methods (ASTM)
- Association of Post-Consumer Recyclers (APR)
- Biodegradable Products Institute
- EuropaBio
- European Bioplastics
- EUROOPEN
- Japan BioPlastics Association
- Japan Hygienic Olefin and Styrene Plastics Association
- Society of Plastics Engineers
- Society of the Plastics Industries (SPI)
- The Sustainable Packaging Coalition
- USCC – US Composting Council

###

Ingeo™ innovations are made uniquely from NatureWorks® biopolymer

