Celebrating 75 years of polyester

INDIAN Polyester – 2016
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Celebrating 75 years of polyester…

A tribute to
John Rex Whinfield CBE
&
James Tennant Dickson
Definitions

**polyester**

Pronunciation: /ˌpɒlɪˈɛstər/

*noun*

A synthetic resin in which the polymer units are linked by ester groups, used chiefly to make synthetic textile fibres.

**fibre**

Pronunciation: /ˈfaɪbər/

(US fiber)

*noun*

A thread or filament from which a vegetable tissue, mineral substance, or textile is formed
Why celebrate polyester?

• Scrunch it, pull it, wash it – without any wear and wrinkles, that’s what polyester has become famous for

• Polyester has become the fabric of choice in a changing economy of speed, efficiency and convenience

• If the food industry produced fries and coke, the textile industry has supplemented it with Polyester – quick, cheap and easy
World fibre mill consumption profile
1998 - 2020

Polyester overtakes cotton in 2002

Million tonnes

1998
34.1%
39.2%
5.6%
4.7%
7.9%
5.6%
3.0%

2020
57.4%
25.5%
3.6%
6.2%
4.5%
1.7%
1.1%

Data sourced from PCI Wood Mackenzie.
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Polyester growth v GDP

Data sources:
1. PCI Wood Mackenzie.
2. World Bank national accounts data, and OECD National Accounts.
The history of polyester
The four questions

• In a paper written in 1953\(^1\) on his development of Polyester, JR Whinfield stated that the answers to four key questions were needed if polyester was to be mass produced:
  – Could a commercial synthesis of terephthalic acid be established?
  – Could the production of the polymer on a large scale be satisfactorily controlled?
  – Could a workable process be found for the conversion of polymer into yarn or fibre?
  – Were the properties of resulting yarns and fibres such that these would find a market in the textile industry at a price at which they could be produced and sold?

• As we explore the development of the polyester industry we will see how they were answered, and then some!

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Polyester - the early years

- First DuPont patent related to polyester chemistry was published in 1937
- Terylene was produced by John Rex Whinfield with the assistance of James Dickson of the Manchester Company Calico Printers’ Association and was the world’s first polyester
- Despite Whinfield and Dickson patenting their discovery in 1941, it was suppressed under wartime secrecy until ICI became interested in its commercial possibilities
The polymer was described as ‘just a few grams of dirty-looking stuff like treacle’ when it was presented to Imperial Chemical Industries (ICI) in 1946, but this unassuming material was to revolutionise fabrics in the 20th century.

“There was quiet satisfaction but no great excitement when the first dirty brown fibres were drawn and certainly we had no idea of the enormous significance of what we had achieved”

– WK Birtwistle, a member of the research team
Polyester - the early years

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In 1947 ICI acquired world rights except in the US which were acquired by DuPont.
Polyester - the early years

- Financially their achievement had cost very little, ‘it was all done with 30 bobs’ worth of equipment’ according to WK Birtwistle (30 bob today would be about ₹130)

- The first piece of Terylene fabric was woven at the Shirley Institute in Manchester in August 1946

- In October 1946 a joint announcement by ICI and the Calico Printers’ Association produced the customary euphoria in the popular press:
  - ‘Anti-freeze Scanties! Big news, not just for women, of a remarkable British discovery’

- The first commercial sale of Terylene in Britain was on 4th October 1948 to the Nottingham firm of Dobson and Braine for the manufacture of lace curtains
Early production

- Early polyester fibre production was led by DuPont
- 1948 saw the first DuPont polyester pilot plant
- First commercial production of polyester by DuPont in 1950
- Dacron production begins at Kinston, North Carolina in 1953

KINSTON, N.C., March 25 -- The Du Pont Company’s $40,000,000 plant for the manufacture of “Dacron” polyester fiber started production here today.

The first of six production units went into operation at the plant built on a 635-acre tract along the Neuse River in the heart of this North Carolina tobacco country. The initial unit is producing “Dacron” in staple and tow forms.
Early production

Night shot of the main building of the Kinston, NC DuPont plant, 1953 © DuPont

packages of Dacron® polyester fibre are ready to leave the new $40 million Kinston plant © DuPont

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Marketing polyester, 1950s style

Meet Charles F. Benzel, Senior Investment Counsellor of Wilmington, Delaware

He staged a dramatic demonstration in a Kansas City swimming pool to impress directors of a mutual fund on the importance of investing in chemical industry stocks and securities

Charles is wearing a suit, necktie and shirt of ‘Fiber V’ (polyester fibre later trademarked as Dacron®), nylon underwear and socks of Orion® acrylic fibre

It is 8:30 in the morning and you may notice that he is standing on a diving board...
Marketing polyester, 1950s style

Well, Charles jumped in and bounced in the water for a few moments
Marketing polyester, 1950s style

Charles hung the apparel to dry in a heated room
In the final scene he addressed the group at luncheon without having pressed or ironed anything

He won his point!
A miraculous suit

Four Minutes Ago
This Suit Was in the Dryer...

The remarkable suit newly "Dacron" styled for machine-washing, spinning-drying, and ironing: the world's first "Automatic Wash 'n' Wear". This amazing suit is made with "Dacron", a soft and comfortable fabric that can be washed by machine and dried in the dryer. It is easy to wash and iron, and is ideal for busy people who want to save time. The "Dacron" fabric is also stain-resistant and durable, making it perfect for everyday use. For more information, please visit www.duPont.com.

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© DuPont
• Whilst DuPont was pushing ahead with Dacron®, on the other side of the Atlantic ICI was not standing still

• 1954 saw three significant developments in the United Kingdom:
  – First production of Terylene polyester fibre at Wilton
  – Production of Terephthalic Acid by nitric acid oxidation of paraxylene started at Wilton
  – First production of Melinex® polyester film at Welwyn
Terylene – the production

Images© ICI plc
Terylene – the site
Terylene – the tourists and fashion shows!
What about the feedstock?
• So far I have talked about the end product, but just as important was the development of the principle feedstock, Terephthalic Acid.

Note that by this time MEG was already in commercial production and so is not included in the story.
What did Whinfield say?

- Could a commercial synthesis of terephthalic acid be established?
- Terephthalic acid was first made in 1836 by French chemist Auguste Laurent.
- The structure was later identified by Swiss chemist Jean Charles Galissard de Marignac.
- However, it remained an idle curiosity until...
... the need for feedstock

• In the beginning the process available involved the oxidation of para-xylene with nitric acid to give crude terephthalic acid (TA)

• Purification was by conversion to dimethyl terephthalate (DMT)

• This started ICI’s obsession with “T” (for Terylene) and the start of production of TA by nitric acid oxidation of para-xylene at Wilton
  – T1, built in ’54 and closed in ’68, 10,000 t capacity
  – T2, built ’54, closed in ’68, 12,000 t capacity
The Mid-Century process, or
The enabler of polyester’s global domination

• The catalytic liquid-phase oxidation of *para*-xylene to TA, known as the Mid-Century process, was jointly developed in the 1950s by Standard Oil (through their AMOCO subsidiary) and Scientific Design

• Scientific Design beat ICI to the patent by about 1 week!

• In 1956, Scientific Design sold worldwide rights to the Mid-Century process to Standard Oil

• ICI licensed technology from Mid-Century Corporation in 1957

• The first commercial plant was built by AMOCO in Joliet, Illinois and it began production in 1958

• In 1965 an AMOCO pilot plant in Joliet began employing a hydrogenation step to purify terephthalic acid

• Which brings us back to T...
The story of “T”

- T3, built in ‘61 and closed down in ’74, using the Mid Century process with a capacity of 16,000 t/annum
- T4 - there was no T4!
- T5, built in ‘65 and shutdown in ’74, an extension of T3 with capacity of 10,000 t/annum
- T6 - built in 1967 and shutdown in 1980, the first proper PTA plant with a capacity of 60,000 t/annum
The story of “T”

T7
Built in 1973 and much more sophisticated
Initial capacity of 120,000 tonnes/annum

Image © ICI plc
The story of “T”

T8 - Built in 1981 and now demolished, but not before...

... the RIL team in training on the T8 PTA Plant at Wilton, UK in 1986

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Terephthalic acid

• And on we go...

• ...T9, T10, T11, 36 INVISTA licensed plants, nearly 30 million tonnes in annual PTA capacity using INVISTA technology

• Almost 80 million tonnes of global capacity in total...

• ... and then we get to Hengli

• 6.6 million tonnes of capacity on one site...

• ...so far
Evolution of scale and cost for PTA

1. Variable costs are above stoichiometric paraxylene
2. Plant scales are for INVISTA designed plants
It’s not just ICI...

From the early days in the ‘50s with Amoco and ICI leading the charge the number of producers and technology suppliers has grown...

...Slowly at first until now...

It’s not just fibre you know!
PET bottles

• It is not only fibre that polyester is good for...

• Say “PET” to most people and they think bottle not fibre
PET bottles

• It wasn’t until 1967 that Nathaniel Wyeth, a DuPont engineer started looking at the potential for carbonated drinks to be stored in plastic bottles

• After trying different materials he realised that a stronger material was needed to cope with the pressure of the contents
• He eventually opted for PET and 1973 saw the First DuPont patents for stretch blow moulded PET bottles
PET bottles

- Dramatic growth has been driven by, amongst others:
  - Economics, PET bottles are light, robust and relatively cheap
  - Aesthetics, PET bottles offer clarity and shapes beyond the capability of other packaging materials
  - Substitution of other materials, beginning with PVC
  - Recyclability
  - Renewable?
The PET plastic bottle became popular for a lot of reasons: it doesn't break; it's resealable; it's lightweight; and it's recyclable. Since its introduction, the PET plastic bottle has evolved as science and technology have progressed. We've been able to make the PET plastic bottle more environmentally sustainable by improving efficiency, increasing recycling and advancing recycled material use.

From “Yesterday to Today” by the Coca-Cola Company, 1st January 2012
Evolution of scale for CP units

- Up to 350 kta (fibre) and 1,050 kta (resin) single stream lines in development and construction
...and then there's film!!
Polyester Film

• Both DuPont and ICI continued their polyester research, but not as fibre, this time as films

• BoPET (Biaxially-oriented polyethylene terephthalate) film was developed in the mid-1950s, originally by DuPont, ICI and Hoechst

• Commercialized in 1952, Mylar® replaced Cellophane as the major product of the DuPont Film Dept.

• These PET Films, thanks to their properties, allowed producers to venture into new applications such as magnetic audio tapes, video tapes, capacitor dielectrics and packaging
Polyester Film

In 1964, NASA launched Echo II, a 40 m diameter balloon constructed from 9µm thick Mylar® film sandwiched between two layers of 4.5µm aluminum foil and bonded together.

By the early 1970s, Mylar® film represented the largest sale by DuPont in the area of films, replacing Cellophane.

PET film is now widely used in flexible packaging for its puncture resistance and barrier properties.
The polyester advantage
The polyester advantage!

PET
GOOD FOR THE PLANET
GOOD FOR BUSINESS

• Consumers can feel good about selecting garments engineered with EcoMade technology
• Plastic bottles and other recyclable items destined for landfills have been transformed into fibers through a six-step manufacturing process
• Made from 97% recycled resources, these fibers can be used in apparel and non-apparel products

PLASTIC BOTTLES
Used, post-consumer plastic water bottles are collected

FLAKES
Bottles are cleaned and ground into flakes

CHIPS
The flakes are converted into chips

POY YARN
The chips are then made into POY yarn

DTY YARN
The POY yarn is converted into DTY yarn suitable for apparel

GARMENTS
Fabrics containing this fiber may meet COOLMAX® and THERMOLITE® brand performance standards and may feature technology's branding
Polyester in India
Polyester in India

• The story begins with ICI, as does much of polyester

• The ICI India story began way back in 1911 when Brunner Mond & Co, one of the four companies that combined in 1926 to form ICI, opened a trading office in Kolkata to sell alkalis and dyes

• Chemical and Fibres of India Ltd came up in Thane in 1963, manufacturing polyester staple fibre

• India’s first polyester plant?
Polyester in India

First fibre CP licence between RIL and DuPont was signed in 1979

Followed by PTA in 1985, both at Patalganga
Polyester in India

- In 1993 RIL and ICI India formed a strategic alliance in the polyester business
- ICI India's polyester business, sited at Thane was reformed and became known as Terene Fibres India
- Exit ICI, onwards and upwards Reliance...
What of the future?
Where next for polyester?

• Hopefully over the next two days we will see learned speakers expand on the future, rather than the past of polyester
  – New polyesters such as PTT, PEF or...?
  – New attributes and properties – is it market pull or development push?
  – New applications, what else can we substitute?
  – Turning waste into value, can we increase the polyester recycling advantage?
  – Stuff we haven’t even thought of yet!
About INVISTA

The advertisement bit
1941 - Polyester discovered by Whinfield & Dickson in Manchester, UK
1949 - First development production of polyester
1967 - First production of PTA, Purified Terephthalic Acid at Wilton
1982 - First PTA licensed plant commissioned in India

1937 - First DuPont patents related to polyester chemistry
1950 - First commercial production of polyester
1973 - First DuPont patents for stretch blow moulded PET bottles
1988 - First PTA licensed plant commissioned in India

DuPont acquired ICI's polyester business in 1998

2004
INVISTA acquired by Koch Industries

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INVISTA’s Shareholder

- Businesses/industries:
  - Commodity Trading
  - Electronic Components
  - Energy
  - Fertilizers
  - Forest and Consumer Products
  - Glass
  - Minerals
  - Polymers and Fibers
  - Process and Pollution Control Equipment and Technologies
  - Ranching
  - Refining, Chemicals and Biofuels

INVISTA is an independently managed, wholly owned subsidiary of Koch Industries, Inc.
In 2004, subsidiaries of Koch Industries, Inc. acquired INVISTA.
*Koch revenues fluctuate with the price of commodities. They have been estimated by Forbes as high as $115 billion.
INVISTA in polyester

OxyClear

Coolmax

Polyshield

Dacron

Thermolite

Polyclear

SenzAA
What has driven polyester growth?

- Population and GDP growth, we all need clothes and cotton is limited
- Unlike cotton, polyester production is reliable
- Functionality
  - Capability to cover multiple applications
  - Easy care
  - Adaptable to hot climates, cold climates, active wear, elegant wear, work wear, leisure wear
- Packaging is light, tough, transparent, mouldable
- Highly recyclable, if we can collect it...
- Entry level economics are achievable, start at the end and work backwards
The miracle polymer

- Polyester really is the miracle polymer
- It is expected to continue to grow as new and innovative uses are brought forward
- Everywhere we look we are seeing new applications, new market opportunities and exciting developments
- At INVISTA, our predecessors were there at the beginning, they were polyesters past...
- ... and in a small way we consider ourselves to be polyesters present and future
- So let us celebrate polyester, 75 years young!!
Celebrating 75 years of polyester...

Thank you to
John Rex Whinfield CBE
&
James Tennant Dickson...

...let’s look forward to another 75 years of innovation...

Crimplene for men

...and I really am sorry about Crimplene!
Thank you!!

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