Rayon Fibers

The Versatile Choice for Wipes

Matthew North

The Future of Wipes – Atlanta
December 2008

Kelheim Fibres

The future of wipes…

- Sustainable raw materials
- Efficient processing
- Enhanced properties
- Reduced cost
- Consumer benefits
- Environmentally neutral disposal

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Rayon - The Versatile Choice for Wipes

- Kelheim Fibres GmbH believes that rayon has a role to play in each of these areas and that our products can help the nonwovens industry meet the future needs of its customers
- The rayon industry has accepted the responsibility of servicing the nonwoven industry with forward oriented solutions for environmentally and economically safe and consumer oriented products.
- The market leaders in this respect are the EU based producers Kelheim Fibres GmbH and Lenzing AG with manufacturing locations in the EU, the USA and Asia.

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Kelheim Fibres GmbH

- Manufacturer of Speciality Rayon Fibers
  - Located in Southern Germany
  - Global Market Leader for the production of fibers for tampons and hygienic applications
  - Combining the heritage and experience of leading fiber producers:

    Courtaulds
    Hoechst
    Akzo Nobel

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The History of Rayon

Rayon – A traditional fiber with surprising versatility -

These are the milestones in the history of Rayon:

1892 Discovery of rayon making; Target was to have a cheaper and more readily available source for silk

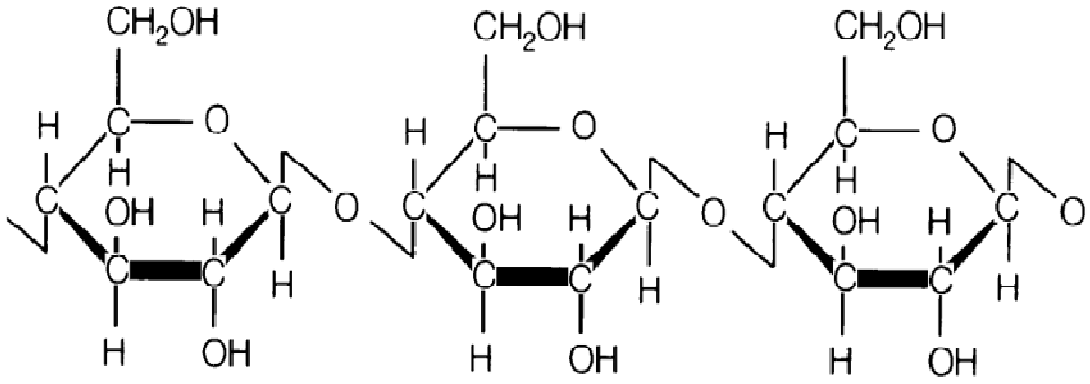
1904 Samuel Courtaulds Ltd buys rights on rayon making and develops commercial process

1930s Staple process expands, originally only developed to get rid of waste from filament process

1960s Staple process becomes majority, filament process decreases

Cellulose…

- …the world‘s most abundant naturally-occuring polymer
- …the building block of all plant life
- …appears in an extraordinary range of final forms



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Rayon – Cellulose in Fiber Form

- Produced with sustainable raw-materials. 40 billion metric tonnes of cellulose are generated naturally each year.
- Raw material grown in managed plantations, no virgin forests are used.
- Wood pulp manufactured according to FSC regulations.
- Fully biodegradable.
- No crude-oil based raw materials.
- No animal based raw materials.

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Rayon Fiber

”Rayon is a manufactured regenerated cellulosic fiber. Rayon is produced from naturally occurring polymers and therefore it is not a synthetic fiber. It is known by the names viscose rayon and artificial silk in the textile industry.”

Source: Kelheim Fibres Definition 2008

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Sustainability

Sustainable development is development that “meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Source: The Brundtland Commission, Norway

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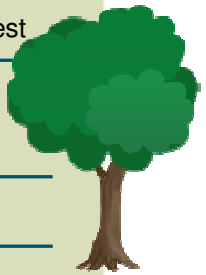
Rayon and Sustainability

The manufacture of rayon fibers is highly efficient in its use of resources, particularly water and land. No fertilizer is required for the growth of the raw materials and no pesticides are used at any stage.

Per tonne of finished fiber	COTTON	MAN-MADE CELLULOSE
Land use	17,000 m² fertile farmland	8,000 m² natural increase of forest
Water	7,000 – 29,000 m³ artificial irrigation; Aral Sea catastrophe!	500 m³ process and cooling water
Fertiliser	700-1,100 kg	None
Energy	Approx. 40 GJ	Approx. 75GJ
Health	Cases of poisoning 1,500,000/a, Cases of death: 28,000/a (WHO-statistics)	Maximum allowable concentration for H_2S and CS_2
Genetic modification	Widely used	Not used



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Rayon and Sustainability

- To produce one metric tonne of rayon the amount of water required is up to 98% less than is required for cotton, which needs between 7.000 and 29.000 m3 of water per metric tonne.
- 53% of global cotton plantings, mainly located in arid regions, are artificially irrigated with severe impacts on the environment.

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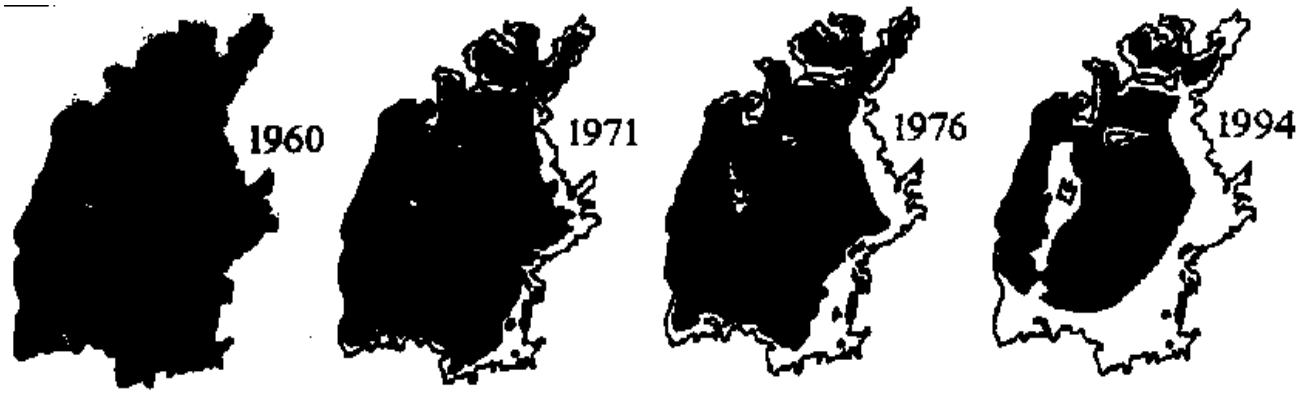
The Aral Lake Disaster



YEAR	AVERAGE LEVEL (m)	AVERAGE AREA (km²)	AVERAGE VOLUME (km³)	AVERAGE SALINITY (g/l)
1960	53.4	66,900	1090	10
1971	51.1	60,200	925	11
1976	48.3	55,700	763	14
1994		31,938	298	
large sea	36.8	28,856	273	>35
small sea	40.8	3,082	25	~25
2000		25,217	212	
large sea	33.4	21,776	186	>60
small sea	41.6	3,441	26	~20

Philip Micklin 1995

Source: The United Nations University 1998

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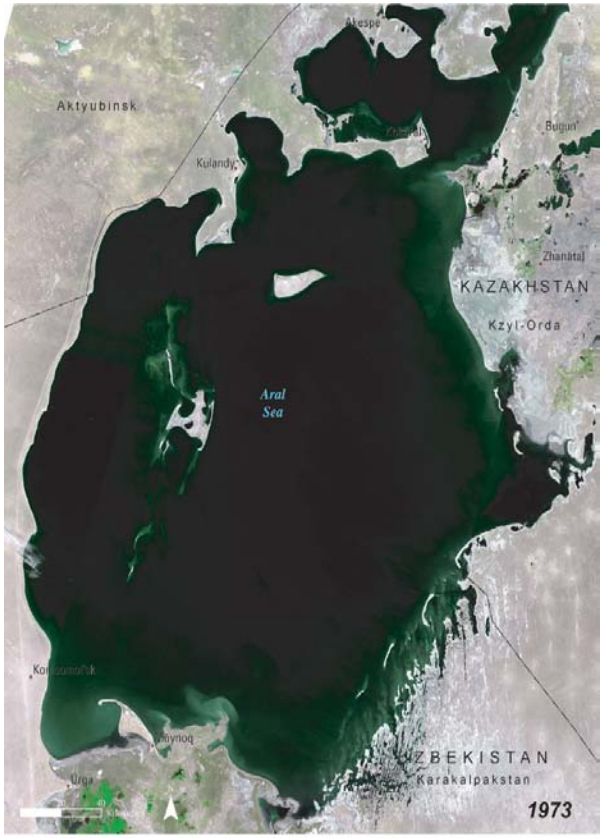
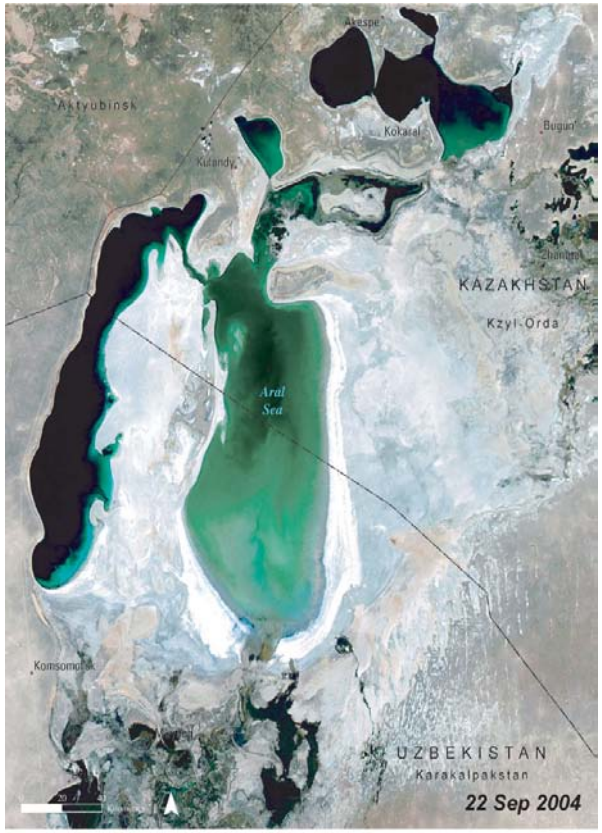
The Aral Lake Disaster





Source: The United Nations Environment Programme 2005

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Rayon and Sustainability

- To produce one metric tonne of rayon the amount of water required is up to 98% less than is required for cotton, which needs between 7.000 and 29.000 m3 of water per metric tonne.
- 53% of global cotton plantings, mainly located in arid regions, are artificially irrigated with severe impacts on the environment.
- In the production of rayon, water is mainly used in the production process for cooling so can largely be reused in the system.
- Efficient use of waste water treatment plant in rayon manufacturing minimise the impact of potential pollutants on the environment.

Rayon and Sustainability - Emissions

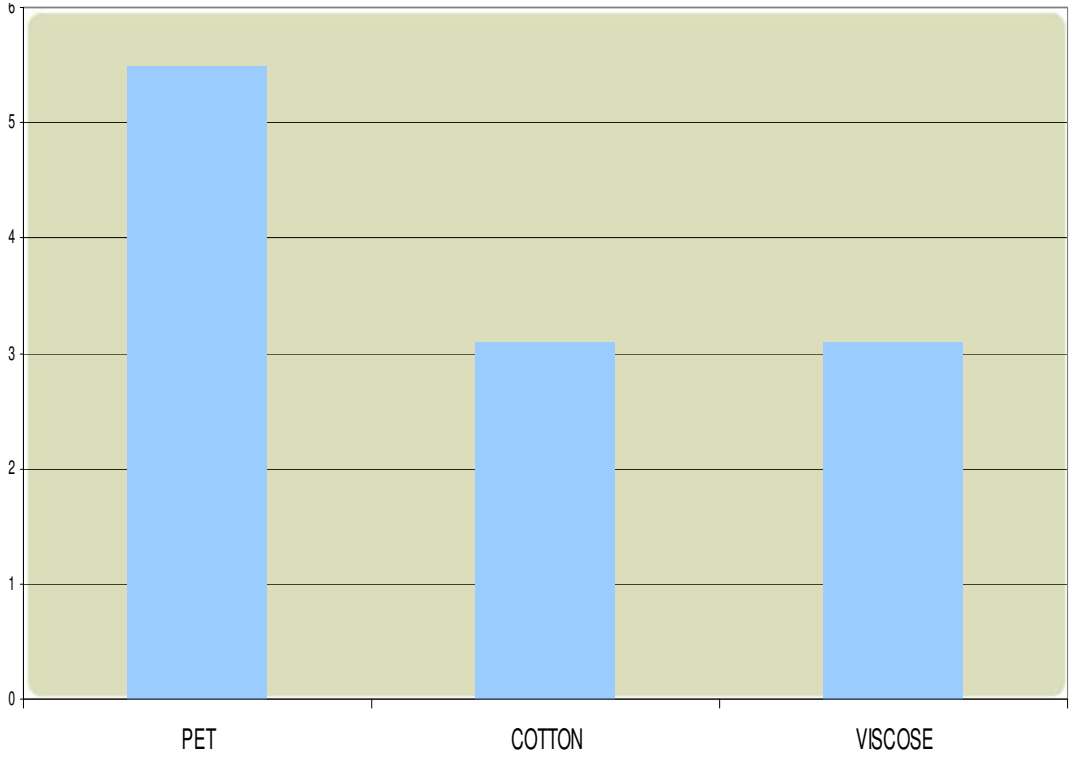
- Rayon production has lower CO_2 emissions than the production of other common fibers

  (source Utrecht university)

- Waste gases from the production of rayon are cleaned efficiently

- Special processes allow the recovery of chemicals which are be reused in the production process

Net GWP(T CO2 eq/T of fiber), cradle to factory gate + post consumer waste incineration with energy recovery **(recovery rate =60%)**



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Rayon and Sustainability – A Natural Cycle

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Efficient Processing

- Rayon fibers have a proven track record in processing in all nonwoven technologies
- Kelheim Fibres customers acknowledge that Danufil rayon fibers are ideal for processing on the latest spunlace equipment
- Kelheim Fibres has developed products which deliver high yields and reduced waste in processing
- Fabrics produced from blends of rayon with synthetic fibers or in 100% are processable on all commonly used converting equipment

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Efficient Processing – Fiber Developments

- Kelheim Fibres is in the final stages of the development of a high cohesion rayon fiber, intended to further improve cardability
- Short cut rayon fibers – the alternative to spunlacing for wipes
  - Wet short cut fibers (d'tex 0,7 – 3,3, 4mm – 12mm cut length) for wet laid (paper) processes
  - Objective: increased strength while maintaining biodegradability
  - Dry short cut fibers (d'tex 0,9 – 3,3, 3mm – 12mm cut length) for dry laid (e.g. air laid) processes
  - Objective: improved fabric properties (softness, wicking) while maintaining biodegradability

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Enhanced Properties

- The rayon process, in conjunction with the properties of the natural polymer used, remains one of the most versatile fiber production processes
- Modified fiber cross sections can be produced, such as the trilobal cross section Kelheim Fibres product Galaxy, the leading fiber used globally in the tampon industry

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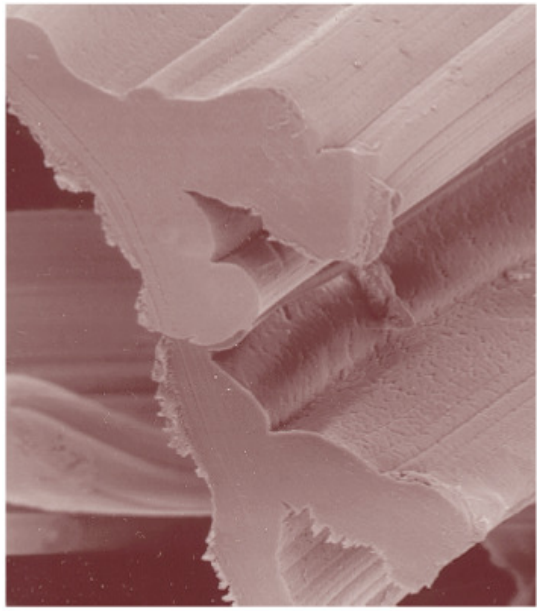
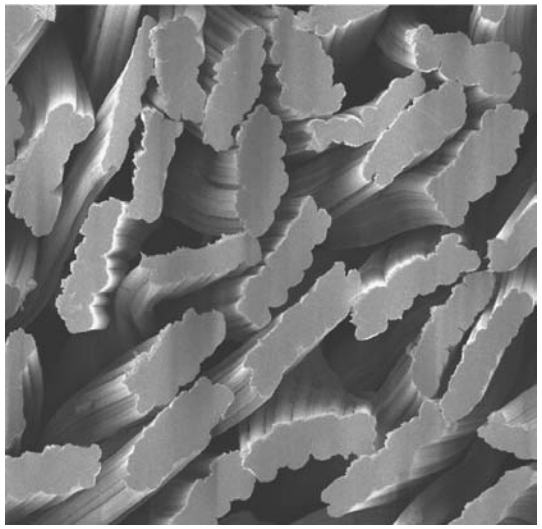
Modified Cross-Section Rayon Fibers

Galaxy®, the leading rayon fiber in the tampon industry





Kelheim Fibres Viloft® flat cross-section rayon fiber

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Modified Cross-Section Rayon Fibers

- Galaxy® trilobal fibers can be used – in appropriate constructions – to deliver enhanced properties in wipes products, e.g.
  - Enhanced absorbency
  - Improved liquid retention properties
  - Additional bulk
- Galaxy® trilobal fibers are available in both standard and short cut staple lengths
- Viloft® flat cross-section fibers can deliver improved fabric softness
- Kelheim Fibres is developing other modified cross-section fibers e.g. hollow fibers, multi-limbed fibers

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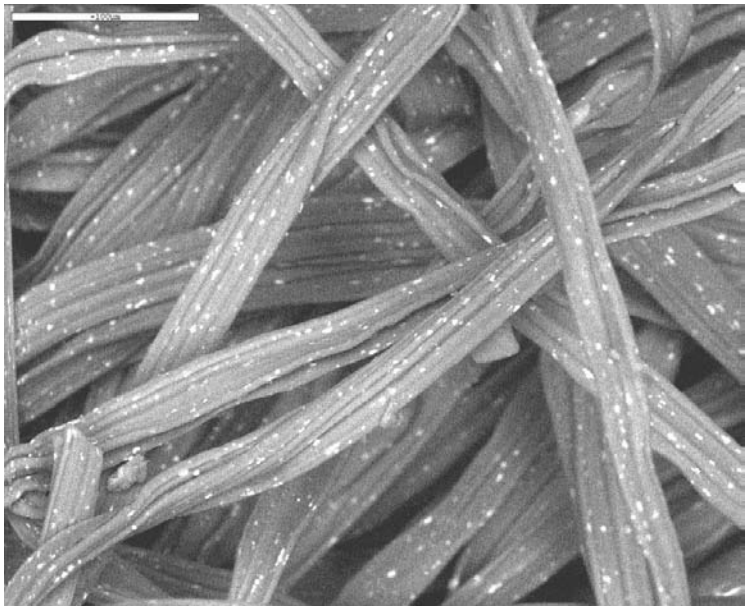
Enhanced Properties

- The rayon process, in conjunction with the properties of the natural polymer used, remains one of the most versatile fiber production processes
- Modified fiber cross sections can be produced, such as the trilobal cross section Kelheim Fibres product Galaxy, the leading fiber used globally in the tampon industry
- The process is also receptive to the incorporation of a broad range of additives, delivering permanent properties to the fibers

Rayon Fibers Incorporating Additives

Rayon made in Kelheim can be manufactured with a broad range of additives and ingredients



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Rayon Fibers Incorporating Additives

- Kelheim Fibres is able to produce fibers incorporating anti-microbial compounds (both metal-ion and organically based)
  - Enhanced hygienic performance
  - Longer shelf life
  - Reduced use of preservatives
- Kelheim Fibres is developing a range of alloyed rayon fibers with enhanced surface properties
  - Fibers with reversible adhesive properties
  - Fibers with odour capture properties
- Other compounds can be spun into fiber
  - Pigments for coloured fiber (standard)
  - Active carbon
  - Abrasives

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Reduced Cost

- Fiber is a significant element in the cost of any wipes product
- Kelheim Fibres produces a microfiber rayon which can be used to produce ultra-light wipes products with improved capillary performance
- Kelheim Fibres is developing a standard denier fiber with increased opacity with the objective of improving cover in nonwoven fabrics for wipes products

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Consumer Benefits

- Fabrics constructed with rayon fibers offer improved softness and a better handle than fabrics made from other fibers
- Rayon fabrics deliver enhanced absorption properties
- Rayon fabrics offer consistent product performance and quality
- Rayon fabrics can be disposed of through the wet and the dry route in an environmentally neutral manner
- Rayon fibers are pure and free of substances which may cause allergic reactions

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Consumer Benefits with Rayon Fibers

In a consumer panel carried out independently of Kelheim Fibres using Viloft® Nonwoven fabrics in comparison to standard wipes:

- 79% of the testers rated Viloft® Nonwoven fabrics as softer
- 57% commented that the skin immediately after use felt smooth and silky/soft
- 54% commented that the skin condition after use was soft and smooth

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Environmentally Neutral Disposal

- **Biodegradability**

  Biodegradation is the process by which organic substances are broken down by living organisms.

  Source: www.wikipedia.com February 2008

- **Flushability**

  A product is considered flushable if it is able to pass through a toilet bowl and afterwards through a household drainage. It shall not block onsite or municipal wastewater treatment systems, and has to disperse in a way that it is not recognizable in the environment after a reasonable period of time.

  Source: Kelheim Fibres Definition 2006

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Environmentally Neutral Disposal

What is biodegradation?

- Biodegradation occurs through the action of enzymes created by living organisms
- Breaking a product down to carbon dioxide (CO_2) and water (H_2O).
- Cellulosic fibers commonly used in nonwoven products such as viscose and cotton are known to be biodegradable, whereas synthetic fibers are not.
- Biodegradation can take place in aerobic (with oxygen) or anaerobic (without oxygen) degradation.

Biodegradation through Composting

- Rayon fibers were found to have degraded completely after 6 weeks in a static aerated compost pile carried out in a field test.
- Cotton fiber suffered a weight loss of approximately 80 % under the same conditions
- Synthetic fibers such as polyester, showed very little signs of degradation

Source: Kelheim Fibres/ Courtaulds Research

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Landfill Disposal

- Organic matter buried in the ground rots over a period of time by the bacterial process of anaerobic digestion.
- A landfill site is not easy to define or simulate, as it is somewhat heterogeneous. Soil burial tests (BS 6085 /AATCC 30) are accepted methods of assessing the biodegradability of a product.
- Viscose and cotton fibers degrade completely within 12 weeks.
- Synthetic fibers gain weight initially, and only show slight strength and weight loss after 24 weeks burial.
- The result of the biodegradation studies carried out to date correlate well with the knowledge we have regarding the structure and chemical resistance of cellulosic and synthetic fibers.

Incineration

- Mass incineration plants especially in large conurbations, with facilities for recovering energy from waste, can earn substantial amounts of money from the sale of electricity to power generating companies.
- Cellulosic fibers, such as rayon, burn readily with a heat of combustion of 15 kJ/g.
- Such plants also have the added advantage of reducing the volume of refuse sent to landfill sites by as much as 90%.

Wet Disposal - Flushability

- Nonwovens industry producers have been working on developing wipes that will flush
- To create a flushable nonwoven product, the right combination of strength, easy break up and dispersion must be found
- In the absence of regulation, a lot of this has to do mainly with the size of the wipe, creating potential problems
- To be considered truly flushable the wipe must also be biodegradable

Industry Standards for Flushability

- In 2004 work started by the two major industry oganisations of the Nonwoven industry on the subject of flushability.
- The EDANA/INDA guideline was published in mid-2008 but is not mandatory and has not brought the clarity the industry was seeking.
- In effect, work to define a globally accepted standard for flushable products is still ongoing

Solutions for Flushability

- Reduced surface area of wipe
- Low strength bonding
- Chemically triggered dispersion
- 100% biodegradable raw materials
- Kelheim Fibres product – Viloft® nonwoven offers the following benefits:
  - Can be processed on existing spunlace equipment
  - 100% biodegradable
  - Fabrics made from Viloft® nonwoven have been proven to disperse better than similarly constructed fabrics using standard rayon or rayon/synthetic blends

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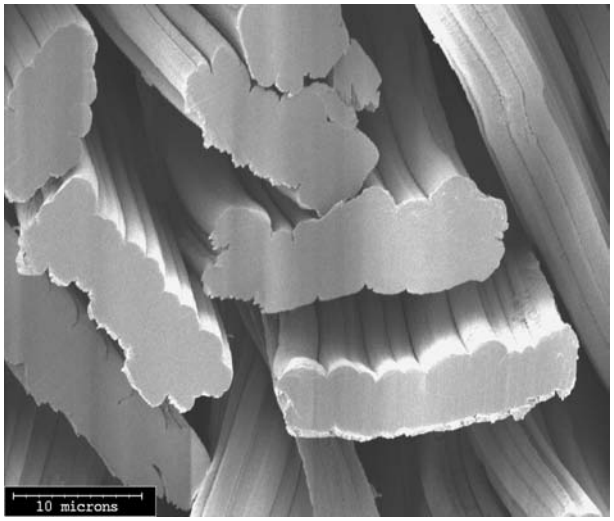
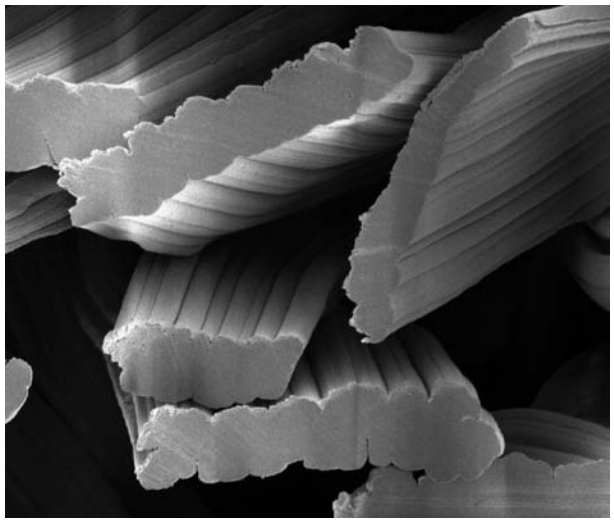
Viloft® Nonwoven – A Solution for Flushability

Viloft® Nonwoven is a modified cross-section rayon fiber with unique flat cross-section and crenellated surface.





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Why do Viloft® Nonwoven fabrics disperse?

- Fabric strengths one third lower in CD and MD, but in comparison to weaker rayon fabrics, the construct is less hairy, softer and shows no signs of pilling, and exhibits better dispersion.
- Behaviour during bonding (i.e. spunlacing) is different. Viloft® Nonwoven entangles in a different manner to other fibers.
- Surface effects with the flat fiber lead to easier opening of the structure under water.
- Viloft® Nonwoven has different swelling characteristics to standard rayon and Polyester fibers.

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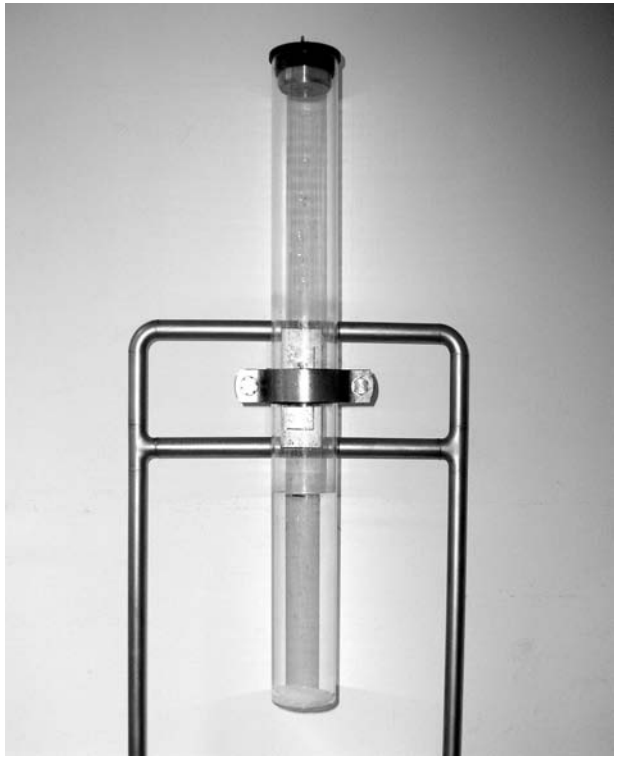
Improved Dispersion of Viloft® Nonwoven

- Kelheim Fibres uses a tube flush-tester to evaluate the disintegration capabilities of fabrics.
- The fabrics are added to water in a clear plastic pipe that is rotated through 180 degrees.
- The dispersion of any fabric can thus be assessed.



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Results of Dispersion Testing

Typical results from the tube flush test (comparable fabrics produced on trial lines with fibers provided by Kelheim Fibres):

Type of fabric	Typical MD	Typical CD	Turns
100% Viloft Nonwoven 50gsm	50	15	6
100% Viloft Nonwoven 40gsm combined with 10 gsm pulp	60	12	6
100% Viloft Nonwoven 30gsm combined with 20 gsm pulp	40	10	6
50% Viloft Nonwoven 50% rayon	90	15	14
100% Standard Rayon lower strength	75	15	41
60% Standard Rayon 40% PET	95	11	> 50
60% Viloft Nonwoven 40% PET	85	10	> 50
100% PET	170	25	> 50
100% Standard Rayon	80	20	> 50

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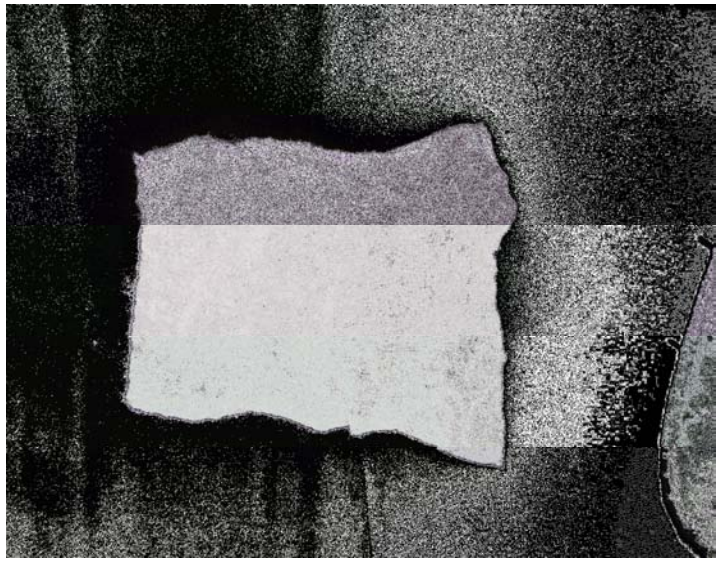
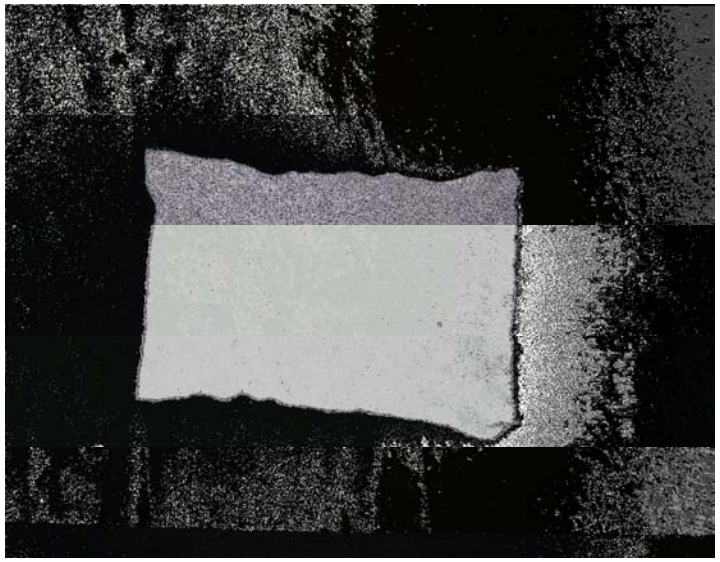
Results of Dispersion Testing

100% Viloft® Nonwoven



100 % Standard Rayon



After 2 turns

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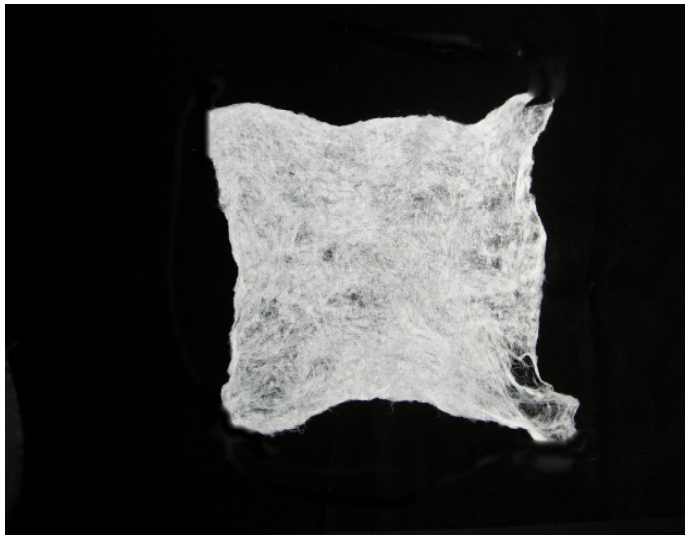
Results of Dispersion Testing

100% Viloft® Nonwoven

100 % Standard Rayon



After 14 turns

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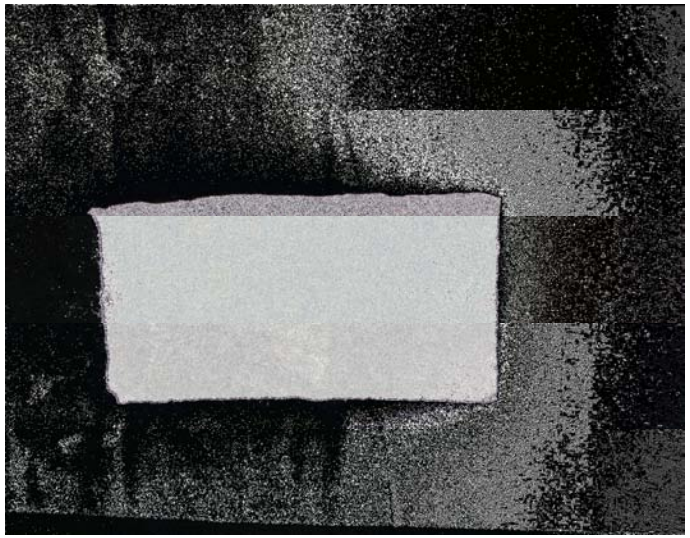
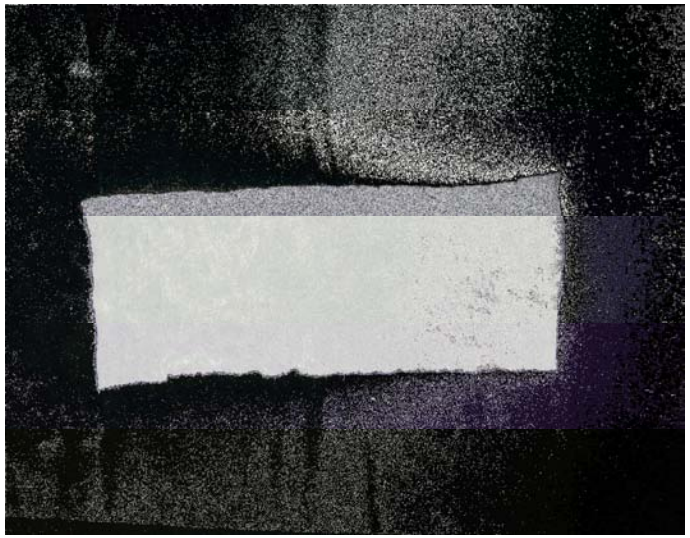
Results of Dispersion Testing

60% Viloft Nonwoven 40% PES



After 2 turns

60% Viloft Nonwoven 40% PES



After 50 turns

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Sewage Treatment

- Several studies have been conducted by Kelheim Fibres (Courtaulds) to assess the biodegradability of rayon products in sewage treatment.
- To achieve this, the samples were individually packaged and placed into an anaerobic digester at a sewage farm.
- Stoke Bardolph sewage farm was chosen because it deals with domestic waste, the environment where most rayon related products can be found in the UK.
- For other countries, e.g. USA alternative methods of disposal are used (septic tanks) and hence these results may not be wholly applicable.

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Sewage Treatment

Samples were retrieved at intervals
of 2, 6, 10, 14 and 21 days
and weighed to determine the % weight loss.
The results are tabulated below.

Fibre Type	After 2 Days	After 6 Days	After 10 Days	After 14 Days	After 21 Days
100%Galaxy	18.3%	81.3%	90.1%	95.7%	98.4%
100% Rayon	20.5%	88.2%	93.3%	96.5%	97.5%
100% Cotton	9.3%	71.9%	90.4%	94.5%	97.3%

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Sewage Treatment - Conclusions

- Rayon fibers degrade completely within 8 days in a typical sewage farm anaerobic digester, where the residence cycle is about 20 days.
- The synthetic fibers tested in comparison show slight reductions in tensile strength after 12 weeks in an anaerobic digester. Similar results would be obtained in septic tanks.
- Rayon degrades faster than cotton due to its lower crystallinity, though the rate of degradation is dependent on the surface area available for attack.

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In conclusion…

- Rayon is a highly versatile raw material offering the key properties of sustainability and biodegradability
- The versatility of rayon fibers make them ideal in helping nonwovens manufacturers meet the challenges of the wipes market
- Kelheim Fibres is unique in its ability to develop and produce rayon fibers with enhanced properties

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When can we talk about your requirements for the future of wipes?

Thank you for your attention.

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