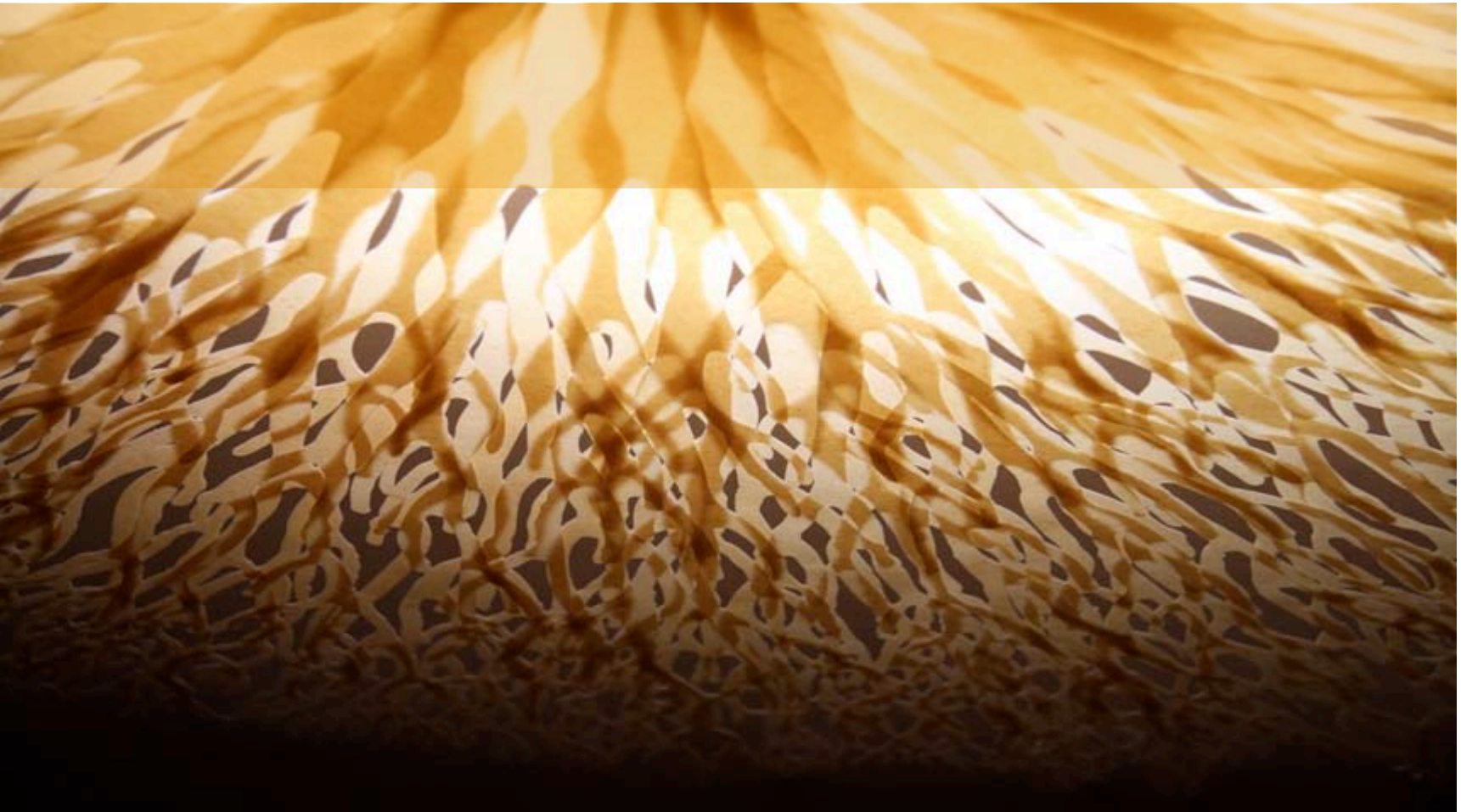


Overview Of Scion Research : Bioplastics

Alan Fernyhough, 20th October, 2011



Scion – who we are

NZ Forest Research Institute Ltd

- One of 8 Crown Research Institutes
- Established in 1947
- 44M NZD turnover
- 340 science and support staff
- Based primarily in Rotorua
 - Christchurch, Wellington and Auckland

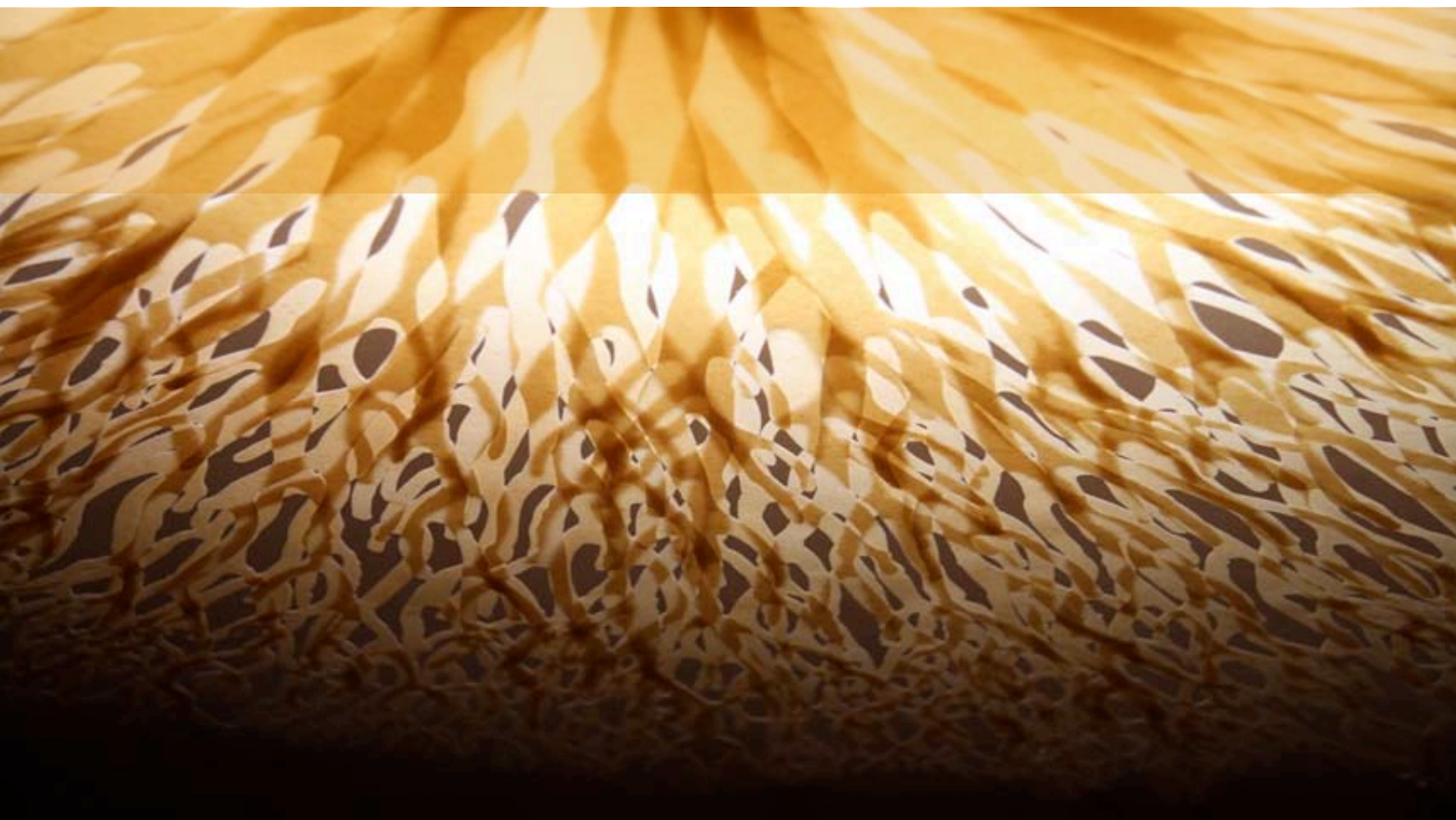


Scion – what we do

- Forestry skills transitioned to **bioeconomy** skills
- **Core Purpose:** *innovation & growth in ...forestry, wood & biomaterials*
- **Three Research Groups**
 - New Forests and Forest Science
(biosecurity, breeding programs, fire)
 - Sustainable Design
(environment, climate change, optimising land value, bioenergy)
 - **Manufacturing & Bioproduct Development (~80)**
 - *Polymers & Chemicals*
 - Wood & Fibres (inc. pulp/paper & packaging)
 - Biotransformations



Bioplastics Roadmap (Updated 2011) & Bioplastics Research at Scion



SCION BIOPLASTICS ROADMAP: PRIORITIES & OPPORTUNITIES

- **Enhanced exports for sectors using plastics (packaging or parts) - drawing on distinctive performance & lower footprint manufacturing technologies**
- **Support New Zealand manufacturers & primary exporters/brand owners in bioplastics and related materials technologies/expertise**

Outcome 1: New manufacturing and packaging technologies implemented for bioplastics & related biomaterials

Outcome 2: Increased NZ biomaterial content in exported plastic products

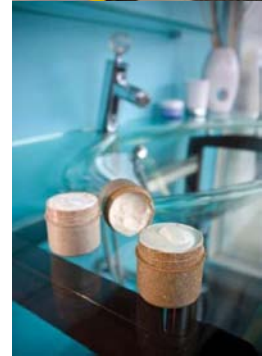
Outcome 3: Reduced materials/ manufacturing costs associated with new biomaterials

Outcome 4: NZ made biopolymer/chemical manufacturing demonstrated in plastics

Outcome 5: Scion maintained as an internationally recognised leading Centre of Expertise in integrated bioplastics technologies

Scion Bioplastics Research Summary

- **Make: new bio-monomers, polymers & additives**
 - Extractions (NZ resources)
 - Chemical reactions & polymerisations
 - Microbial polymerisations & gene technologies
 - *Biopolyesters* & precursors ...
 - Functional chemical/polymer additives
- **Modify: plastics for new performance**
 - Extrusion compounding & *reactive extrusion / processing*
 - Long wood fibres
 - Functionalised pulps & biomasses
 - Extractives/additives/polymers/minerals (*where feasible from NZ/above*)
- **Mould: demonstrator plastic products (testing/industry transfer)**
 - Injection Moulding / Extrusion
 - Thermoforming / Film
 - Foam
 - (Rotational Moulding)



Scion Bioplastics Research Summary

Make – Modify - Mould

Example NZ biomasses & waste streams

- **Wood & Forestry Processes**
- **Pine Bark**
- **Other NZ Natural Fibres/Biomasses**
- **Other NZ Natural Extractives**
- **NZ Processing Waste Streams**
- **NZ Minerals**



Scion – Bioplastics Research

Three Example Commercial Developments

using functionalised “biomasses”

1. *BioPeg* : Controllably Degradable Bioplastics
2. *KiwiPlast* : Bioplastics From Fruit Waste
3. *LignoMaxx*® : Lignotech STEX Functional Additives

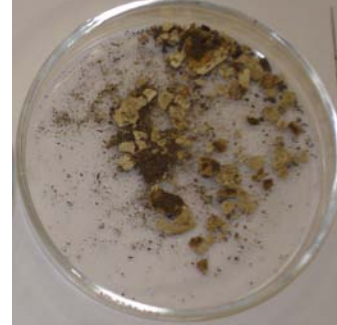
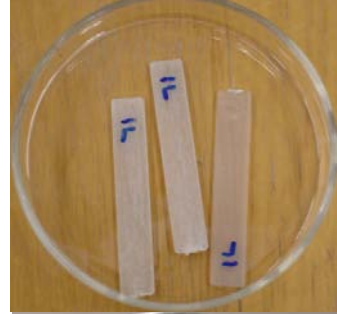
1. Controllably Degradable Bioplastics

- **The Technology?**

- Biomass modified bioplastics
 - Compatibilised / stabilised forestry residues
 - Plastics processability & stability
 - Mechanical integrity
 - Differential degradation rates

- **Demonstration Product/Process**

- Specific 1st Application: Erosion Control Peg
 - Two component design by Mulford
 - Replaces steel or ABS
 - Natural, renewable and *degradable* materials
 - Tough enough to be hit with a hammer



1. Controllably Degradable Bioplastics: Commercialisation

▪ Status

- Compounded via Clariant *under license*
- Biopegs moulded by Mulford (Ludowici)
- Biopegs marketed by Maccaferri Plastics

▪ What's new ? / Future

- Wider synergistic applications
 - “Safely degradable”
 - Tree protectors, plant pots,.....
 - Water/marine applications
- Controlled release of actives
 - Horticulture
 - Animal health / Vet.



1. Further New Products: Biomass Modified Bioplastics: Recyclable, Compostable Cosmetics Pot



- Biobased and natural
- NZ resources
- Heat resistant PLA base
- Tolerant to hot-fill oils, waxes

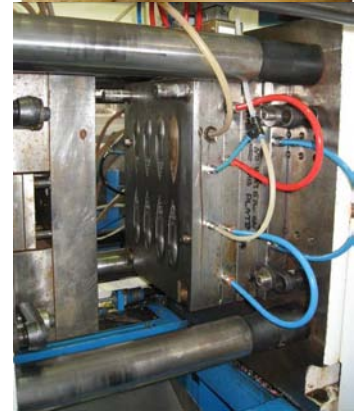
2. KiwiPlast: Bioplastic Products from Fruit Wastes

▪ The Technology?

- Processed fruit waste biomass-bioplastic
 - Compatibilised / stabilised
 - Effective full utilisation of *whole* fruit waste/residues
 - Plastics processability / stability
 - Mechanical integrity

▪ Demonstration Product/Process

- Specific 1st Application: Zespri Spife
 - Existing polystyrene spife
 - Natural, renewable: kiwifruit residue derived
 - End-of-Life compostable



2. KiwiPlast - Commercialisation

- **Status**
 - Commercial processing-compounding (Scion & industry)
 - Injection moulding trials (Scion & industry)
 - Materials & processing logistics substantially addressed
 - Initial test marketing / consumer study
- **What's new? / Future**
 - New designs / similar products
 - Further testing
 - Wider synergistic applications
 - Packaging
 - Other applications & other biomass residues



2. New Bio-spifes: Manufacturing Trials



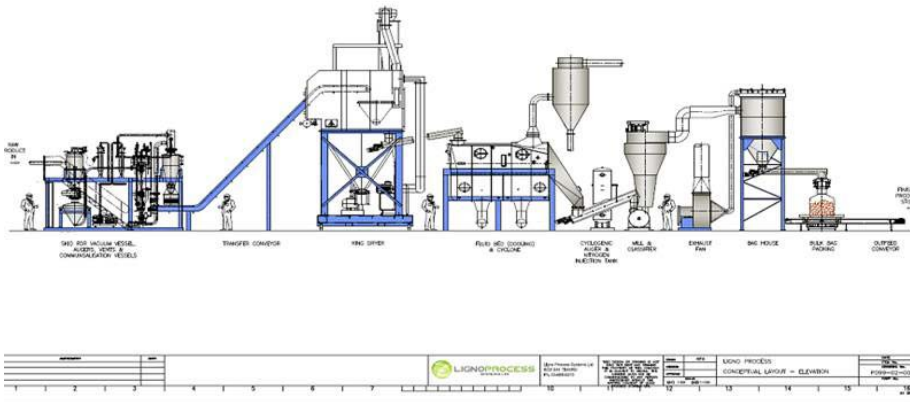
2. New Products & Further Manufacturing Trials: Packaging Film & Thermoformed Trays



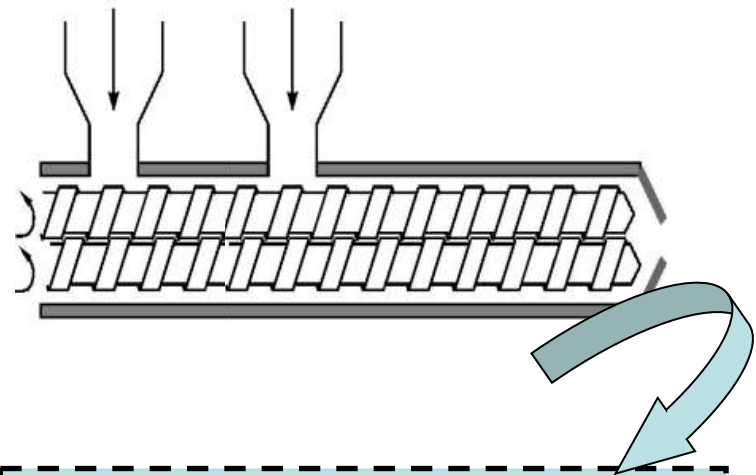
3. LignoMaxx Bio-additive for Plastics & Bioplastics

The Technology: Steam Explosion (STEX) of Biomass

Stage 1: Lignotech STEX Biomass Treatment



Stages 2 & 3: Modifications & Extrusion



Enhances (for biomass):

- Flow
- Reactivity
- Compatibility
- Functionality
- Uniformity/reproducibility

innovative, sustainable, plastically processable functional biomaterial – injection moulded etc

3. LignoMaxx: Pallet Trial (US): 40wt% STEX DDGS

Demonstration Product

- Applied to *DDGS (Dried Distillers Grains & Solubles)*
- By-product of US corn ethanol production
- Non-food source feedstock/readily available
- US Freight pallet

Status

- US National Composites Centre
- Passed tests/specifications (pallets)

What's new ? & Future

- Improved mouldability
- Further commercial trials
- Other products / biomasses
- Up-cycling plastics / recyclates

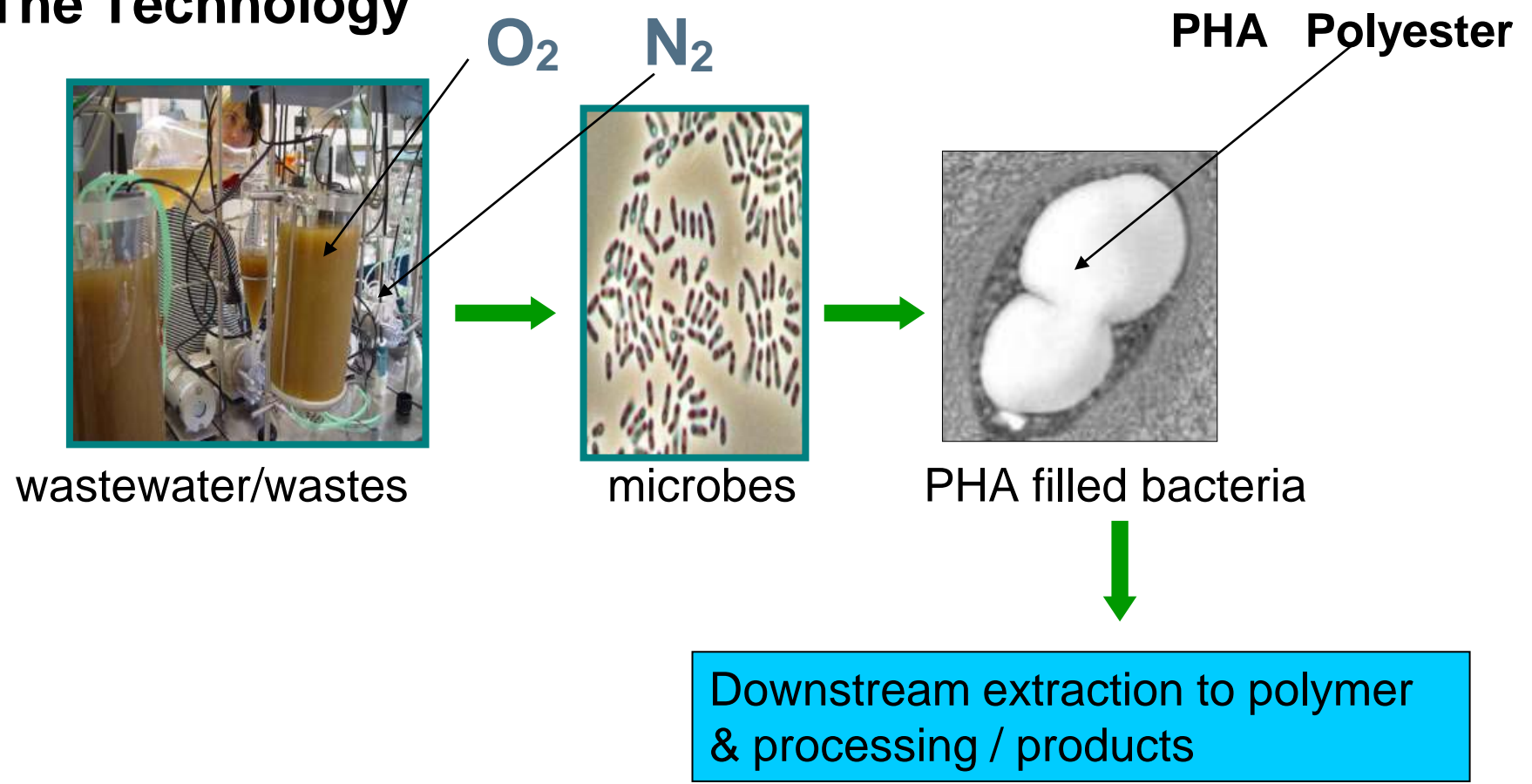


A photograph of a forest with tall, thin trees and moss on their trunks. The text is overlaid on a white rectangular box in the center of the image.

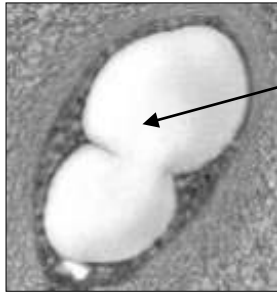
Examples of other Bioplastics Research

Microbial Bioplastics (PHAs) - from Biomass/Wastes

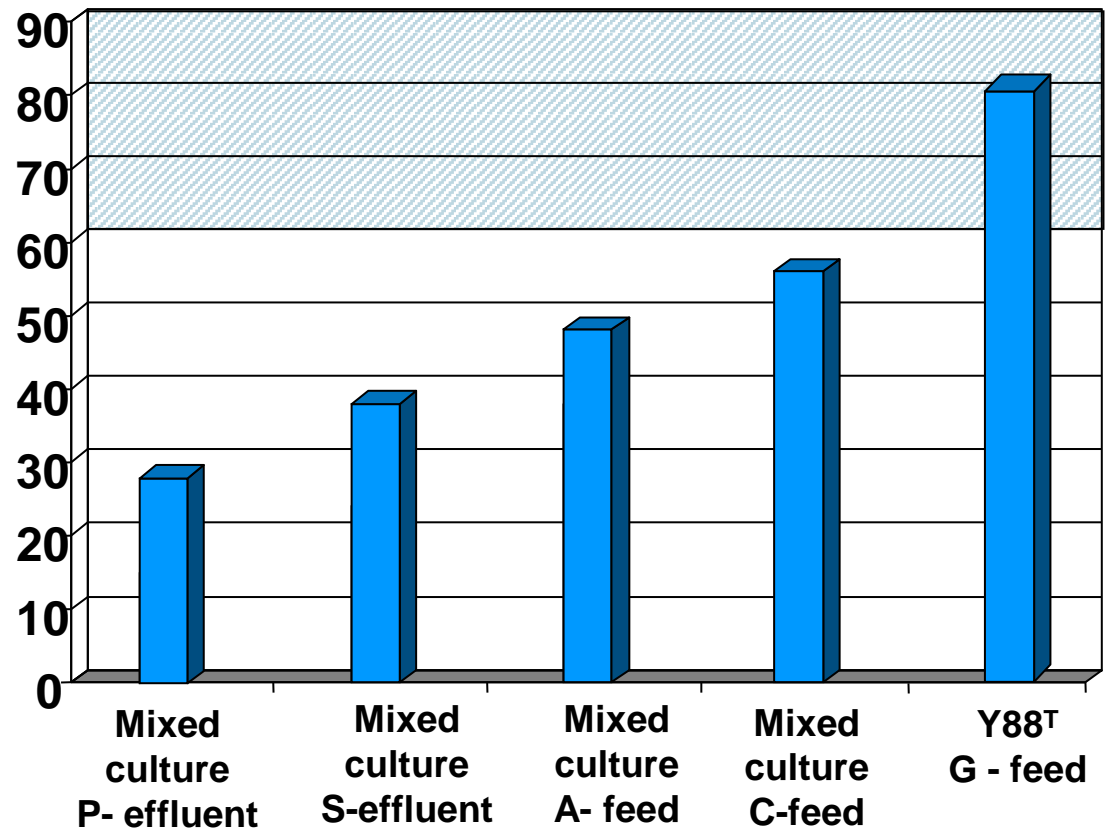
The Technology



What's new? / Future



% PHA



- **PHA Productivity**
- Various biomass/sugar feedstocks & wastes
- **Whole cell processing** : avoids expensive extraction
- Downstream integrated processing
- Continuous **scale-up production** & harvesting
- Modified/New PHA biopolymers - gene technologies

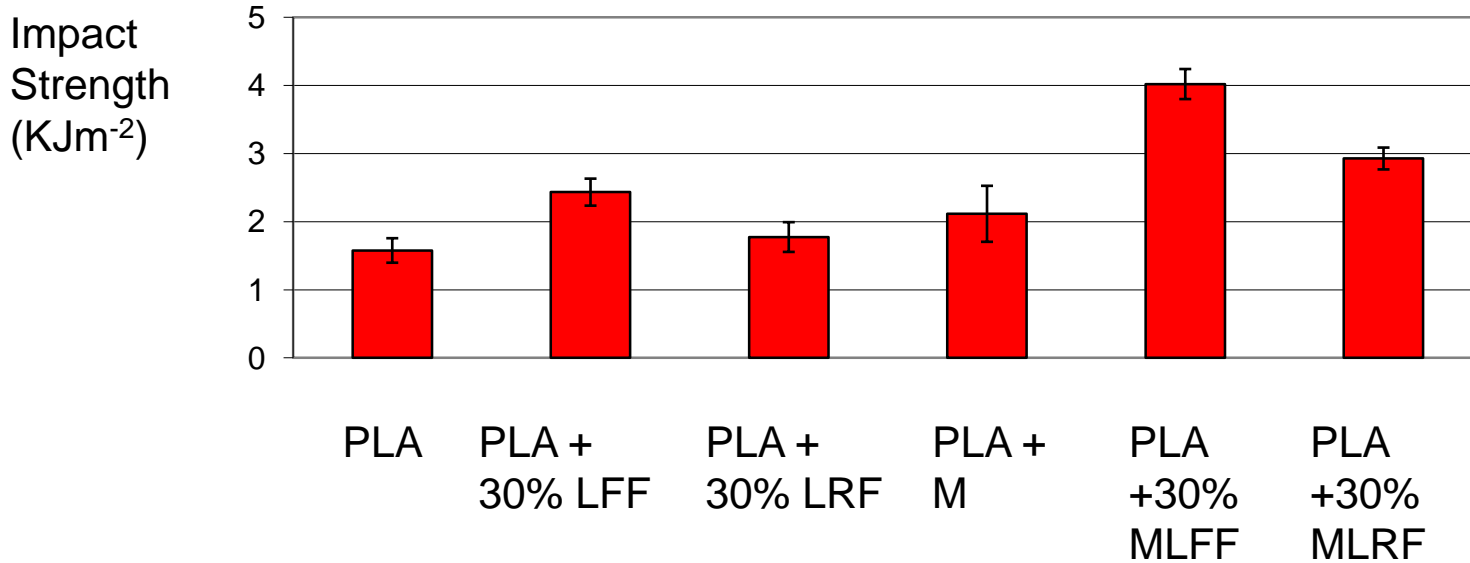
Waste To Gold

Pilot Plant: Waste to Energy (Scion-RDC)

Future: Scale Up / Adapt for Waste to Plastics?

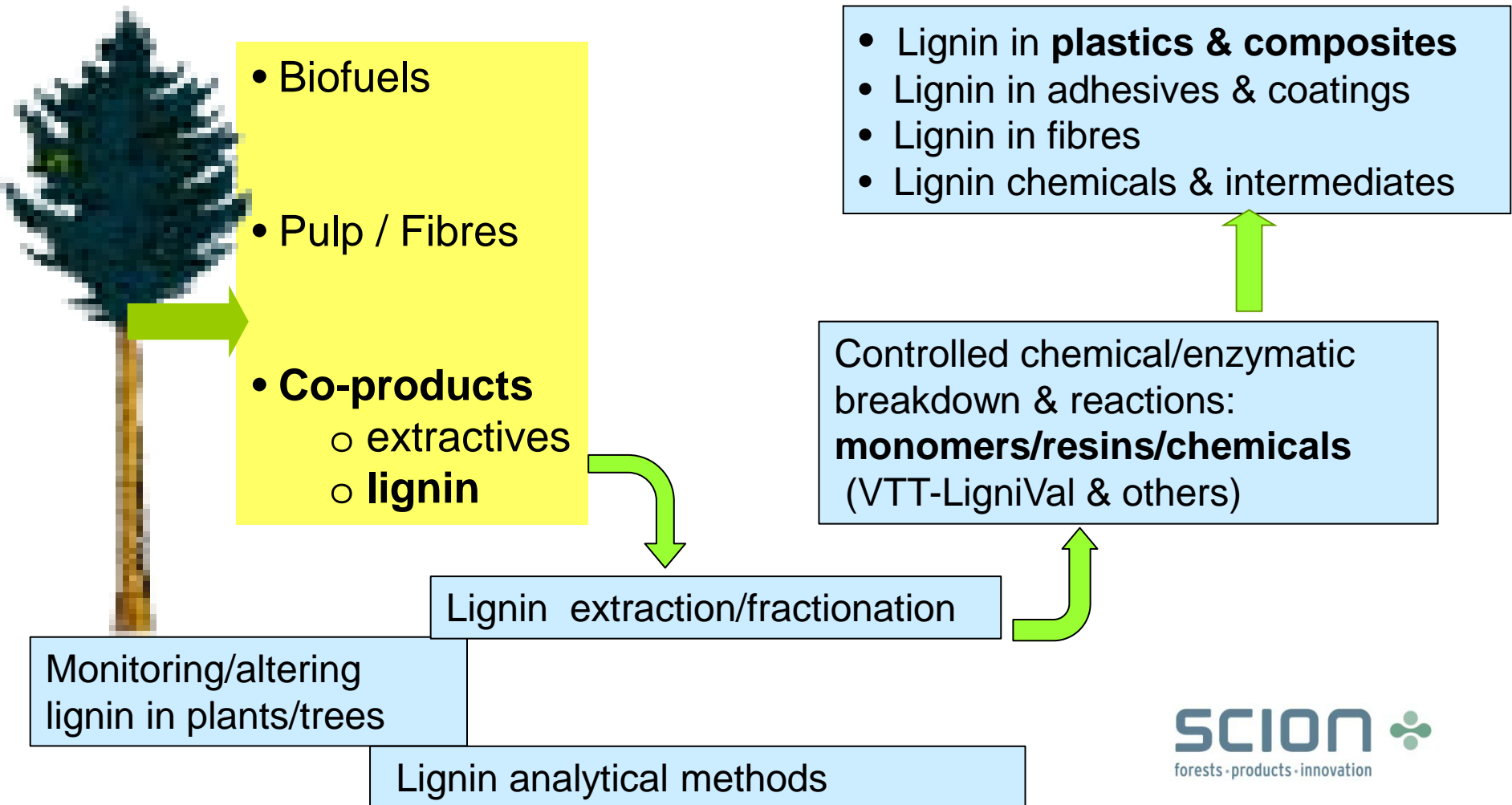


Long Fibres can improve Impact Strength of PLA

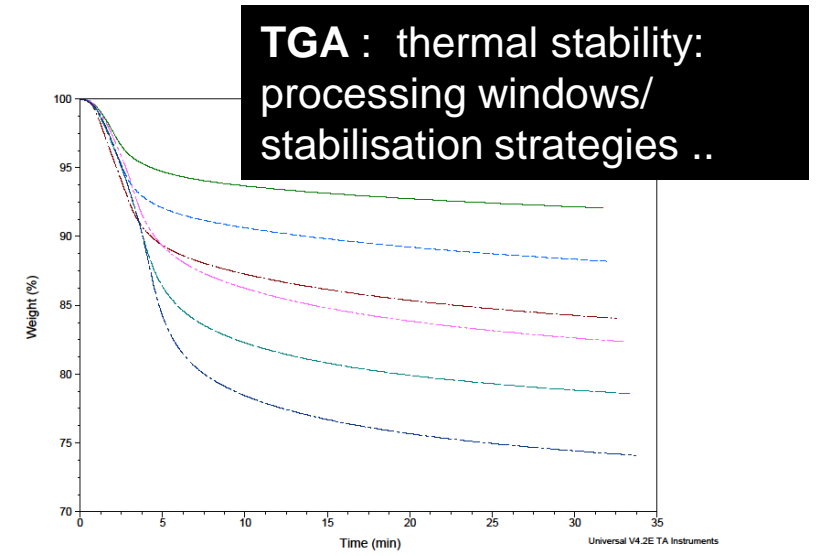
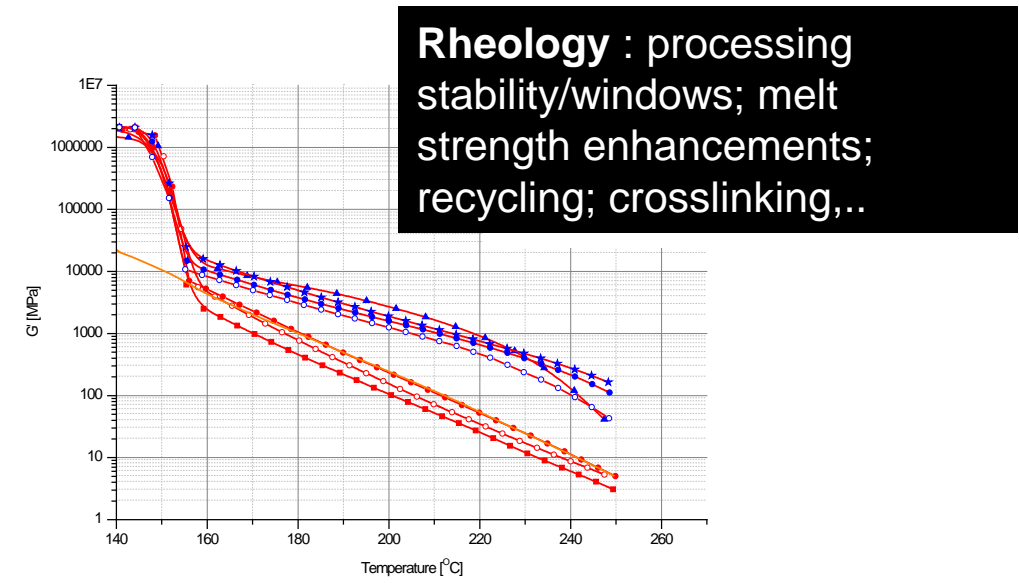
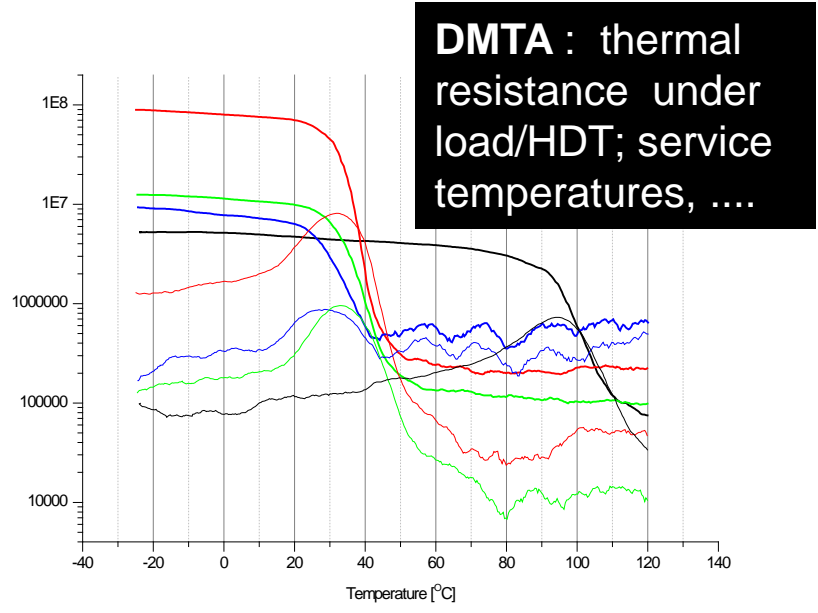
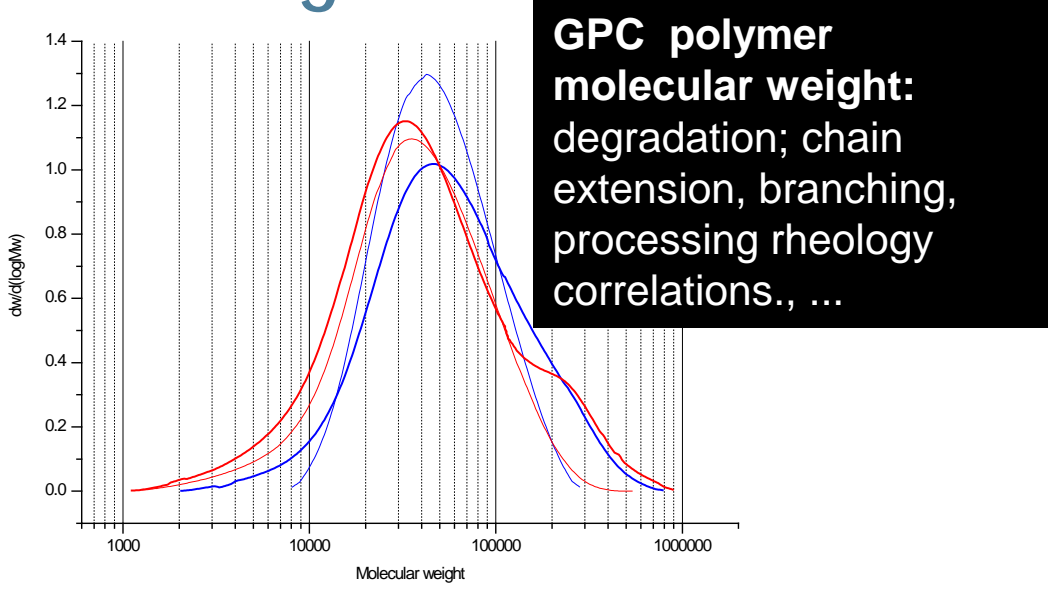


Lignin Research

for every 1 litre biofuel from wood ~1 kg of lignin is co-produced
replacing 10% of NZ's oil imports with softwood liquid biofuel could generate ~1 Mt lignin



Polymers, Biomasses, Extractives & Additives: Screening & Databases

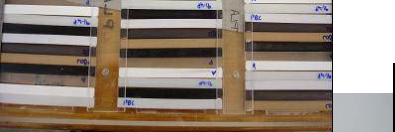


Polymers, Biomasses, Extractives & Additives: Screening & Databases

**FTIR, NMR, GC-,
LC-,MS,UV, ICP
,...: chemical
composition &
changes,....**

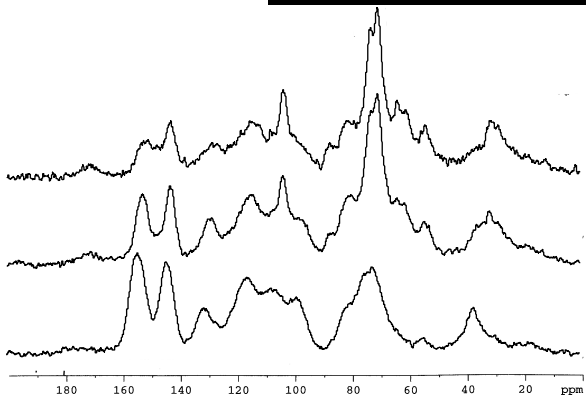


**UV /accelerated
weathering :**
degradation-durability;
colour; aging
effects/inhibition

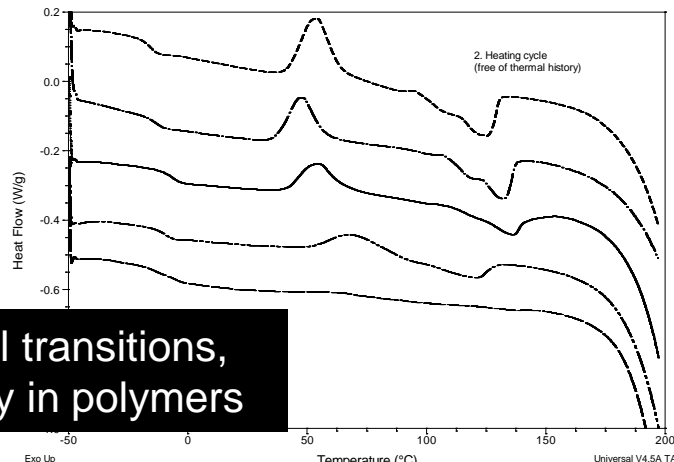
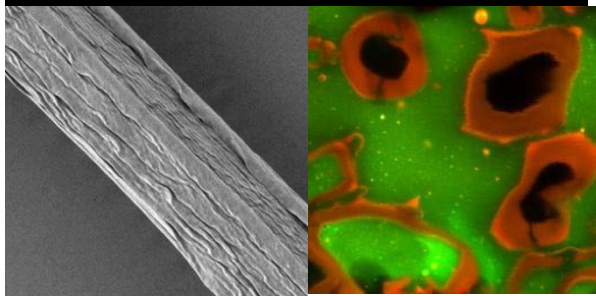


**Microbial/fungal
challenge/decay tests**
degradation-durability,

Solid State ¹³C NMR

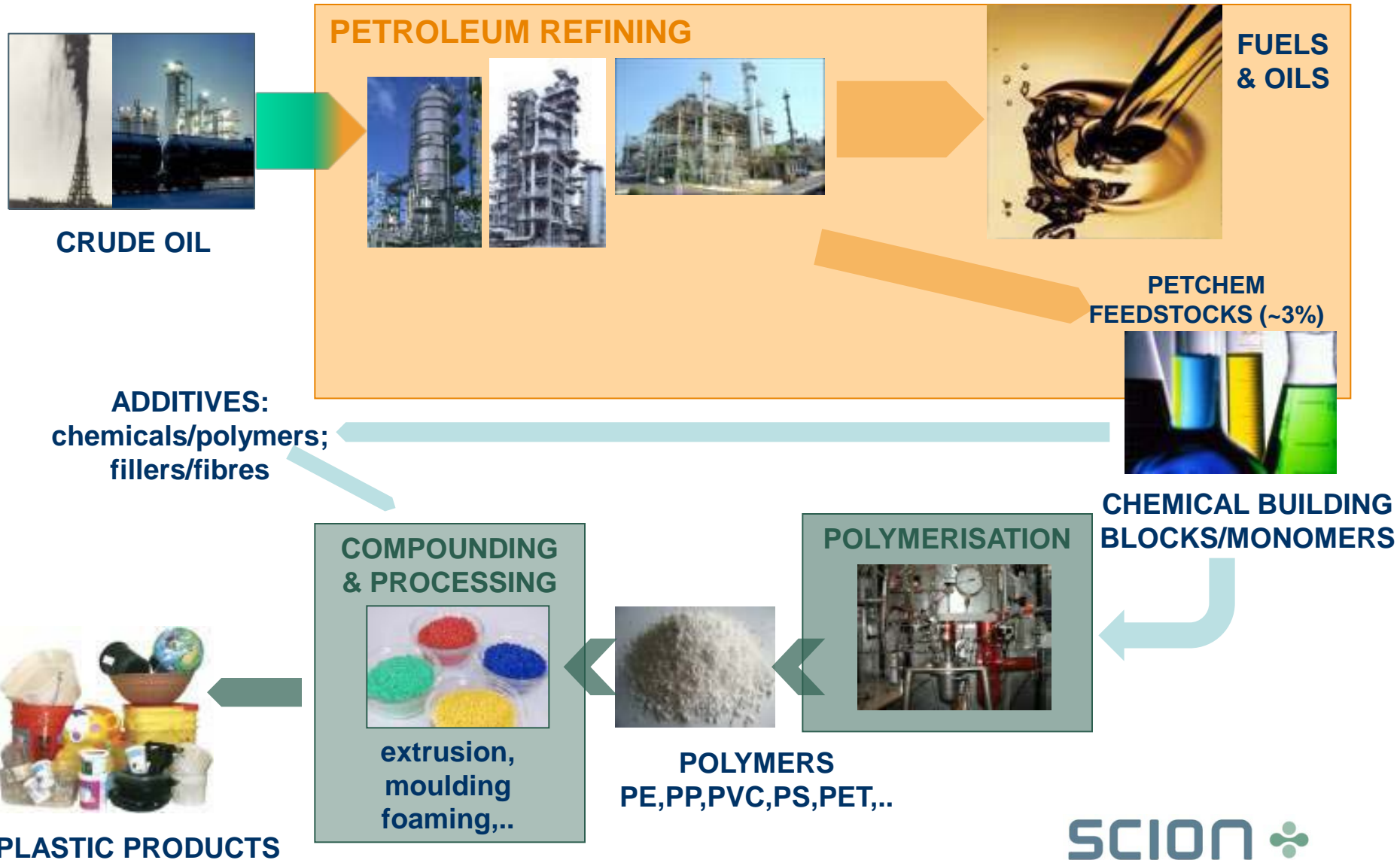


Microscopy: morphology
compatibility, dispersion, ..

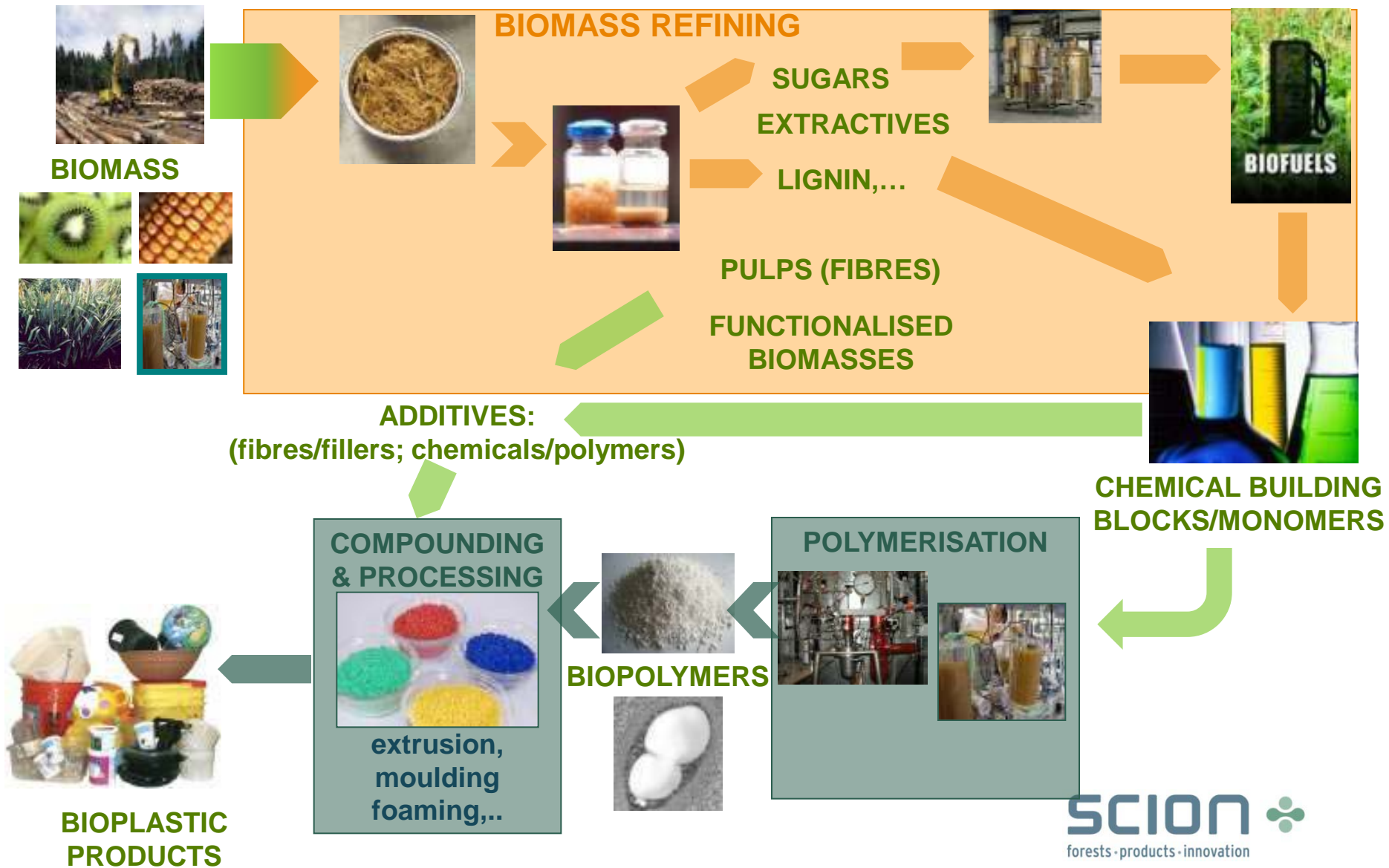


**DSC/MDSC – thermal transitions,
reactions & crystallinity in polymers**

Petroleum Fuels, Chemicals & Plastics



Biomass → BioFuels, BioChemicals & BioPlastics



Thank You

