# Introduction to the modification of Natural Fibres

- The modification of natural fibres has been proven by many organisations, including ourselves at Adtech Ltd & Acetylated Fibres Ltd.
- The batch processing of natural fibres in an autoclave, has proved not be commercially viable.
- We've recently developed a continuous process using either maleic or acetic anhydride.

# Environmental Impact

- The manufacture of glass fibre uses high temperatures, adding significantly to the emission of CO2.
- The volume of glass used in composites is estimated to be 4.5 million tons per annum worldwide, representing an annual production of atmospheric CO2 of 3.5 million tonnes (0.77kg per kg).
- With modified natural fibres, the figure would be 0.075 per kg of atmospheric CO2 kg - A tenth of the CO2.

# Modified Natural Fibres Advantages:

- **Improved hydrophobicity by 50%**
- **Also oleophillic**
- **After 8 days exposure to 95% humidity:**

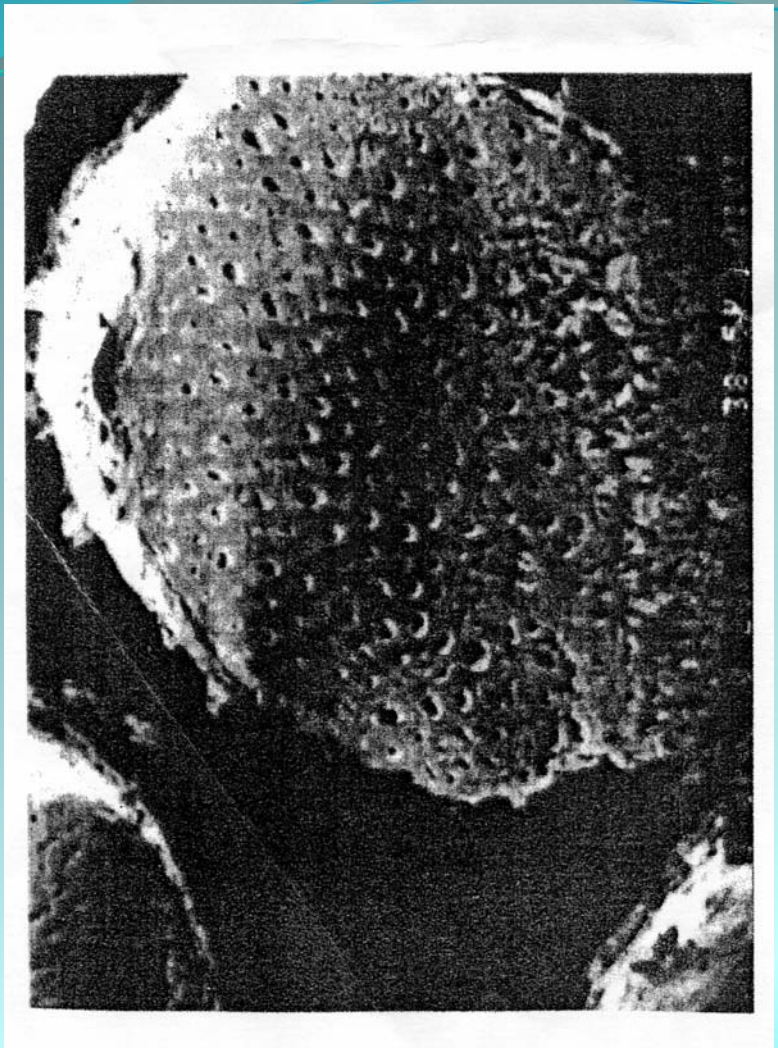
The weight of untreated flax felt increased by 25%.

The weight of modified flax felt increased by 13%.

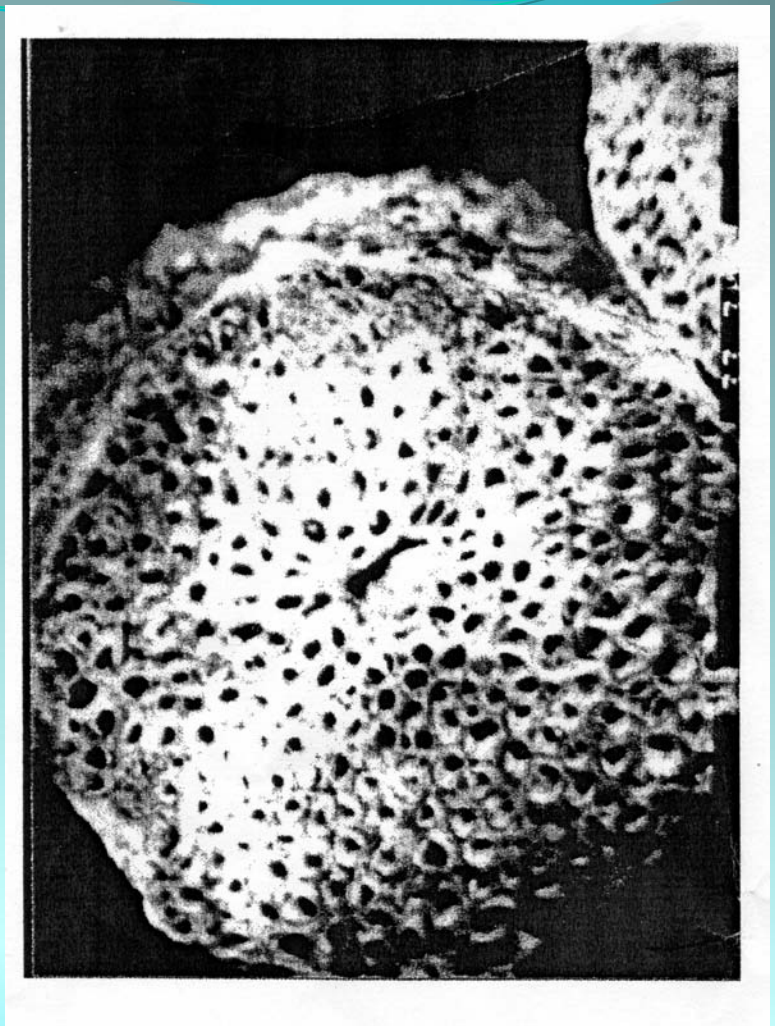
- **Tensile strength:**

Untreated flax fibre felt 50mm width – 0.43 N/sq mm.

Modified flax fibre felt 50mm width – 1.21 N/sq mm.

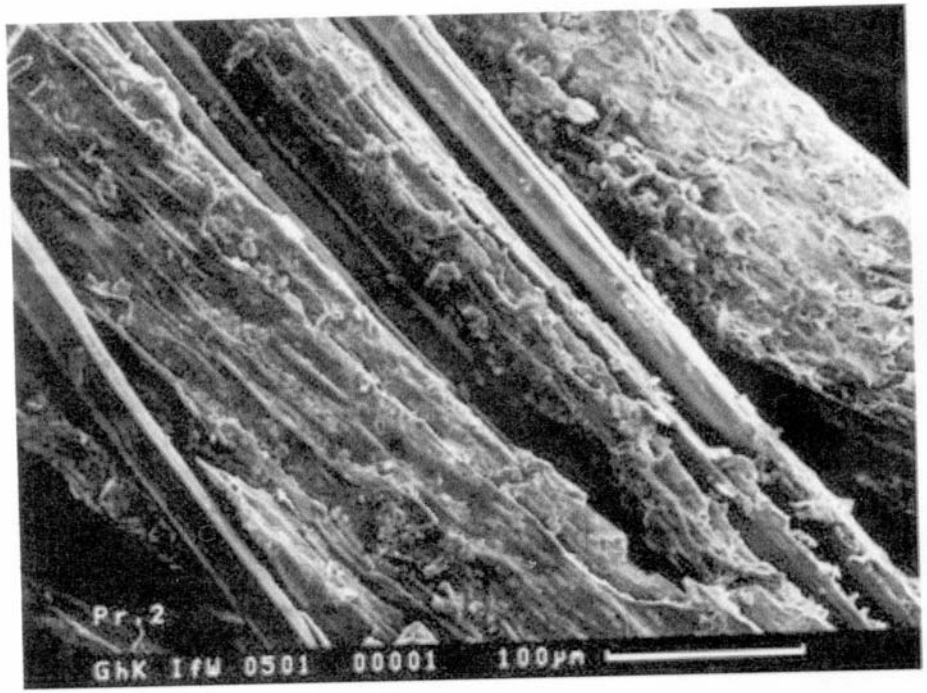


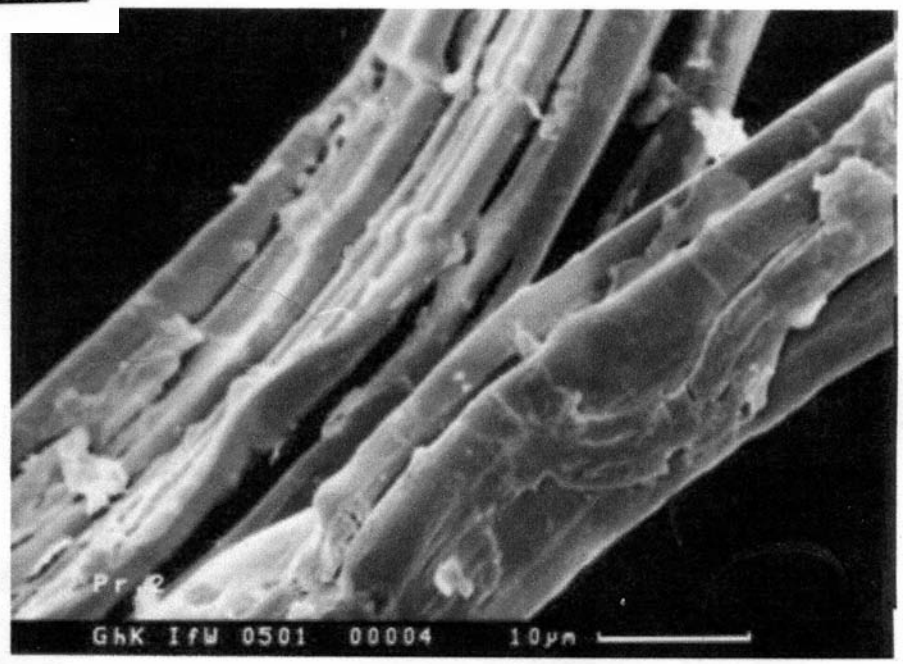
Before Acetylation



After Acetylation

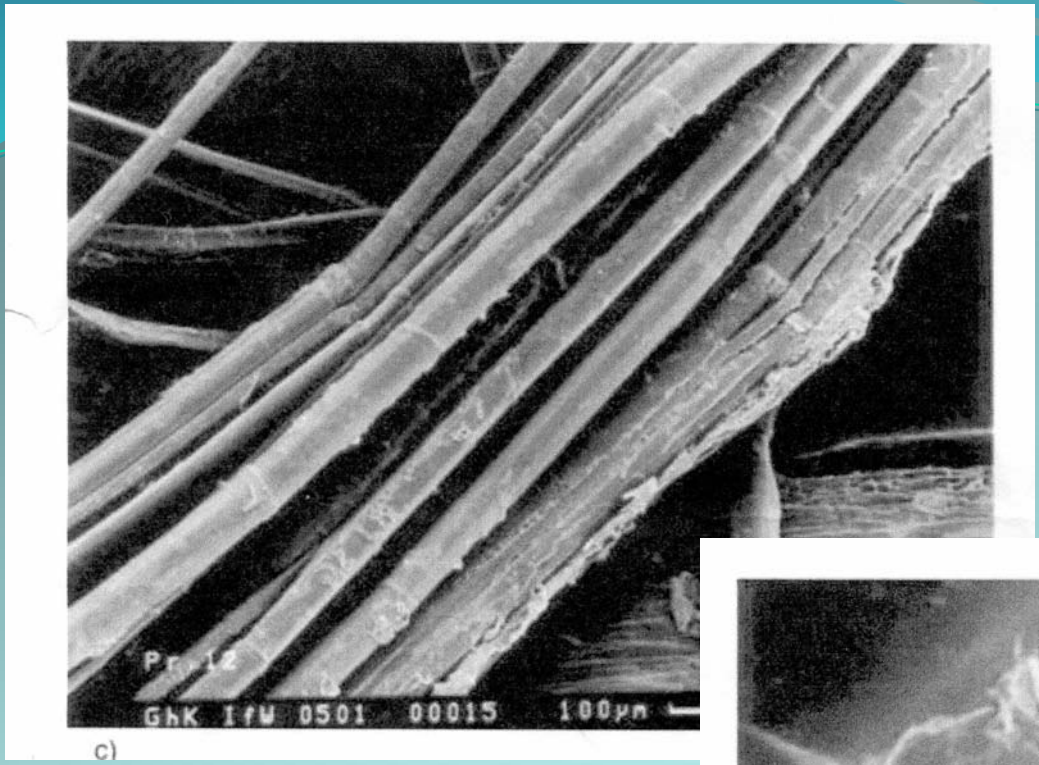
Pictures by Adtech Ltd




Unmodified Natural Fibres

Pictures by Bledzki, Kassel University

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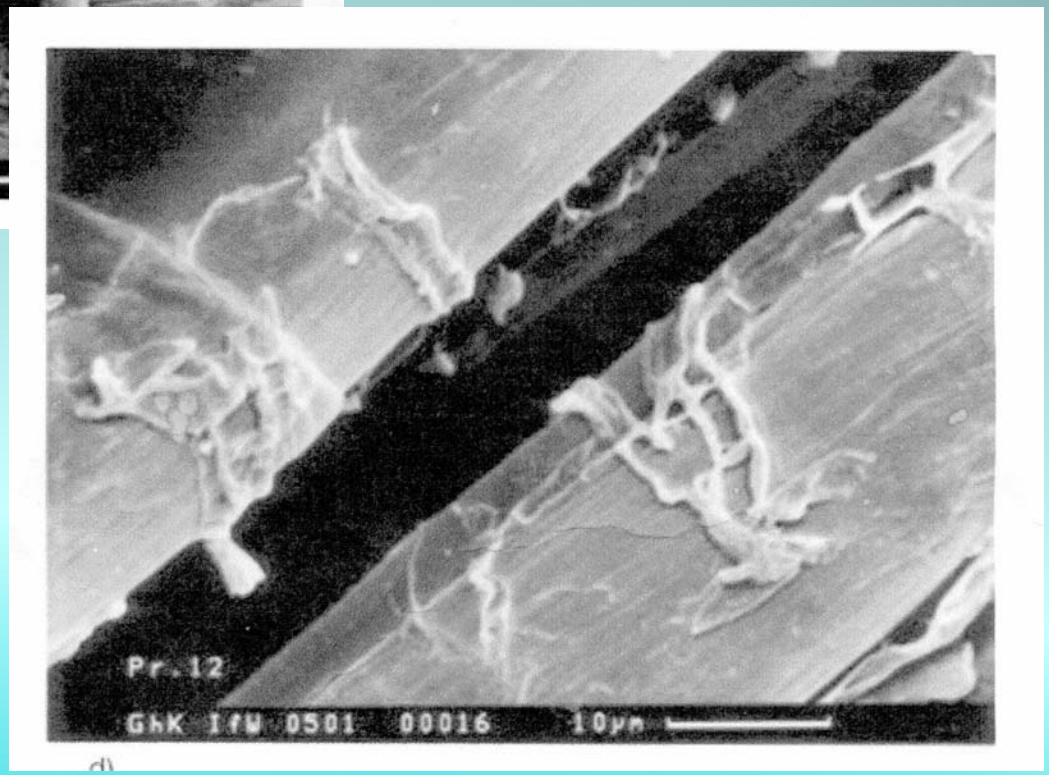
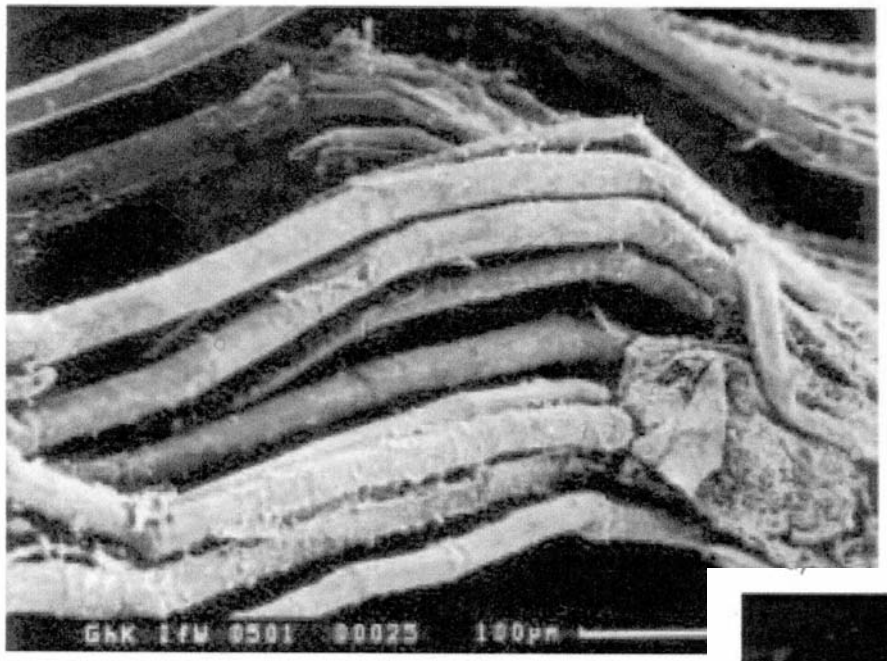



d)

Acetylated Straightened Fibres

18% Acetylation

Pictures by Bledzki, Kassel University

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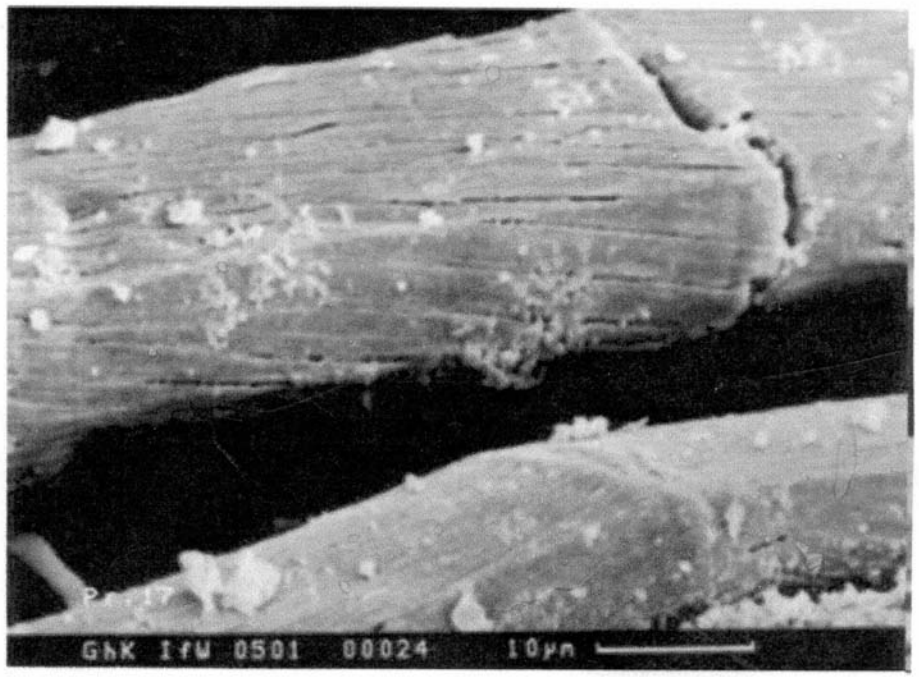



f)

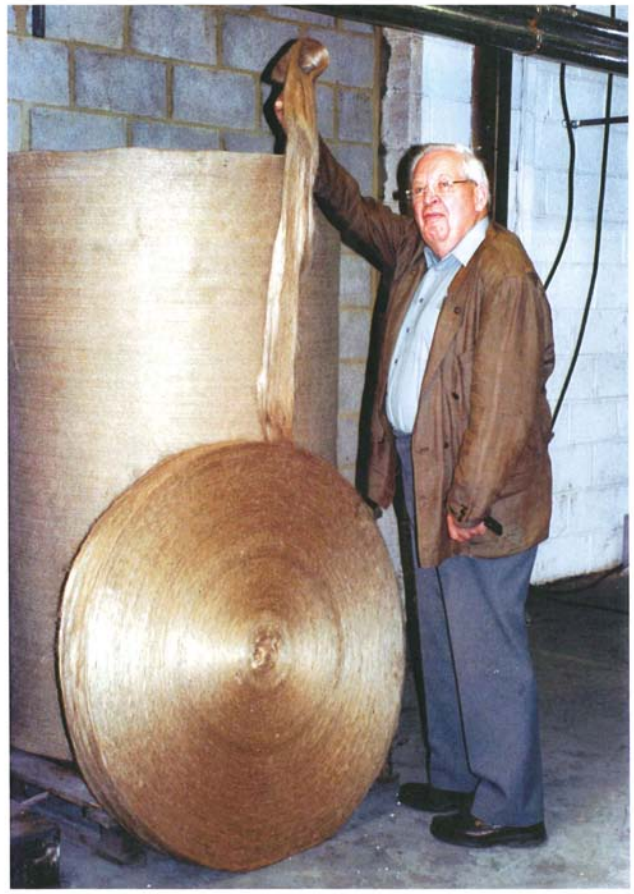
Ruined Fibres at 25% Acetylation

Pictures by Bledzki, Kassel University

# The Process

- The fibres are modified using our continuous patented process by creating a chemical reaction with an anhydride.

- The natural fibres are needled into felt for ease of fitting into moulds. They can also be put into a yarn format for pultrusion or in sliver format for chopping to extrude into thermoplastics.



# The Feedstock

- Any material source of cellulose fibre can be used.
- Most natural fibres are suitable for acetylation.
- We have acetylated coir, jute, linseed, hemp, palm oil fibre and wheat straw. The latter was very brittle.

# Comparison of Glass and Natural Fibre Properties

| | Glass Fibre | Natural Fibre |
|---|---|---|
| Density g/cm$^3$ | 2.54 | 1.10 |
| Tensile Modulus - MPa | 70,000 | 55,000 |
| Specific Tensile Modulus - MPa | 27,500 | 50,000 |
| Tensile Strength - MPa | 3,000 | 1,200 |
| Specific Tensile Strength - MPa | 1,180 | 1,100 |

Specific strength relates actual strength to density (specific gravity). So, actual measured strength is divided by the density of the material (in our case, a composite).

# Comparison of Acetylated Jute with Glass Fibre in Composites

| | Glass Fibre | Acetylated Jute |
|---|---|---|
| Break Strength MPa | 42 - 45 | 40 - 45 |
| Flexural Modulus (Stiffness) MPa | 3,300 – 3,800 | 3,300 – 4,000 |

# Evaluation of Chopped Fibres in Thermoplastic Resins

| | Flexural Strength (MPa) | Flexural Modulus (MPa) |
|---|---|---|
| Polypropylene (pp) | 44 | 1,300 |
| pp + 40% weight acylated jute | 69 | 5,350 |
| pp + 50% weight acylated jute | 67 | 6,280 |

# The Market

# The Market

The target market for modified natural fibres is the composites industry. It is anticipated that natural fibres will replace or at least compliment the traditionally used glass fibre, especially where weight of components is a major consideration.

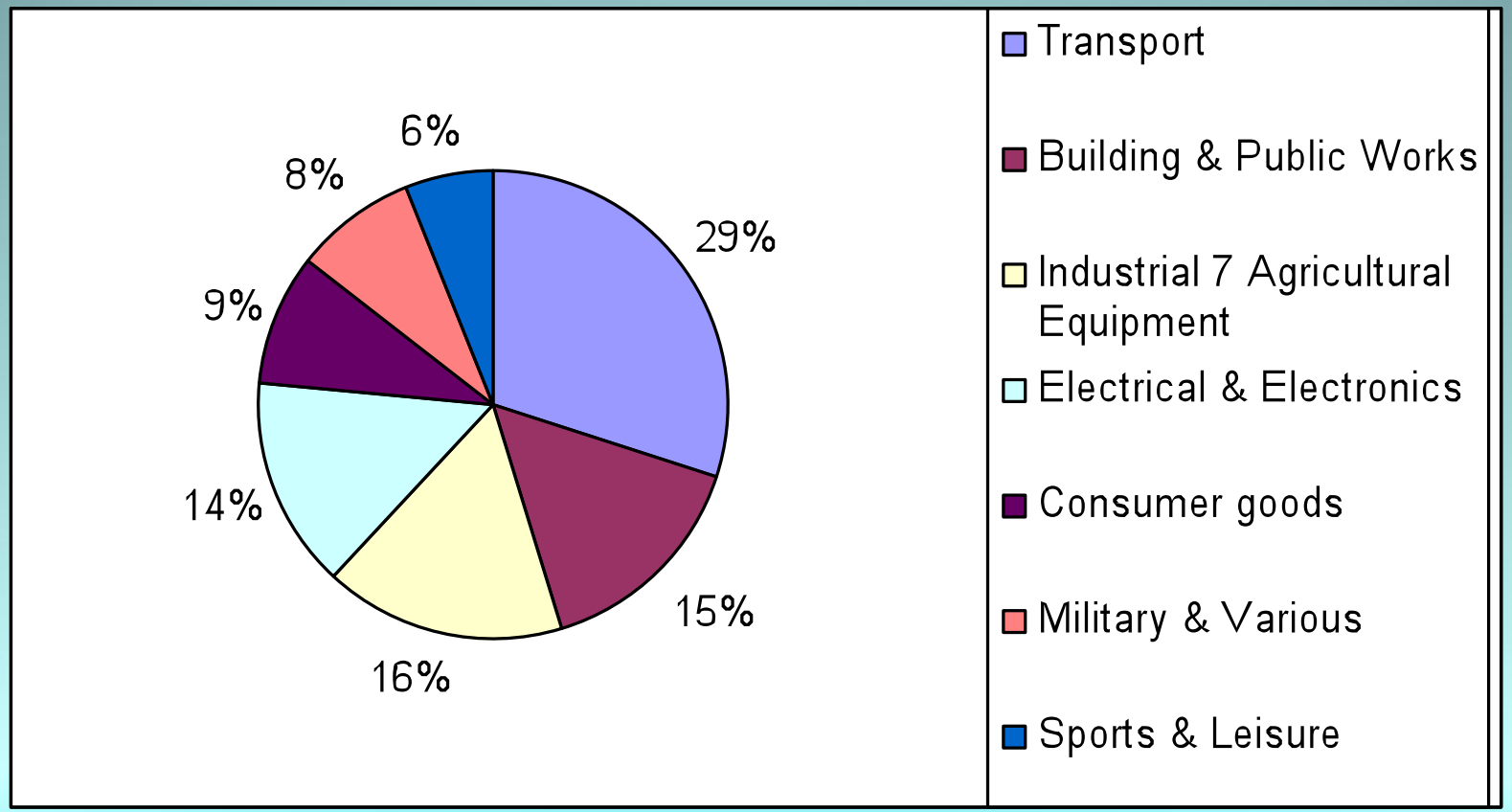
We have had recent enquires for the production of wind turbine blades. Additionally, we've had enquires from Ford, Nissan, Fiat & Land Rover in the automotive industry and New Rail (UK) regarding the construction of high-speed trains.

# The Market Size

**The market size for glass fibre:**

- **The estimated global composites market at over 4.5 million tonnes.**
- **Worldwide growth rate of approx 6%.**
- **European Growth rate approx 10%.**

# Glass Fibre Market by Sector



# Investment

- Michael Carus (Nova-Institute) points out the lack of investment in the natural fibres industry, considering there is huge investment being made in the bioenergy and biofuels industries.

- It has taken Acetylated Fibres Ltd 10 years to get to this point with little support from the EU.

- Any organisation/company dealing with natural fibres can increase their selling price four-fold by utilising the acetylation process to replace glass fibre. This is because we supply double the volume of natural fibre, with equal physical properties.

## The Feed Stock

There is an abundance of natural fibre available throughout the world

## The Modification

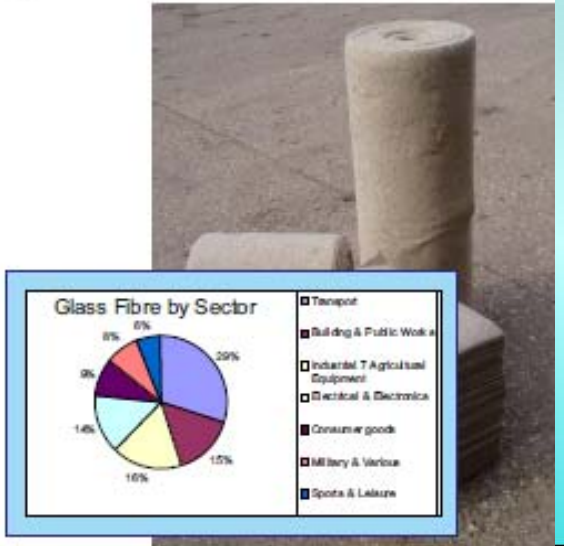
A simple process is used to change the chemical structure of the cellulose.
This makes the fibre hydrophobic.


## Why do we want to do this?

- Modified natural fibre is half the weight of glass fibre, therefore a car body made from natural fibre, weighs less than 66% of an identical car body made from glass fibre.
- The manufacture of glass fibre uses a massive amount of energy adding significantly to the emission of CO2 into the atmosphere.
- Natural fibre production absorbs CO2 while it grows and uses a fraction of the energy of glass fibre during the modification process.
- Natural fibre is a renewable product and many crops are grown for their fruit / seed and the fibre is thrown away.
- Modified natural fibre is as strong as glass fibre.

## The Market Place

Five million tons of glass fibre are used per year around the world. Acylated natural fibre can replace glass fibre in all sectors below.



# ACYLATED CELLULOSE FOR THE MANUFACTURE OF HIGH PERFORMANCE COMPOSITES

Brian Chandler

AFL
ACETYLATED FIBRES LTD

## Project's Achievements

A continuous method for the production of acylated cellulose fibres has been developed


## Project Summary

The project has produced hydrophobic acylated natural fibres from UK-grown crops to replace glass fibre. The treated fibre has half the weight of glass, but gives the same physical properties in a composite. End of life disposal problems are also avoided and in some cases, waste. (e.g. flax seed straw fibre), can be used.

## Project Work

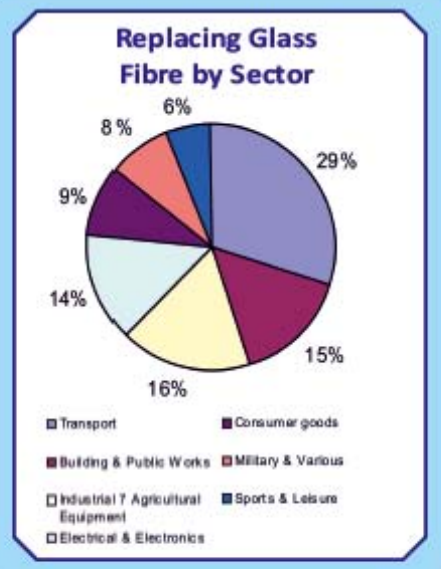
Treated fibre samples have been produced for technical and environmental assessment by project partners BRE. An overall concept for a continuous industrial process for fibre modification and a plant design have also been developed.

## Results

AFL have improved the tensile strength of fibre felt by 300%, made the fibre slightly hydrophobic and established that the acylation treatment makes the fibres oleophillic (giving potential for oil spill recovery). Modified natural fibre is as strong as glass fibre in a composite.

## Carbon Savings and Environmental Benefits

The manufacture of glass fibre uses high temperature processes, adding significantly to the emission of C02. However, natural fibre production absorbs C02 while it grows, uses a fraction of the energy of glass fibre production during the modification process and is a renewable resource. Many crops are grown for their fruit/seeds and fibre is a waste that is disposed of.




## Next Steps

To procure further investment to build a pilot plant as per designs developed through the project. The transport sector; (trains, cars and boats), is the biggest potential market through weight (and energy) savings.

## Contact

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The Technology Strategy Board is a business-led executive non-departmental public body, established by the Government. Its role is to promote and support research into development and exploitation of technology and innovation for the benefit of UK business, in order to increase economic growth and improve quality of life.
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