Design of fiber-based packaging for reduced microplastics generation in the recyclability process

KCL

Eva Sandås and Anu Kettunen

Demand on reducing packaging waste

- The aim of the PPWR that all packaging need to be recyclable in an economically viable way by 2030 puts demand on the design of packaging
- Design for recyclability means:
  - Limiting coatings, plastics, and additives that complicate fiber recovery
  - Minimizing non-fiber components like laminates, barrier layers, and adhesives
  - Innovation must ensure that functional features - *e.g.*, barriers for food protection - do not compromise recyclability

KCL

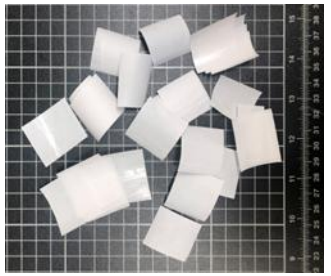
Barrier coatings that are considered recyclable

Coatings that either wash out, disperse, or cleanly separate during pulping without harming fiber quality, process water or mill operations.

- Water-dispersible/water-soluble coatings
  - certain dispersion coatings (Acrylic, SB, PVAc, PVOH) or modified biopolymers
- Repulpable barrier coatings
  - Must pass industry recyclability tests (*e.g.*, CEPI, PTS, or Aticelca methods)
- Minimizing coat weight and avoiding problematic materials
  - *e.g.* PE/PP laminates, or Aluminum foil - or combined these must be recycled separately as Poly-al
- Mono-material mindset

KCL

Design and development of recyclable packaging

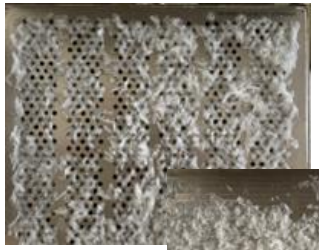


KCL can help in the development of recyclable packaging

- choice of materials
- development of base and coatings
- choice of adhesives
- scale ups from lab to industrial scale

Recycled packages and packaging material need to result in

- good quality recovered fibers
- limited accumulation of chemicals and fines in processing waters



but also

- limited or no accumulation of microplastics

KCL is a validated CEPI recyclability laboratory for testing packages and packaging materials. In addition, we also provide tailored testing in the development phase of your materials.

KCL

Microplastics vs. synthetic polymer microparticles (SPM)

Microplastics = discrete objects

- Composed of synthetic polymers or chemically modified natural polymers
- Within the size range
  - Microplastic particles (L and W ≤ 5 mm, L/W ≤ 3)
  - Microplastic fibres (L ≤ 15 mm, L/W ≥ 3)
- Nondegradable (Annex 15)
- Insoluble in water (≤ 2 g/l, Annex 16)

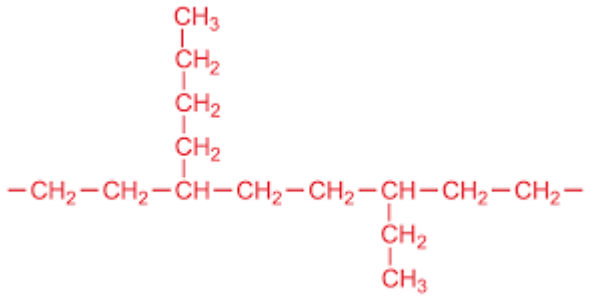
SPM = source of microplastics

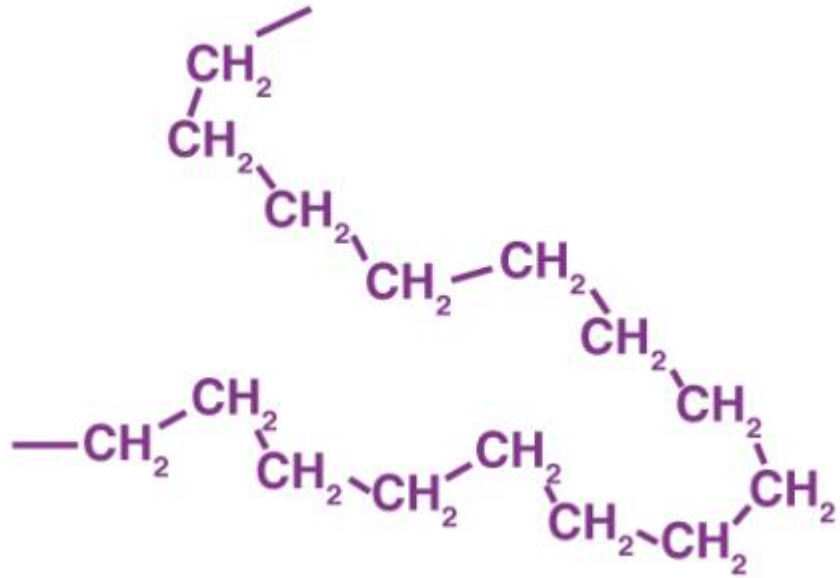
Current legislation implies reporting obligation in 2027 (of 2026 data) for sites intentionally adding SPM, but with the aim to reduce microplastic emissions to the environment with 30 % by 2030, new regulation is likely to emerge

KCL

Priority polymers and microplastics diversity

• PE (LDPE and HDPE)	polyethylene	$(C_2H_4)_n$
• PP	polypropylene	$(C_3H_6)_n$
• PET	polyethylene terephthalate	$(C_{10}H_8O_4)_n$
• PS	polystyrene	$(C_8H_8)_n$
• PVC	polyvinyl chloride	$(C_2H_3Cl)_n$
• PA	polyamide	$(C_7H_{12}N_2O_2)_n$
• PU	polyurethane	$(C_3H_8N_2O)_n$
• PMMA	polymethylmethacrylate	$(C_5H_8O_2)_n$
• PTFE	polytetrafluroethylene	$(C_2F_4)_n$
• PC	polycarbonate	$(C_5H_8O_2)_n$



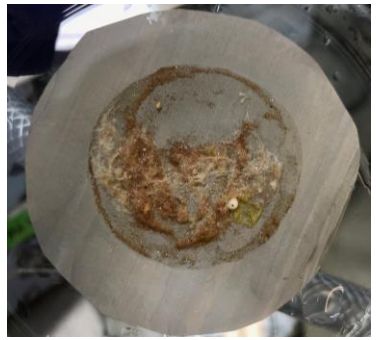


- PLA — polylactic acid
- POM — polyoxymethylene
- EVA — ethylene vinyl alcohol
- PVAc — polyvinyl acetate
- Other — biopolymers

KCL

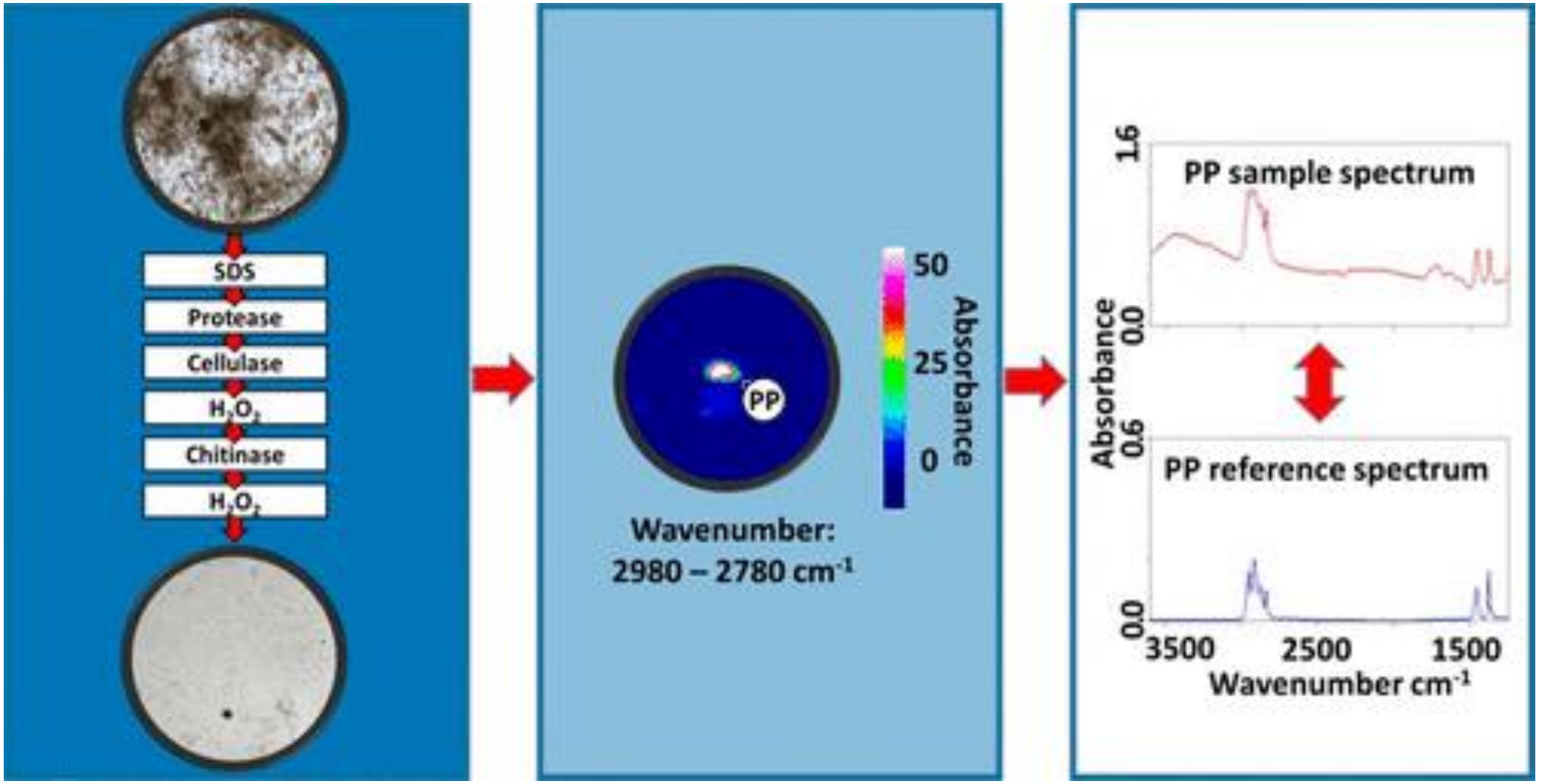
KCL RDI project on microplastic analytics

- Samples
  - Process samples, incoming and outgoing fluxes and end products from various clients
  - Sampling intervals, replicates, controls
  - Sampling protocol minimizing contamination
  - Sample pretreatment
- Collaboration with University of Eastern Finland
  - M.Sc. Thesis concentrating on positive and negative controls in industrial environment just about to start
- Partnership with Top Analytica, Turku
  - Quantification and identification with spectroscopic FTIR analysis
- Supported by Business Finland



KCL

Microplastic detection (Löder *et al*. 2017)



KCL

Löder, M.G.J., Imhof, H.K., Ladehoff, M., Löschel, L.A., Lorenz, C., Mintenig, S., Piehl, S., Primpke, S., Schrank, I., Laforsch, C., Gerdts, G. Enzymatic Purification of Microplastics in Environmental Samples. *Environ Sci and Technol*. 2017. 51:14283-14292.

From water samples to samples with high fibre

State-of-the-art laboratories are able to analyze

- Drinking water, river water, lake water, sea water
- Body fluids and tissues
- Soil samples
- (Sludge samples)

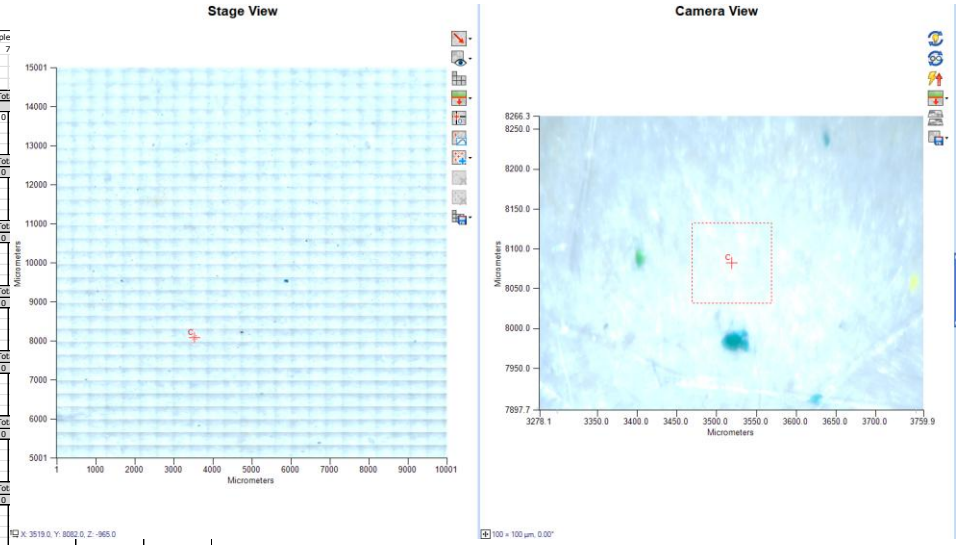
KCL recently developed a leading-edge capability of analyzing reliably samples with high fibre, such as recycled end product

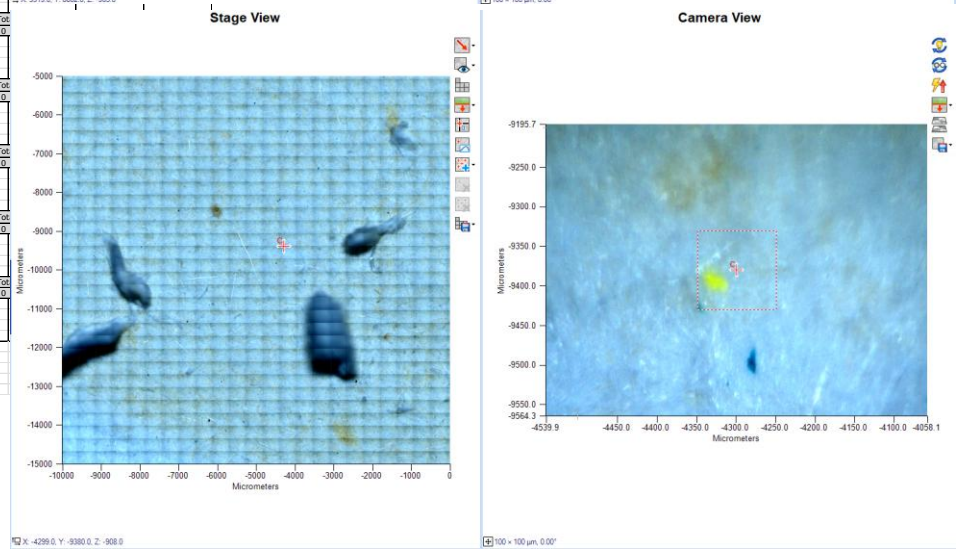
- Pretreatment essential for the protocol
- Ongoing finetuning for different samples types

KCL

Spectroscopic analysis with FTIR in ATR mode, calculation and identification of microplastic particles

Method: 1 g (d.m.) of pulp treated to remove wood-based material, the treated sample was filtered through fiberglass filter with a diameter of 4.7 cm The filter has been examined with a microscope connected to FTIR spectroscopy, particles identified using FTIR in ATR mode.		Sample Mass, g d.m.	Sample name 1		Sample name 2		Sample name 3		Sample name 4		Sample name 5		Sample name 6		Sample 7
SE = Standard error of mean			Average	SE	Average	SE	Average	SE	Average	SE	Average	SE	Average	SE	Average
Total number of microplastics	MP		Total MP		Total		Total		Total		Total		Total		Tot
	10 - 5000 µm = total amount														
	500-5000 µm		0	0	0	0	0	0	0	0	0	0	0	0	0
Size (µm)	100-500 µm	#/g d.m.													
	50-100 µm														
	10-50 µm														
Polyethylene	PE, both LPDE and HPDE	$(C_2H_4)_n$	Total PE, both LPDE and HPDE		Total		Total		Total		Total		Total		Tot
	10 - 5000 µm = total amount		0	0	0	0	0	0	0	0	0	0	0	0	0
	500-5000 µm														
Size (µm)	100-500 µm	#/g d.m.													
	50-100 µm														
	10-50 µm														
Polypropylene	PP	$(C_3H_6)_n$	Total PP		Total		Total		Total		Total		Total		Tot
	10 - 5000 µm = total amount		0	0	0	0	0	0	0	0	0	0	0	0	0
	500-5000 µm														
Size (µm)	100-500 µm	#/g d.m.													
	50-100 µm														
	10-50 µm														
Polyethylene terephthalate	PET	$(C_{10}H_8O_4)_n$	Total PET		Total		Total		Total		Total		Total		Tot
	10 - 5000 µm = total amount		0	0	0	0	0	0	0	0	0	0	0	0	0
	500-5000 µm														
Size (µm)	100-500 µm	#/g d.m.													
	50-100 µm														
	10-50 µm														
Polystyrene	PS	$(C_8H_8)_n$	Total PS		Total		Total		Total		Total		Total		Tot
	10 - 5000 µm = total amount		0	0	0	0	0	0	0	0	0	0	0	0	0
	500-5000 µm														
Size (µm)	100-500 µm	#/g d.m.													
	50-100 µm														
	10-50 µm														
Polyvinyl chloride	PVC	$(C_2H_3Cl)_n$	Total PVC		Total		Total		Total		Total		Total		Tot
	10 - 5000 µm = total amount		0	0	0	0	0	0	0	0	0	0	0	0	0
	500-5000 µm														
Size (µm)	100-500 µm	#/g d.m.													
	50-100 µm														
	10-50 µm														
Polyamide	PA	$(C_{12}H_{22}N_2O_2)_n$	Total PA		Total		Total		Total		Total		Total		Tot
	10 - 5000 µm = total amount		0	0	0	0	0	0	0	0	0	0	0	0	0
	500-5000 µm														
Size (µm)	100-500 µm	#/g d.m.													
	50-100 µm														
	10-50 µm														
Polyurethane	PU	$(C_3H_8N_2O)_n$	Total PU		Total		Total		Total		Total		Total		Tot
	10 - 5000 µm = total amount		0	0	0	0	0	0	0	0	0	0	0	0	0
	500-5000 µm														
Size (µm)	100-500 µm	#/g d.m.													
	50-100 µm														
	10-50 µm														
Poly(methyl methacrylate)	PMMA	$(C_5H_8O_2)_n$	Total PMMA		Total		Total		Total		Total		Total		Tot
	10 - 5000 µm = total amount		0	0	0	0	0	0	0	0	0	0	0	0	0
	500-5000 µm														
Size (µm)	100-500 µm	#/g d.m.													
	50-100 µm														
	10-50 µm														
Polytetrafluroethylene	PTFE	$(C_2F_4)_n$	Total PTFE		Total		Total		Total		Total		Total		Tot
	10 - 5000 µm = total amount		0	0	0	0	0	0	0	0	0	0	0	0	0
	500-5000 µm														
Size (µm)	100-500 µm	#/g d.m.													
	50-100 µm														
	10-50 µm														
Polycarbonate	PC	$(C_3H_4O_2)_n$	Total PC		Total		Total		Total		Total		Total		Tot
	10 - 5000 µm = total amount		0	0	0	0	0	0	0	0	0	0	0	0	0
	500-5000 µm														
Size (µm)	100-500 µm	#/g d.m.													
	50-100 µm														
	10-50 µm														
Other type of microplastics	Other		Total Other		Total		Total		Total		Total		Total		Tot
	10 - 5000 µm = total amount		0	0	0	0	0	0	0	0	0	0	0	0	0
	500-5000 µm														
Size (µm)	100-500 µm	#/g d.m.													
	50-100 µm														
	10-50 µm														
Arrival date	Date														
Date of sample processing	Date /														
Dates of FTIR analysis	dates /														
Approval:	Date / Anu Kettunen														





KCL

Take home message

- Validated CEPI recyclability testing of packing materials can be combined with microplastic analysis
- Microplastic analysis can be carried out from process waters, incoming and outgoing fluxes, sludges and end products, including samples with high fiber content
- Strategies to control and minimize microplastics can only be implied, when reliable measurements of microplastics are available

KCL

Thank you!

Contacts

Eva Sandås
eva.sandas@kcl.fi
+358 40 738 7842

Anu Kettunen
anu.kettunen@kcl.fi
+358 40 511 2144

www.kcl.fi