Presidential Green Chemistry Awards: Learning from the Champions

May 10, 2018

GREEN CHEMISTRY & COMMERCE COUNCIL

Business Mainstreaming Green Chemistry

Presidential Green Chemistry Awards: Learning from the Champions

Dr. Myron Shaffer
Covestro

Who is Covestro?

Key 2017 Financials: €14.1 B global net sales

Our Business Units:

Polyurethanes

Raw materials for rigid and flexible foams

Polycarbonates

Granules and sheets for a wide variety of applications

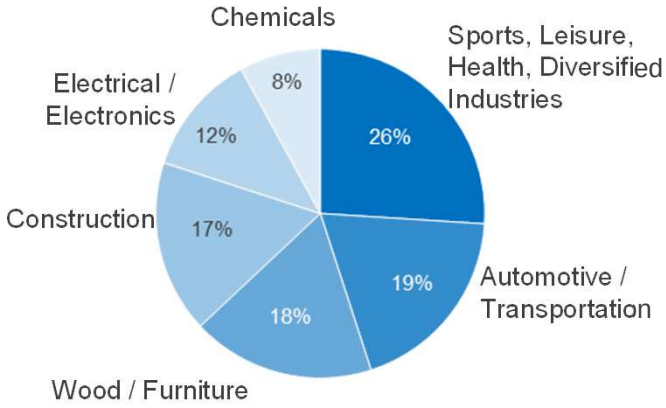
Coatings, Adhesives & Specialties

Raw materials for coatings, adhesives and specialties

+

Basic Chemicals

Markets We Serve:



Presidential Green Chemistry Awards

2001 Greener Synthetic Pathways Award
Bayer Corporation Bayer AG (technology acquired by LANXESS)
Baypure™ CX (Sodium Iminodisuccinate): An Environmentally Friendly and Readily Biodegradable Chelating Agent

GREEN CHEMISTRY CHALLENGE
A U.S. EPA Program

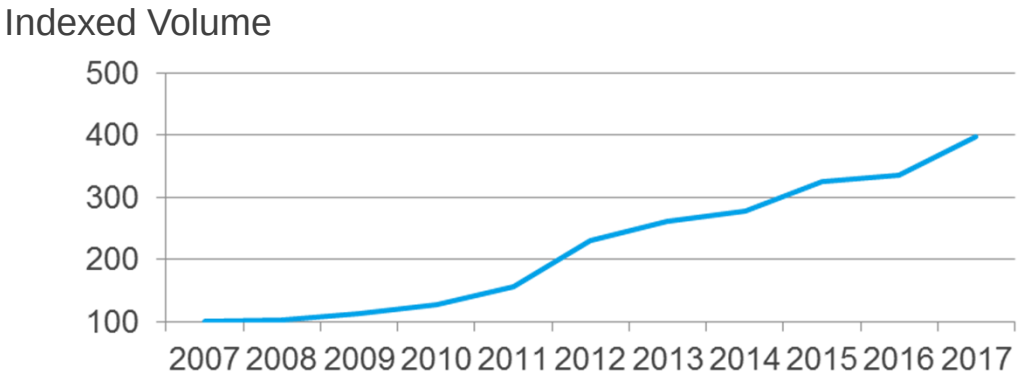
Problem: Solventborne products can have high VOCs
Green chemistry: safer solvents, reduction in VOC

2000 Greener Reaction Conditions Award:
Bayer Corporation
Two-Component Waterborne Polyurethane Coatings
Innovation and Benefits:

- Developed a series of high-performance, water-based, two-component polyurethane coatings
- Eliminate most or all of the organic solvents
- Water-based polyurethane coatings reduce volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions by 50–90 percent.

Lessons Learned

- ✓ Patience to withstand a long commercial path
- ✓ Market acceptance of innovations can be slow
- ✓ Testing requirements lengthen the timeframe
- ✓ Performance has to be equivalent or better at the same price point



Key Factors for Success

- ✓ Sustainability = improving system performance and reducing odor
- ✓ Recognize the initial target market may not be the final success
- ✓ New technology can be a paradigm shift
- ✓ Additional innovation is needed to fully commercialize
- ✓ Barriers: new processes, CAPEX requirements, status quo mindset
- ✓ Understand the regulatory environment
- ✓ But innovations may not necessarily be regulatory driven

- ✓ Patience = willingness to invest time and money

NatureWorks

Presidential Green Chemistry Award Ten+ Years On

Brian S. Glasbrenner
Global Commercial Leader – Performance Chemicals

Green Chemistry & Commerce Council
May 10, 2018

2002 Presidential Green Chemistry Award Recipient

GREEN CHEMISTRY
A U.S. EPA Program

- *Promotes the environmental and economic benefits of novel green chemistry.*
- *Recognizes chemical technologies that incorporate green chemistry into chemical design, manufacture, and use.*

"Innovation and Benefits: The NatureWorks process makes biobased, compostable, and recyclable polylactic acid polymers using 20–50 percent less fossil fuel resources than comparable petroleum-based polymers… synthesis eliminates organic solvents and other hazardous materials, completely recycles product and byproduct streams, and efficiently uses catalysts to reduce energy consumption and improve yield"

http://www.epa.gov/greenchemistry

NatureWorks

Back in 1989, we had a big, crazy idea.

What if we could turn greenhouse gases like carbon dioxide into products?

150,000 MT
Ingeo PLA plant in Blair, NE USA

2 Billion lb. Milestone in 2017
Aggregate volume sold since 2005

Dedicated Applications Development and R&D Facilities, Including new CASE lab in 2018

Jointly owned by Cargill and PTTGC

Established global market channels

- Commercial partnerships with global brands
- Sales team in 15 countries across North America, Latin America, Europe, and Asia

Strong environmental expertise and product characteristics

- Peer reviewed LCA's and eco-profile demonstrate smaller carbon footprint and lower fossil energy use
- Products enable portfolio of end-of-life options
- Dedicated internal team for understanding environmental and end-of-life impacts

NatureWorks

NatureWorks

Building on our core technology, we continue to innovate.

ingeo™

Naturally Advanced Materials

- 3D Printing
- Beauty & Household
- Building & Construction
- Cards, Cartons, Non-Food Pkg
- Electronics & Appliances
- Food & Beverage
- Food Serviceware
- Landscape & Agriculture
- Medical & Hygiene

Vercet™

Creating Performance Through Chemistry

Coatings
- Water-borne
- Solvent-borne
- 100% Solids
- Alkyds & Polyesters

Adhesives
- Hot Melt
- Reactive
- Binder Resins
- Water-borne

Functional Intermediates
- Surfactants
- Solvents
- Food Ingredients
- Fine Chemicals

NatureWorks

naturally advanced materials

Presidential Green Chemistry Award Metrics

- Ingeo™ (NatureWorks™) PLA (polylactic acid) is the first family of polymers derived entirely from annually renewable resources that can compete on performance and total cost of ownership (TCO) in various fibers and plastic packaging applications.
- The NatureWorks (Cargill Dow LLC) PLA process offers significant environmental benefits in addition to the outstanding performance attributes of the polymer.
  - Ingeo™ PLA products are made in a revolutionary new process developed by NatureWorks that incorporates all 12 green chemistry principles.
  - The process consists of three separate and distinct steps that lead to the production of lactic acid, lactide, and PLA high Mw polymer.
  - Each of the process steps is free of organic solvent: water is used in the fermentation while molten lactide and polymer serve as the reaction media in monomer and polymer production.
  - Each step not only has exceptionally high yields (over 95 percent) but also utilizes internal recycle streams to eliminate waste. Small (ppm) amounts of catalyst are used in both the lactide synthesis and polymerization to further enhance efficiency and reduce energy consumption.
  - Additionally, the lactic acid is derived from annually renewable resources, PLA requires 20–50 percent less fossil resources than comparable petroleum-based plastics, and PLA is fully compostable or readily hydrolyzed into lactic acid for recycling back into the process.

Presidential Green Chemistry Award Metrics

- While the technology to create PLA has been known for many years, previous attempts at large-scale production were targeted solely at niche compostable applications and were not commercially viable. Only now has NatureWorks been able to perfect the process and enhance the physical properties of Ingeo™ PLA resins to compete on performance and TCO in various applications with petroleum-based plastics.
- The NatureWorks process embodies the well-known principles of green chemistry.
  - Preventing pollution at the source through the use of a natural fermentation process to produce lactic acid
  - Substituting annually renewable materials for petroleum-based feedstock
  - Eliminating the use of solvents and other hazardous materials
  - Completely recycling product and byproduct streams
  - Efficiently using catalysts to reduce energy consumption and improve yield.
  - In addition, Ingeo™ PLA products can be either recycled or composted after use.

Cargill BioIndustrial Solutions

www.cargill.com

Cargill

GREEN CHEMISTRY CHALLENGE

A U.S. EPA Program

BiOH®

A Cargill Innovation

2007

FR3™

ENVIROTEMP™ NATURAL ESTER FLUID

2013

BiOH®
A Cargill Innovation

BiOH polyols help flexible polyurethane manufacturers increase their renewable content and reduce their environmental footprint.

A preliminary life cycle analysis indicates that replacement of petroleum-based polyols with BiOH polyols results in:

- 36% less global warming emissions
- 61% reduction in non-renewable energy use
- 23% reduction in the total energy demand
- For every million pounds of BiOH polyol produced to replace petroleum- based polyols, about 2,200 barrels (nearly 700,000 pounds) of crude oil are saved

Cargill

FR3™

ENVIROTEMP™ NATURAL ESTER FLUID

Envirotemp™ FR3™ Natural Ester Transformer Fluid

Cargill

FR3 fluid designed to deliver:

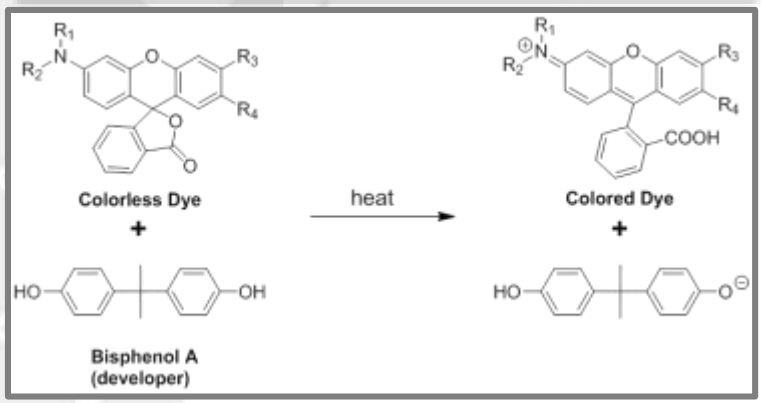
1. **Cost efficiencies, optimized transformer performance, grid reliability**
   - **Extend insulation system life**
   - **Increase loadability**

2. **Increased fire safety**

3. **Improved environmental footprint with best-in-class environmental properties**

Breakthrough Sustainable Imaging Technology for Thermal Paper

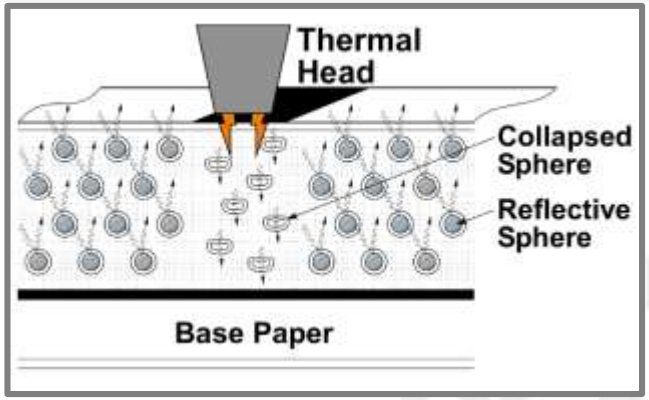
Traditional Technology



No clearly safer alternatives to BPA were found

- EPA initiative to find alternatives for BPA
- Input from stakeholders from business, government, academia, and environmental organizations.
- Most alternatives have *Moderate* or *High* hazard designations for human health or aquatic toxicity endpoints

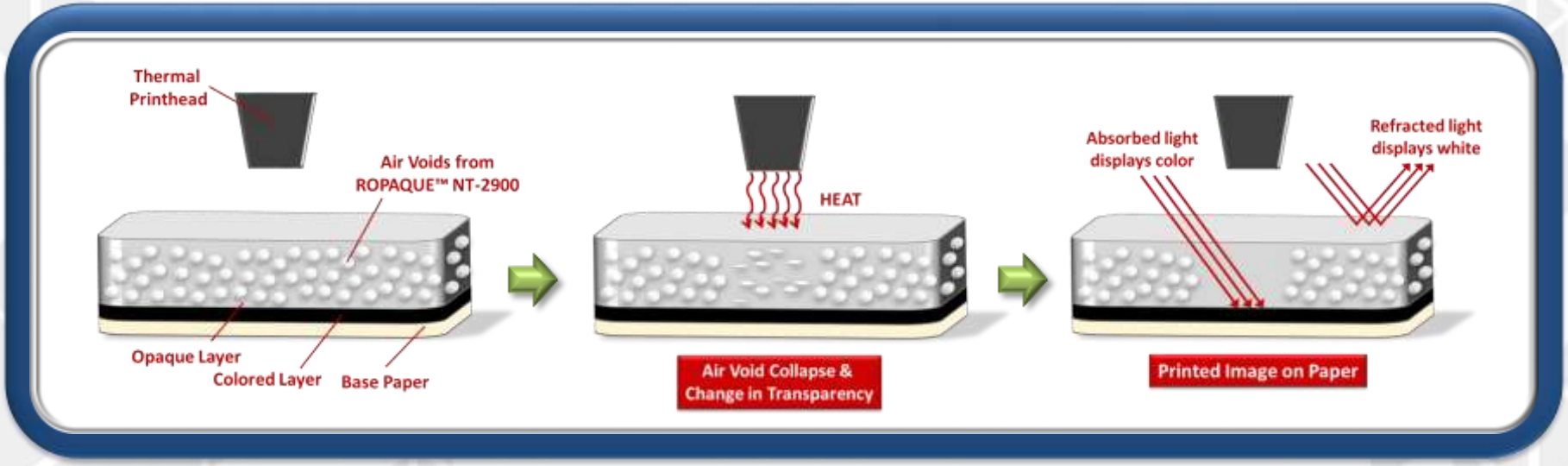
Dow Technology



Physical change rather than chemical reaction

- Imaging chemicals under scrutiny replaced with **air** and benign **polymer**
- Permanent imaging
- Food contact approved
- Compatible with existing printers

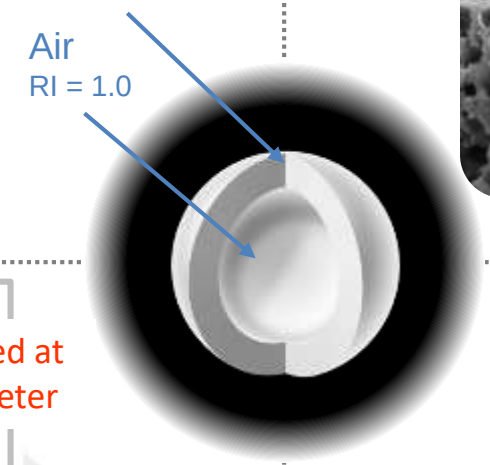
New Imaging Technology is Enabled by ROPAQUE™ NT-2900 Hollow Spheres

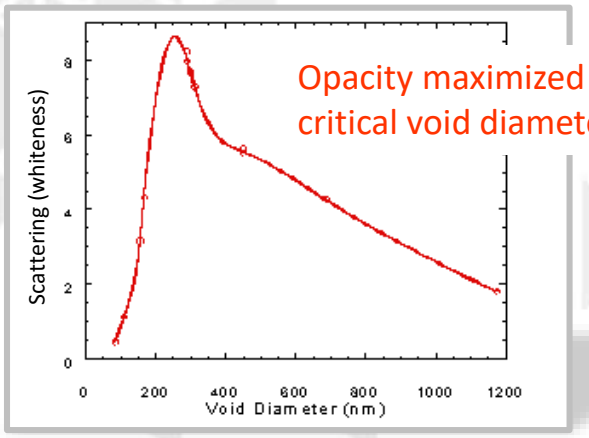


Similar to snow covering an asphalt road, the hollow spheres appear white when applied over a dark base paper.
Upon heating in a thermal printer, the air voids collapse to reveal the color beneath.

Performance Achieved Through Polymer Design and Formulation Expertise

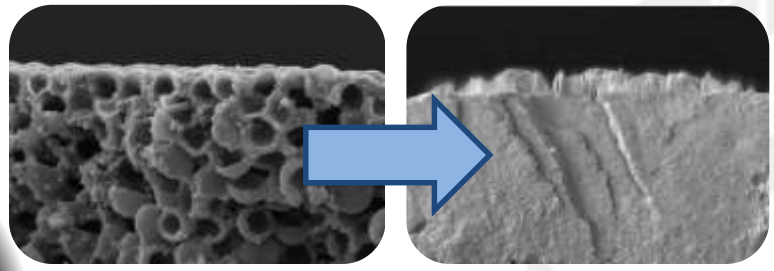
The refractive index difference between the air void and the surrounding polymer gives opaque polymer the ability to scatter light



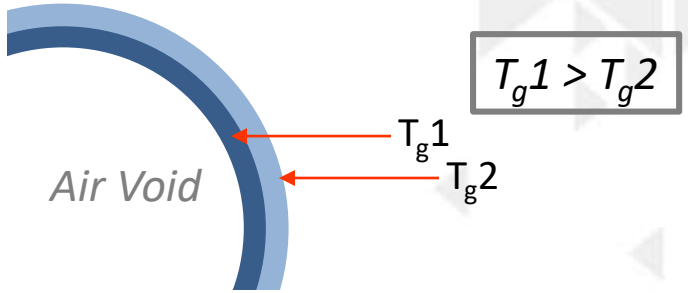


Opacity maximized at critical void diameter

Before Printing ***After Printing***



When printed, polymer collapse was optimized through polymer morphology

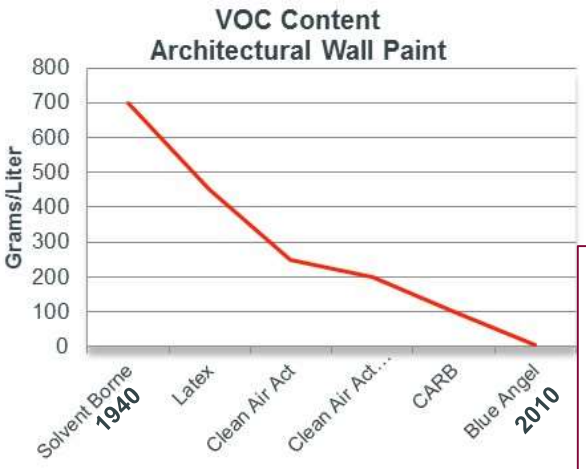


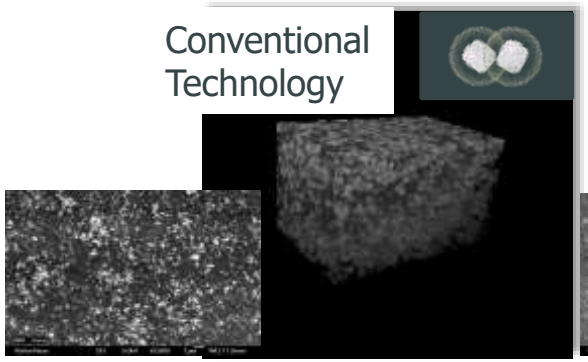
BLUE 4EST™ Thermal Paper, Free of Chemical Developers

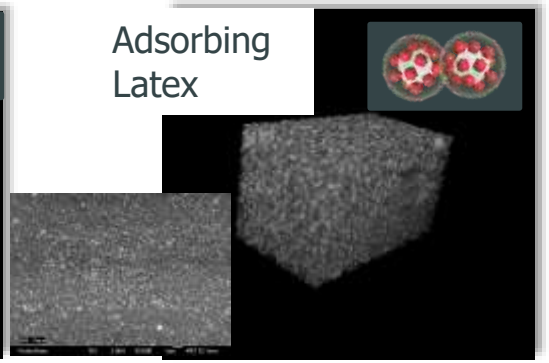
- Environmentally friendly
- Better aging with UV stability, longer lasting image
- Consumer can easily distinguish it from traditional thermal paper

- Phenol-free point-of-sale receipt paper
- Compatible with existing thermal printers
- First thermal paper for ***DIRECT FOOD CONTACT***

Dow Adsorbing Latex Technology (2013 Winner)





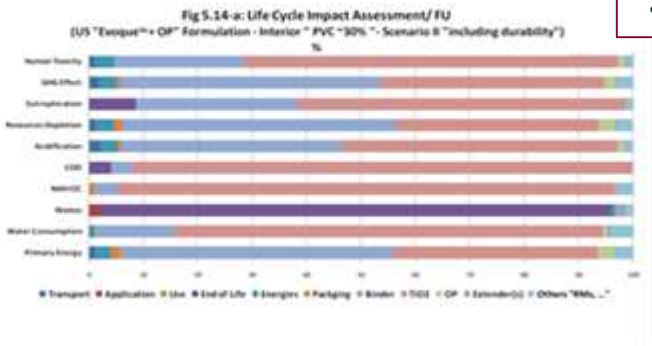


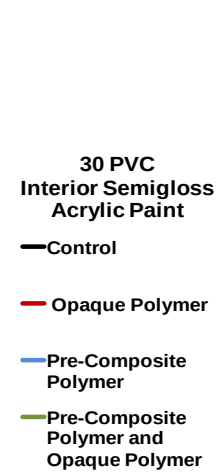
Sustainability
- Reduced resource consumption and CO_2 emissions
- Reduced impact on air and water quality

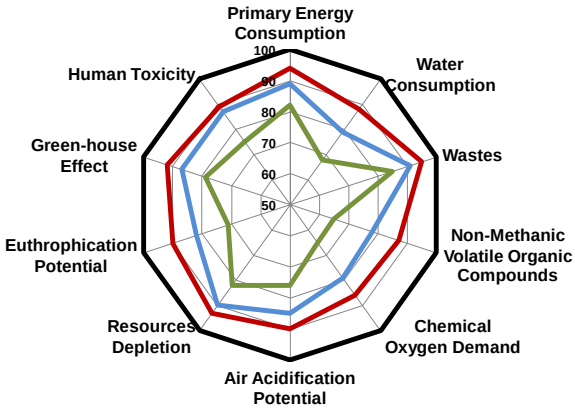
Performance
- Fewer coats, Greater durability
- Longer re-paint intervals, Multi functional

Cost
- Lower raw material and formulated cost
- Lower transportation and application cost

Life Cycle Assessment (ISO 14040/44, Third Party Validation)







Red is TiO_2

- "Comparative Life Cycle Assessment (LCA) of Water-borne paints for internal and external wall decoration and protection," Presentation to Peers for Project Review, Dr. H. Kheradmand, LCA and Sustainable Development Expert, Dow Coating Materials (DCM) EMEA, September 20, 2011.
- Trapani, A.; Bleuzen, M.; Kheradmand, H.; Koller, A. The Use of TiO2-Polymer Composites to Lower Environmental Impact and Improve Performance of Waterborne Paints, Paintistanbul 2012, September.

James Bohling, Dow

Thermal Paper Technology (2017)

Adsorbing Latex Technology (2013)

Audra Wendt, Cargill, Inc

Vegetable Oil Dielectric Insulating Fluid (2013)

BiOH™ polyol (2007)

Brian Glasbrenner, Natureworks

Ingeo™ Polylactic Acid (PLA) (2002)

Myron Shaffer, Covestro

Waterborne Polyurethane Coatings (2000)