

INNOVATION

History and Trends in the Plastics Industry...Implications for its Future

Presented by – Margaret Baumann
G.H. Associates, Lebanon, NJ
Boston ANTEC May 2005

Background

- Since the 1950's plastics has grown to major industry that effects all of our lives
- Plastics remain the most versatile and energy efficient materials used today
- Since 1976 plastic has become the most used material in the world
- Most people living in NA or Europe do not know a world without plastics
- Trade shows have served as a platform to introduce these new and improved technologies to industry

Plastics Industry Growth

- Plastics material in US has grown an average of 7.7% per year for past 40 years
- Expansion in third world has been dramatic
- China and India experiencing nearly double digit growth for plastics material and process
- China and India represent tremendous potential buying power as life styles improve
- Consumption has slowed in US and Europe making Far East attractive market

How it started...

- Plastics came of age in World War II
- Traditional materials were being used in war effort
- War in Pacific cut off supply of rubber
- Plastics became acceptable as substitute for traditional materials
- Trade shows developed to showcase the wonders of plastic
- 1st show (National Plastics Exposition) held in NYC in 1946 open to public , attendance was so overwhelming future shows limited to trade only

National Plastics Expositions from 1946 to 1971

| | # of exhibitors | Area (sq. ft.) | Attendees | Resin Produced, Billion lbs |
|------|-----------------|-------------------|-----------|--------------------------------|
| 1946 | 164 | 24,600 | 87,000 | |
| 1947 | 143 | 30,000 | 13,000 | |
| 1948 | 133 | 35,000 | 39,000 | |
| 1950 | 125 | 40,000 | 14,000 | |
| 1952 | 137 | 36,000 | 18,000 | 2.3 |
| 1954 | 172 | 41,000 | 18,000 | 2.8 |
| 1956 | 225 | 45,000 | 28,000 | 4 |
| 1958 | 208 | 43,000 | 20,000 | 4.6 |
| 1961 | 258 | 64,000 | 35,000 | 6.9 |
| 1963 | 280 | 79,000 | 30,000 | 9.4 |
| 1966 | 301 | 151,000 | 35,000 | 14.2 |
| 1968 | 360 | 215,000 | 40,000 | 17.2 |
| 1971 | 375 | 234,000 | 37,000 | 21.2 |

National Plastics Expositions from 1973 to 2003

| | # of exhibitors | Area (sq. ft.) | Attendees | Resin Produced, Billion lbs |
|--|-----------------|----------------|-----------|-----------------------------|
| 1973 (began 3 year cycle) | 315 | 266,000 | 37,000 | 29.2 |
| 1976 | 469 | 291,000 | 38,000 | 29.2 |
| 1979 | 520 | 341,000 | 43,000 | 41.6 |
| 1982 | 590 | 419,000 | 41,000 | 36.6 |
| 1985 | 738 | 767,000 | 56,000 | 47.9 |
| 1988 | 1035 | 676,000 | 73,000 | 59.4 |
| 1991 | 1200 | 767,000 | 66,000 | 62.8 |
| 1994 | 1275 | 793,000 | 69,000 | 75.9 |
| 1997 | 1726 | 1,015,000 | 83,000 | 84 |
| 2000 | 2014 | 1,130,000 | 90,142 | 100 |
| 2003 | 1932 | 1,020,000 | 63,238 | 107 |

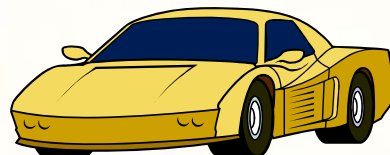
INNOVATION

Historic Perspective 1946-1952

- 1946-1952 establishment of plastics trade shows, associations (trade and technical) – plastics coming into their own as a emerging major industry
- Nylon changed the way people dressed worldwide
- Teflon® – became common in the electronic, chemical and automotive industries. The market for Teflon® boomed when it became available for non-stick cookware
- In 1950 the largest plastic part made was a 42 pound Admiral television
- In 1952 “engineering plastics” came into use and a door liner for an Admiral refrigerator was produced using injection molding
- Rigid vinyl was introduced

1952-1975 - Proliferation of plastics materials and expansion of fabrication technology

- Rigid vinyl – PVC was promoted
- Construction market is today the second largest for plastic materials and represents significant potential for innovative plastics systems
- Non-woven fabrics emerged
- Blow molded bottles replaced glass
- With ability to produce large molded parts – the Corvette was introduced
- The small appliance market was penetrated and the phone market boomed and the first portable hair dryer was possible.
- Foamed plastics allowed for protective packaging, insulation and new nylon materials were available



INNOVATION

1975-1982

- New issues face industry - process and material enhancements, globalization and recycling
- Reaction injection molding introduced
- Noise control a focus; light weight composites
- Co-injection molding enabled usage of recycled materials as core materials
- In 1979 the production of plastics in the US exceeds steel

1982-2000

- Industry is maturing in
 - Automation
 - Design
 - Productivity enhancements gaining importance
- Channels to market changed including distribution and the internet
- Consolidation in various parts of industry
- More new materials introduced
- Billion dollar buyouts and mega-mergers become common in the 1990s
- Biodegradable and recycled content materials continued to be a focus
- Computer aided design and software introduced and grew in importance

In 2000 the plastics industry become the fourth largest manufacturing segment in the US – following only transportation, electronics and the chemical industries.

Examples of Consolidation in the Industry...

Historic leaders in the plastics industry that have disappeared from plastics industry

| Materials | Comments | Equipment | Comments | Custom processor/ | Comments |
|--------------|---|--|------------------------|------------------------------|---|
| ICI | Sold off most of its plastics businesses-e.g.nylon to DuPont, PP to BASF | Davis and Standard; Killion Extruders | Now part of Crompton | United Technology Automotive | Now part of Lear |
| Celanese | Acquired by Hoechst, merges with some of Hoechst's other polymer lines-renamed Ticona-spun off and unit of former chemical operations-Celanese AG | Brown Machinery | Now part of Battenfeld | Textron and the Becker Group | Now part of Collins and Aikman |
| B.F.Goodrich | Spun off its PVC business to Geon- now Polyone | | | Polymer Corporation | Acquired by DSM then sold to Quantum Composites |

More Examples of Consolidation in the Industry

| Materials | Comments |
|------------------------------|---|
| BASF | Spun off its PP business to Targor, a JV with Shell. BASF then contributed its PE business to Elenac, a JV with Hoechst, which contributed its Polyethylene business. BASF acquired 50% of PP producer Montell (itself the sum of much earlier spin-offs from Hercules, Montedison and Shell) and has now merged Montell, Targo and Elenac while acquiring Hoechst's interest in Elenac (the whole entity is named Basell)-2000). |
| Dupont Alathon, Arco, Rexene | In 1997 Equistar was formed from the holdings of Oxychem, Lyondell and Quantum |
| Union Carbide | Merged with Dow |

2000-2004

- A global economic slowdown caused by manufacturers of durable goods to accelerate the movement of production to low-labor countries

2005 and the Future

- Globalization will continue to play an important role in the industry

Socio-economic factors/drivers

- Globalization of industry causing migration of lower technology and higher volume manufacturing sectors to lower labor – emerging economic regions of the world
- Lower growth demand in NA and WE
- New polymer plants are not being built in West but in Middle East or Asia
- China, India and South America represent sources of low cost labor and an emerging source of demand for commodity products and services.

Today's Business Environment Impacted Daily by Globalization and its effects

- Outsourcing
- Consolidation
- Increasing raw material prices

2005 and the Future

- Productivity enhancements and new technology will be key to NA competitiveness

Innovation in today's market

- Must provide value that translates into growth
- Most rewarding innovation achieved by recognizing synergy between ideas that are not obviously connected
- Get away from “not invented here” and get closer to customer

Examples of Innovative Material Usage

- Multi-material utilization has moved to plastics and metals integrated into complex structures that result in synergic properties unachievable with respective materials alone
 - One example is a front end molding from “Hybrid” developed by Bayer GmbH – perforated sheet metal parts are inserted into injection mold – plastic melt passes through openings in sheet metal forming rivet heads that provide integrity
 - Another type is Hydroplast Structures developed by GE, Carlisle and Vari-Form

Tooling Innovation

- In today's globally competitive environment tooling costs, lead times and component cycle time play critical role in product success
 - The AIM Frame system combines the high speed machineability and superior heat transfer of aluminum with durability of the industry standard high-strength steel- Aluminum Injection Mold Company
 - High speed machining
 - Rapid tooling and manufacturing

Process Innovation

- Combining injection molding with reaction injection (RIM) in the Skin-Form process
 - Krauss-Maffei has combined thermoplastic injection molding of polyamide with RIM in a single machine to produce components that have structural integrity plus a leather-like feel
 - eliminates several handling and secondary process steps
 - Two-component molding combined with two spinning cubes has potential to provide huge productivity gains-Cincinnati Milacron

Manufacturing Process Innovation

- Another way innovation can impact business is through continuous process improvement or Kaizen
 - Focuses on relentlessly attempting to find ways to enhance every step from product design through assembly
 - Has to be an ongoing process that never ends
- Enhanced Supply chain

2005 and the Future

- New material platforms and equipment modifications will continue to emerge
 - Biotechnology
 - Nanotechnology

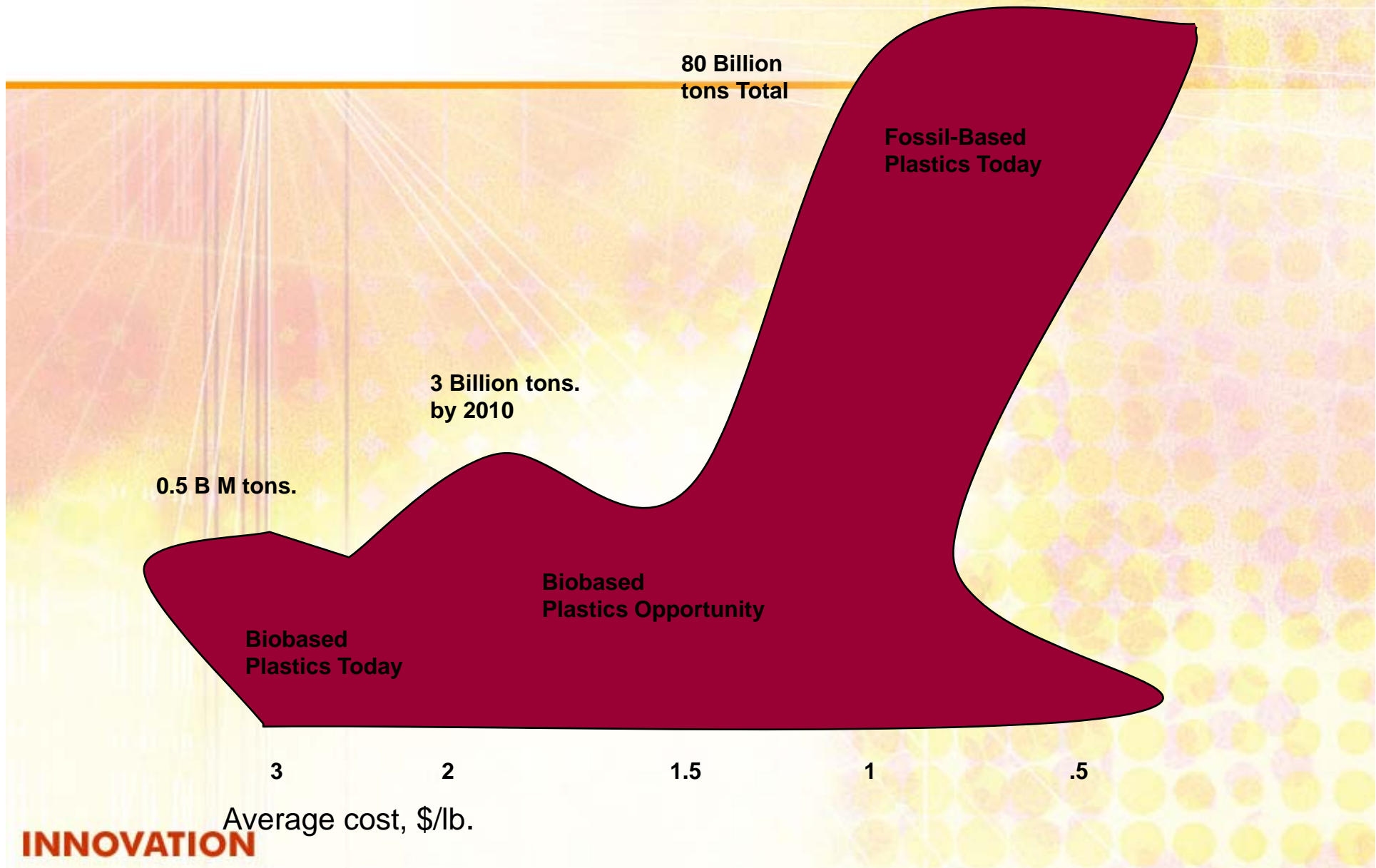
Biotechnology

- It is believed that biotechnology will be one of the key innovation drivers in chemicals and polymers over the next 10 years
- Less than 3% penetration today it is predicted to be 20% by 2010

3 Advances

- BioCatalysis
- Metabolic Engineering
- Plant biotechnology

Bio-based Plastics Opportunity



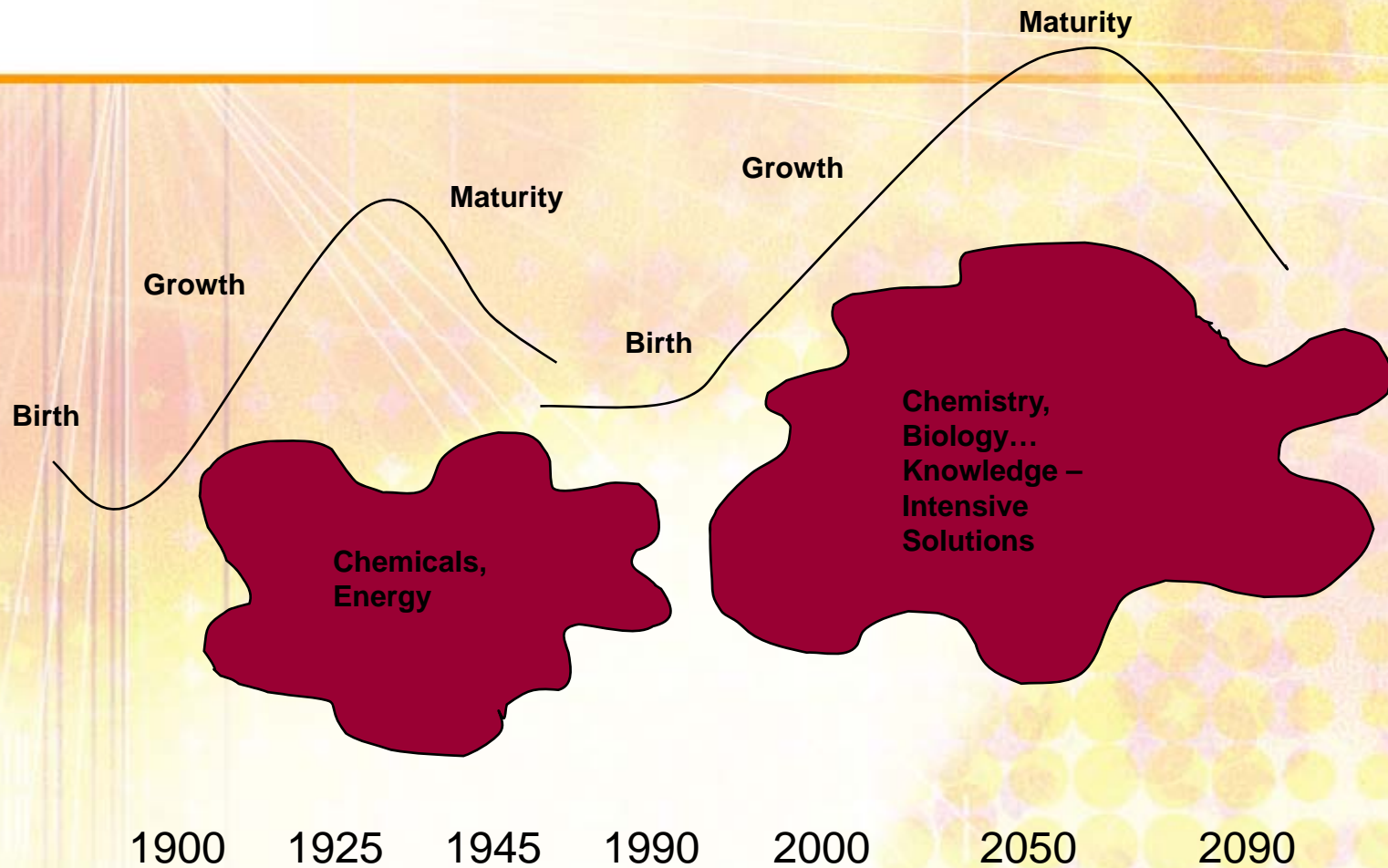
Industrial Biotechnology-why?

- Rising cost of petrochemical feedstocks
 - Potentially more stable over the long run
- Socio-political uncertainty
 - Less dependence on petrochemical feedstocks
- Cost savings/flexibility
- New products/properties

Examples

- PLA (NatureWorks LLC)
- Sorona (DuPont)
- Metabolix
- Toyota/P&G

Evolution of Industrial Chemical Technology



INNOVATION

Nanotechnology

- Nanoscale science and engineering is the creation of functional materials, devices and systems through the control of matter on the nanometer (1 to 100+nm) length scale –
- This is not new but our understanding of it is expanding
- Experts believe US chemical industry will offer a “library” of diverse nanomaterial building blocks that can be synthesized by economically viable manufacturing practices

| Old technology | New technology |
|-----------------------|-----------------------------|
| Carbon black | Carbon Nanotubes |
| Fumed Silica | NEMW |
| Colloidal silver | Quantum dots |
| Zeolites | De-aggregated nanoparticles |
| Catalysts | Nanowires |

Nanotechnology-Innovative Products in Materials

| Industry sector | Features added through Nanotechnology | Innovative product |
|---------------------------|---|--|
| Plastics Industry | Nano powder. Surface improvement, dispersion technology | Thermal insulation, anti-UV, antibacterial, high fade resistant materials |
| Man Made Fiber Industry | Nano-function formulation technology | High strength, anti-bacteria, abrasion resisting, electric conducting, low gas permeation, environmentally friendly packing materials |
| Coating Industry | Nano porous structure technology | Abrasion resistant, antibacterial/UV, high temperature stable, flame retarding, nano-color paste/ink, high thermal conducting material |
| Paper Production Industry | Self-assembly process technology | Food preservation bag, high quality printing paper, high-stiffness film |
| Construction Industry | Nano Interface processing technology | Self-cleaning, thermal insulation, anti-fog |
| Metal Industry | Nanocrystal lattice control technology | High strength steel aluminum alloy, abrasion resisting surface treatment |
| Chemical Industry | Nano-catalysts, sensor, high thermal; conducting materials, glass coating | |

Conclusions for 2005 and the Future

- Globalization will continue to play an important role in the industry
- Productivity enhancements and new technology will be key to NA competitiveness
- New material platforms and equipment modifications will continue to emerge
 - Biotechnology
 - Nanotechnology
- More collaboration/partnerships - industry, academia and government research and funding institutions

INNOVATION

Thank you for
your attention!
Questions?

Margaret Baumann,
G.H. Associates
908.832.2207

e-mail: mhbaumann@earthlink.net