Title: Refining of post-use materials

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Curriculum:
Edwin Keijzers (MSc) is a chemical process engineer, employed as scientist at Wageningen University and Research in the institute Food and Bio-based Research. Since 1997 he has led projects on the use of alternative raw materials for feed, fibre and energy applications. Projects include: development of a biorefinery based on fresh grass for feed, energy and materials, pre-treatment of grasses and straw for the production of bioethanol and bio-hydrogen by fermentation, use of hemp and agricultural waste materials as alternative fibres in paper, use of biobased fibres and glues in board materials (Banana, Straw, Reed, Coir), production of bio-composites of e.g. starch, PLA and natural fibres. The projects combine the technical development of the product and (small scale) processes with the general implication of the new use of raw (waste-) materials on durability, the environment and the community. Projects were performed in close contact with and (partly) funded by industry. Several projects resulted in ready to market and available products e.g. Dutch Cotton (a hemp based alternative for cotton security paper), a cardboard tomato container made from tomato leaves, pulp moulded products made from grass fibres and coir based panels.

Abstract:
In the shift towards a biobased and circular economy the role of lignocellulosic materials will increase. Besides virgin materials (Wood, Miscanthus, hemp), sidestreams (tomato stalks, grass), post-use fibrous materials will be more and more used as raw material. Currently some post-use fibrous materials are recycled to a large extent (e.g. paper), others are composted or used as energy source. The high purity of virgin raw materials contrasts sharply with some circular materials obtained from e.g. household wastes and sewage. Other circular sources, e.g. recycled paper are relatively pure. Already the fibre and cellulose based industries use both biobased and circular raw materials. However, traditionally, due to e.g. (food-)safety reasons there are only few industries that mix virgin and recycled materials. Chemical and mechanical processes developed to produce fibres and cellulose from virgin raw materials cannot be directly used to process circular raw materials because of the contaminations present. Examples of different projects to obtain fibres and cellulose from circular raw materials are given and an overview of the possible refining processes is shown.
Refining of post-use materials

Circular and Biobased Performance Materials Symposium

19-6-19, Edwin Keijser
Introduction

- Cellulose resource matrix
  - Fibre properties

- Recycling of fibres
  - Refining options

- Examples
  - Textile
  - Coffee cups and Beverage Cartons
  - Construction and Building materials
Chemical structure
Chemical and physical properties

- **Fibre dimensions**
  - Fibre length
  - Diameter
  - Lumen
  - Cell wall thickness

- **Cellulose properties**
  - cellulose fibre strength properties
  - microfibril orientation
  - density
  - polymerisation degree / Molecular mass distribution
  - swelling
  - solubility in alkali / ionic liquids

- **Cellulose quality parameters**
  - purity
  - DP
  - crystallinity / amorphous phase
Cellulose resources

Wood

Flax
Cellulose resources
Recycling

- Production
- Conversion
- Distribution
- Consumption

Recycle
ReManufacture
Revamp
Repair
Resale
Recycling/ Landfill

Paper Recycling Company

- Paper company (deinking)
  - 25% loss

- Paper company (cardboard)
  - 0% loss
  - 5% loss
Fibre recycling

Cotton (hemp/jute/flax) → Textile Fibre → Polymers → Fibre-Polymer composites

Wood (grasses, straw) → Cellulose → Virgin Fibre → Virgin paper product → Recycled paper product

Virgin Fibre → Textiles

Virgin Fibre → Chemicals

Recycled Fibers

Polymers → Fibre-Polymer composites → Road and Building Materials
Cellulose resource matrix
Upgrading / fractionation processes

- harvesting / storage and transport
- textile processing
- cleaning / screening

- mechanical pulp
- thermo-mechanical pulp
- Chemi-thermomechanical pulp
- kraft pulping
- sulphite pulping
- alkaline pulping
- organosolv pulping
- acetosolv pulping / MILOX

- steam explosion / ultrasonication
- hydrolysis (enzyme)
- pyrolysis / hydrothermal liquefaction / hydrogenation (HTU) / syngas
- activated carbon
- biopulping / white rot fungi

- viscose process
- lyocell process NNMO
- other processes ammonia / phosphoric acid
- ionic liquids
- nanocellulose
Textile recycling loop
Selective extraction of cotton from mixed textile
- Reduce EU dependency on virgin cotton fibre
- Increase circularity textile industry

Separate cotton from other polymer fractions
Beverage cartons and coffee cups

- Raw material: Virgin Fibres
- Use: Paper industry
  - NL: Hygiene paper
- Different collection systems
  - Prolonged pulping
  - Wet fractionation

Example of beverage carton
Beverage cartons and coffee cups

Milieu-impact van twee verwerkingsroutes voor warme drankenbekers
Vergisting en papierrecycling van karton-PLA koffiebekers, 2018
Tom Ligthart (TNO), Martien van den Oever (WFBR)
Examples of other possible uses

Schut Papier Jeans fibres

Ecor composite panel
Questions?