INNOVATION

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

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Background

- Since the 1950's plastics has grown to a 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
  - Material replacement
  - Innovative uses/applications
- Most people living in NA or Europe do not know a world without plastics
- Trade shows and conferences have served as a platform to introduce these new and innovative 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 and 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

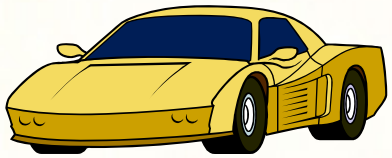
	# of exhibitors	Area (sq. ft.)	Attendees	Resin Produced, Billion lbs
1973 (began 3 year cycle)	315	266,000	37,000	29.2
1976	469	291,000	38,000	29.2
1979	520	341,000	43,000	41.6
1982	590	419,000	41,000	36.6
1985	738	767,000	56,000	47.9
1988	1035	676,000	73,000	59.4
1991	1200	767,000	66,000	62.8
1994	1275	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

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, the phone market boomed and the first portable hair dryer was possible.
- Foamed plastics allowed for protective packaging and insulation
- New nylon materials were available; PC, ABS



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1975-1982

- New issues face industry
  - Globalization
  - recycling
  - Toxicity/material handling
- Process and material enhancements continue
  - Reaction injection molding introduced
  - Noise control a focus
  - Light weight composites
  - Co-injection molding enabled usage of recycled materials as core materials

In 1979-Production of plastics in US exceeds Steel

1982-1990

- Industry is maturing in
  - Automation
  - Design
  - Process enhancements
- Blends and alloys come into vogue
- Channels to market changed, i.e. distribution
- Biodegradable and recycled content materials continued to be a focus
- Computer aided design and software introduced and grew in importance

1990-2000

- Productivity enhancements gaining importance
- Blends and alloys continue to expand
- Channels to market changed including distribution and the internet
- Consolidation in various parts of industry
- More new materials introduced- catalysts in PO;niche high performance plastics (LCPs, high temperature nylons)
- Billion dollar buyouts and mega-mergers become common in the 1990s
- Biodegradable and recycled content loses steam
- Computer aided design and software introduced and grew in importance- end users expecting suppliers to supply more services

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 manufacturers of durable goods to accelerate the movement of production to low-labor countries
  - Business machines and Telecommunications
  - Consumer electronics
  - Toys

2005 and the Future

- Globalization will continue to play an important role in the industry
- Plastics usage will continue to grow globally due to energy efficiency

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- surge in 2004-2005 expected to continue

2005 and the Future

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

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Innovation in today's market

- Must provide value that is cost competitive
- Most rewarding innovation achieved by recognizing synergy between ideas that are not obviously connected- "Think outside the box"!
- "Voice of the 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
  - One example is a front end molding from “Hybrid” developed by Bayer GmbH
  - 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 are critical
  - 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
  - Long glass fiber/”pultrusion” process

Manufacturing Process Innovation

- Another way innovation can impact business is through continuous process improvement
  - 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/process modifications will continue to emerge
  - Biotechnology
  - Nanotechnology

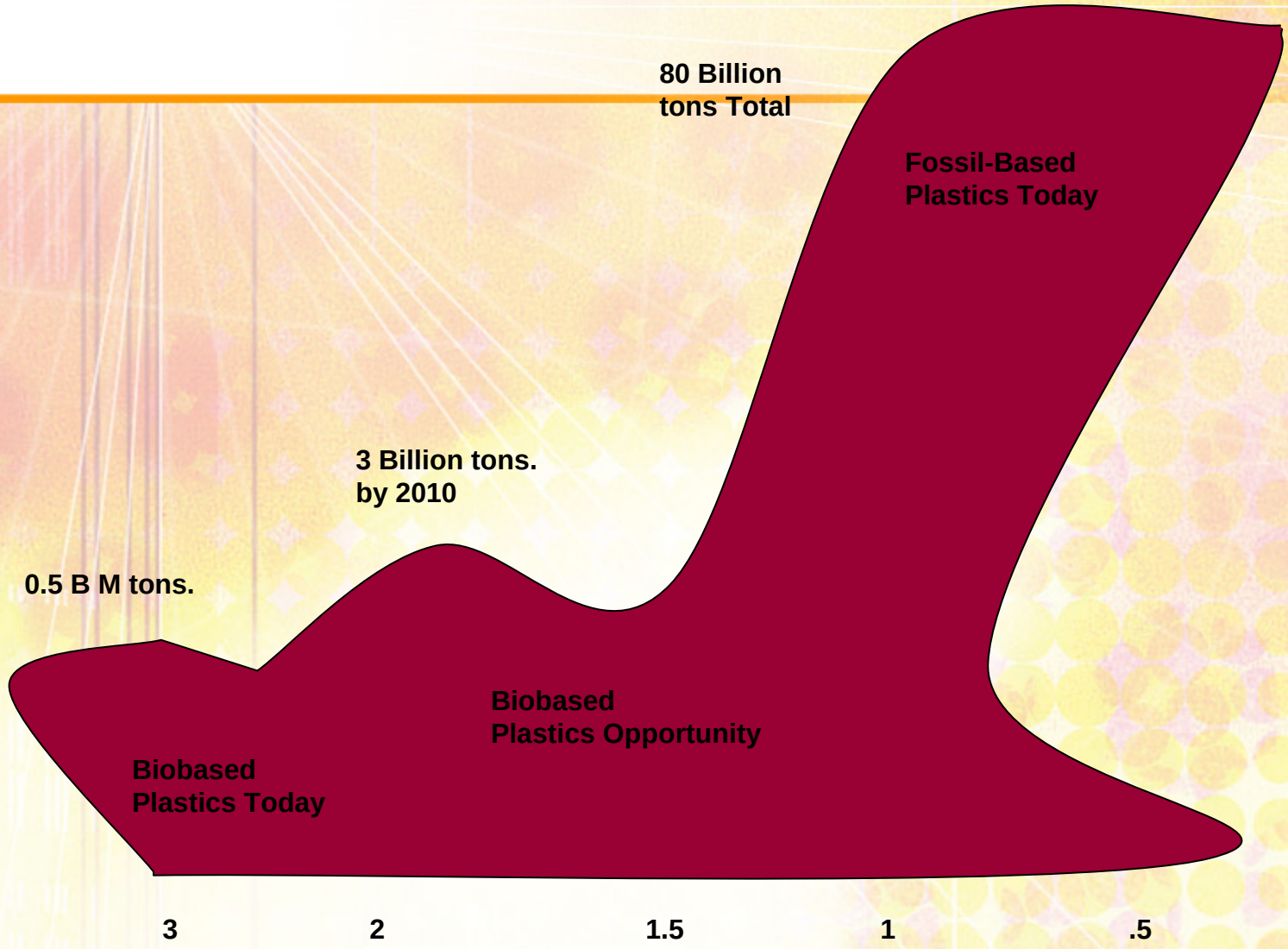
Biotechnology

- It is believed that biotechnology will be on 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



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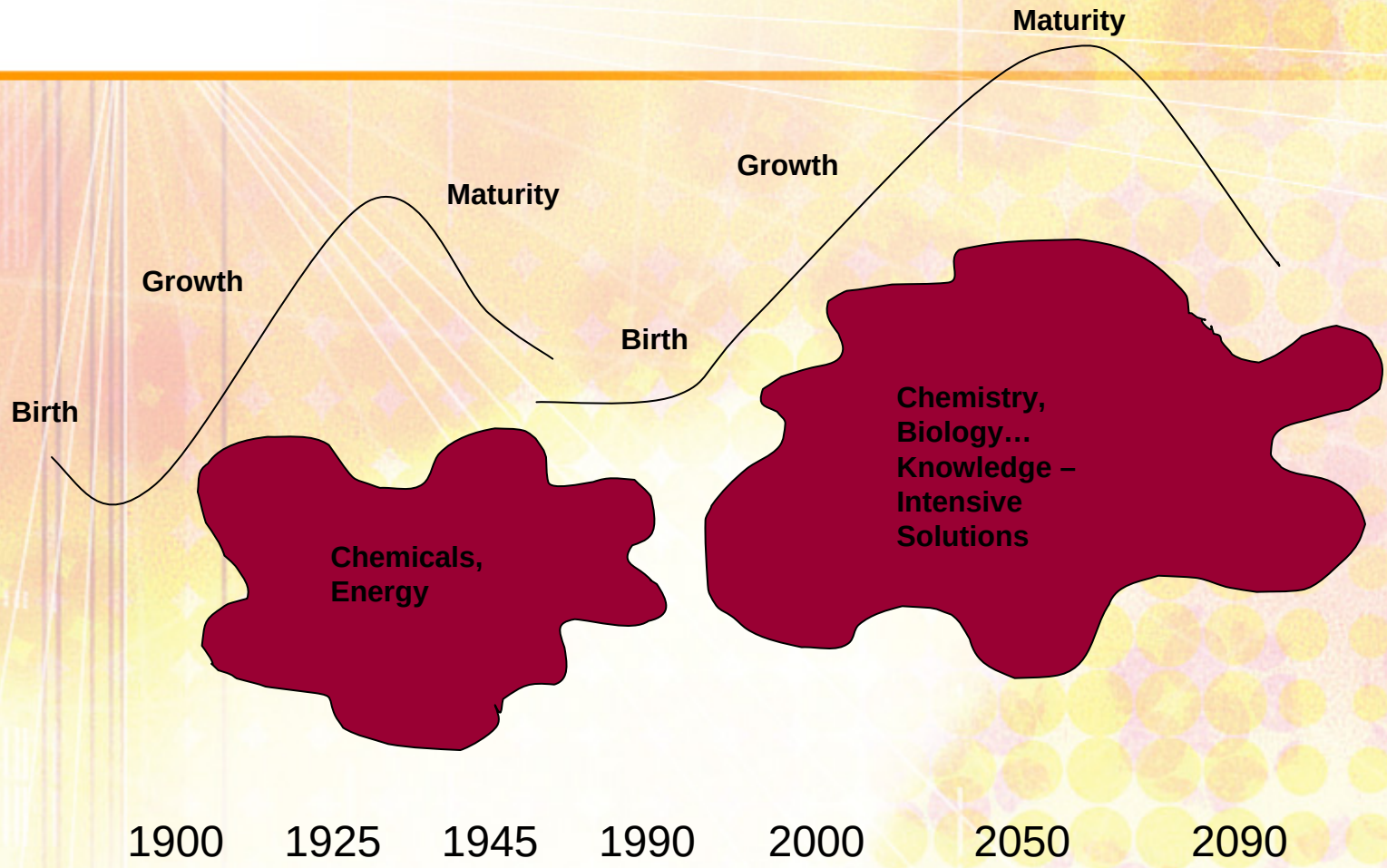
Industrial Biotechnology-why?

- 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/ADM
- Toyota/P&G

Evolution of Industrial Chemical Technology



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	

Innovation is key

- Plastics Industry history
- Collaboration- academia, government and industry key to continued competitiveness

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

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Thank you for your attention! Questions?

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