White Paper

Considerations for process, product and environmental fate testing of soluble bio-digestible barriers for paper and board packaging

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Considerations for process, product and environmental fate testing of soluble bio-digestible barriers for paper and board packaging

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There has been increasing interest in functional barrier coatings to design sustainable paper and board packaging which is recyclable within high volume recycling paper mills. Key areas of focus are water-soluble bio-digestible barrier coatings which facilitate fibre dispersion and recovery during the repulping process yet are biodegraded by the mill's anaerobic and aerobic activated sludge treatments as part of their intended use. These coatings offer potential to replace single-use plastics that are used in multi-material packs which impact negatively on paper circularity.

Introducing any new barrier material, including water-soluble bio-digestible barrier coatings, requires rigorous testing to ensure compatibility with the dynamic paper making process. Limited information is available to guide the selection of tests to develop this scientific evidence. Critical areas requiring validation include repulpability, extent of defiberisation and paper making potential of the fibre, impacts on wet end chemistry, potential for deposition, increased organic loading within process waters, effects on dry sheet properties and finally demonstration that the solubilised coating is mineralised and doesn't impact anaerobic digestion and aerobic activated sludge processes prior to effluent discharge.

This work seeks to apply a range of test methods to develop the scientific evidence to confirm the compatibility of water-soluble bio-digestible barrier coatings within high volume recycling mill processes. The study follows on from earlier work [1] and focusses on Hydropol, [2] a new water-soluble bio-digestible barrier polymer which can be adhesive or extrusion coated onto paper and brings oil and grease resistance together with high gas barrier. Hydropol is designed to solubilise at typical repulping temperatures and durations used by high volume recycling mills and has been shown to increase paper strength properties (tear, burst and tensile strength), and can be heat sealed for form, fill and seal fibre packaging applications.

The work identified that Hydropol extrusion-coated Recycled liner achieved 'Level A+ Recyclable with paper' when tested to the Italian National Recyclability Standard UNI 11743. Substitution of the Recycled liner with Hydropol coated Recycled liner at 5% and 10% w/w on fibre didn't affect key wet end chemistry parameters or dry sheet strength properties when compared to the uncoated control. Micro-colloidal particles and particles identified as stickies (0.1-100µm) associated with pulp substituted with Hydropol coated Recycled liner at 5 and 10% w/w on fibre were observed to be lower in number than those recorded for uncoated Recycled liner itself which suggests that the Hydropol extrusion coating has low deposition potential. The organic loading of the process water increased by 20% with 5% substitution with Hydropol-coated Recycled liner. Biomethane potential (anaerobic biodegradability) and Zahn Wellens (aerobic biodegradability) tests reveal ~34% and 99.3% mineralisation respectively with Hydropol loading rates which equated to over 25% substitution of the fibre furnish with Hydropol coated papers.

1. Introduction

There is increasing demand for barrier fibre-based packaging which is recyclable and eliminates single use plastic such as polyethylene as well as problematic fluorochemicals and paraffin-based waxes. This demand is being driven across a wide range of applications including direct food contact, out of home, on-the-go consumption and e-commerce packaging. The shift to fibre-based packaging has required coatings manufacturers to develop barrier coatings which are compatible with the recycling processes used by high volume recycling mills. However, there remains uncertainty as to the evidence required to demonstrate barrier coating compatibility within the dynamic papermaking process. CEPI Paperbased Packaging Recyclability Guidelines[3] note that the '*design phase should consider the intended purpose and end of life stage of the packaging in order to optimise the recycling of paper packaging*'. Regarding paper-plastic laminates and new alternative barriers the guidelines recommend that packaging designers:

1. *Optimise the adhesion between the laminate sides and the board to facilitate separation*
2. *Ensure that the paper fraction of the packaging breaks down into single fibres when pulped within a specified timeframe*
3. *Give preference to polymers and other sealing agents that can be dealt with efficiently by the papermill process and effluent treatment systems and do not compromise the finished product, the production process or the environment whilst being recycled.*

Useful guidance also exists within the Italian National Recyclability Standard UNI 11743[4] to inform coating manufacturers how to demonstrate repulpability and recyclability within high volume recycling mills. The standard provides a method for determining on a laboratory scale the level of recyclability of fibre-based packaging through examination of process parameters (quantity of coarse rejects, flakes and macrostickie adhesive particles with a diameter less than 2mm) and quality parameters of the paper sheet obtained with the recycled fibres (sheet formation, adhesiveness and optical inhomogeneity). To achieve 'Level A+ Recyclable with paper', the highest level of recyclability, a coated paper must defiberise when repulped at a consistency of 2.5% w/w, at 40°C, pH 7.0 and 30,000 stirrer revolutions for a duration of 10 minutes and meet the following assessed parameters:

- Coarse rejects – <1.5% of the weight of the test sample
- Macrostickie area – <2000µm.(mm^2/kg)
- Fibre flakes (%) – <5.0% of the weight of the test sample
- Adhesiveness – absent
- Optical inhomogeneities – level 1.

Fully water-soluble bio-digestible barrier systems for fibre-based packaging are of interest because they offer potential for fibre release and dispersion yet once solubilised the coating is mineralised by the mill's effluent treatment plant as part of its intended use.[5] Such barrier systems align with CEPI design criteria points 2 and 3.

Aquapak's Hydropol is a bio-digestible barrier system which is designed to solubilise within the repulping conditions applied by high volume recycling mills (40°C, 10 minutes). Hydropol is based on a well-established polymer polyvinyl alcohol (PVOH). Historically, PVOH has not become a mainstream packaging material because it is difficult to thermally process in its standard 'flake' form, limiting its usage to niche products where solution casting can be used such as coatings for dishwasher tablets and laundry detergent pods. Aquapak has developed proprietary methods to convert PVOH flake into pellets which are compatible with industry-standard thermoplastic processing equipment used to thermally extrude polymer film directly onto paper or to make mono film which can be adhesive laminated to paper. This development opens up the opportunity to make functional fibre-based packaging which is oil and grease resistant (>Kit 12), has high barrier to ingress and egress of gas, exhibits increased paper strength, such as tear, burst and tensile, is heat sealable for form, fill and seal packaging applications, yet fully recyclable.

The transition to sustainable paper and board packaging has placed pressure on regulators, NGO's and testing organisations to agree EU-wide test methodology to determine the recyclability of fibre-based packaging. The Italian National Recyclability Standard UNI 11743 forms the basis of a harmonised CEPI recyclability test method that is under development. The UNI 11743 standard isn't intended to address the wider papermill interactions which might arise following the solubilisation of a water-soluble bio-digestible coating. These include impacts on wet end chemistry, potential for deposition, increased organic load within process waters, impacts on paper sheet physical properties and mineralisation across anaerobic and aerobic activated sludge treatments ahead of safe discharge of the effluent.

Scope of work

The aim of this study was to investigate the repulpability and recyclability of Hydropol coated Recycled liner 100gsm (DS Smith plc) to the Italian National Recyclability Standard UNI 11743. Additionally, the wider impacts arising from coating solubilisation were investigated following substitution of Hydropol coated Recycled liner at 5% and 10% by weight of fibre furnish, namely impacts on wet end chemistry parameters, potential for deposition, increased organic loading of process waters and mineralisation across anaerobic and aerobic activated sludge treatments. These substitution rates would likely represent the highest levels of Hydropol coated Recycled liner that a recycling mill might receive. A schematic of the testing regime and assessment parameters is shown in *Figure 1*.

2. Materials and methods

2.1 Preparation of Hydropol extrusion coated papers

Hydropol was extrusion coated directly onto paper (Recycled liner 100gsm – DS Smith plc) using Aquapak's pilot extrusion coater. The coater is equipped with a die which delivers a coat width of 200mm and 10µm gauge (*Figure 2*).

2.2 Repulpability and recyclability assessment of Hydropol extrusion coated paper

Repulpability tests were carried out in a standard laboratory disintegrator using procedures described in UNI 11743 and recyclability evaluated according to Test Method MC 501:2017.[6]

Hydropol coated or uncoated Recycled liner (control) were repulped at a consistency of 2.5% w/w, 40°C, pH 7.0 and 30,000 stirrer revolutions for a duration of 10 minutes (*Figure 1*).

Measurement of coarse rejects

Repulped stock was diluted to 5 litres corresponding to a pulp consistency of 1% w/w and fractionated using a Sommerville fractionator equipped with a screen plate with 5mm holes. Coarse rejects retained by the screen after 5 minutes with a flow of mains water at 8l/min were recovered onto a filter paper and dried in an oven (105°C) to constant weight.

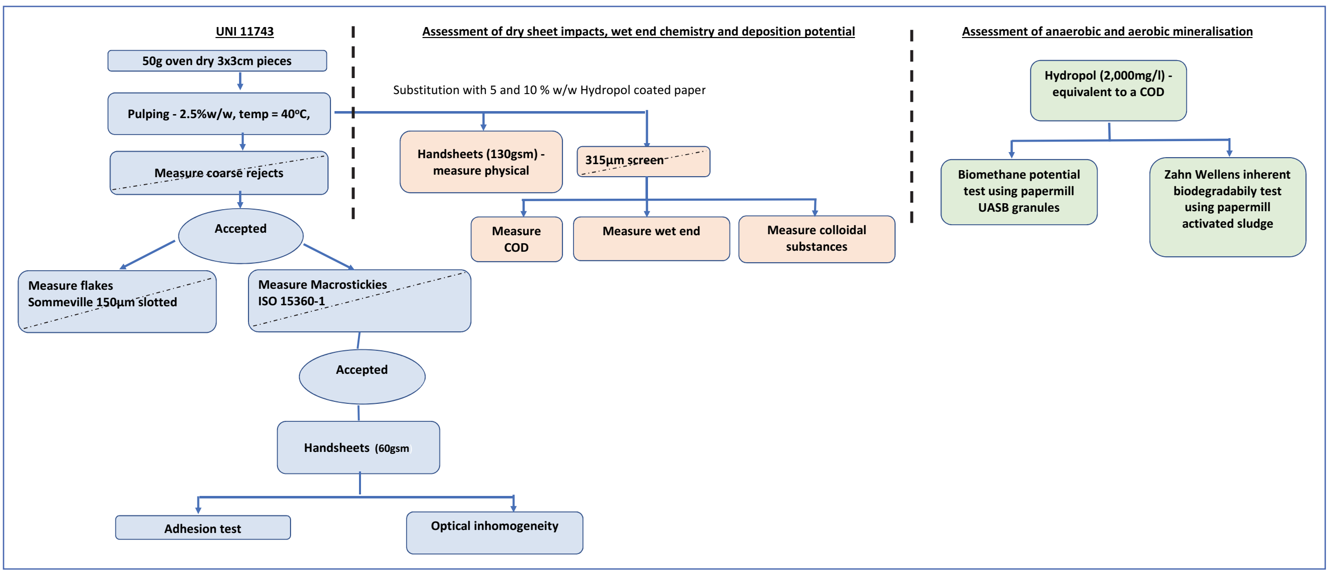

Figure 1. Schematic of test methodology

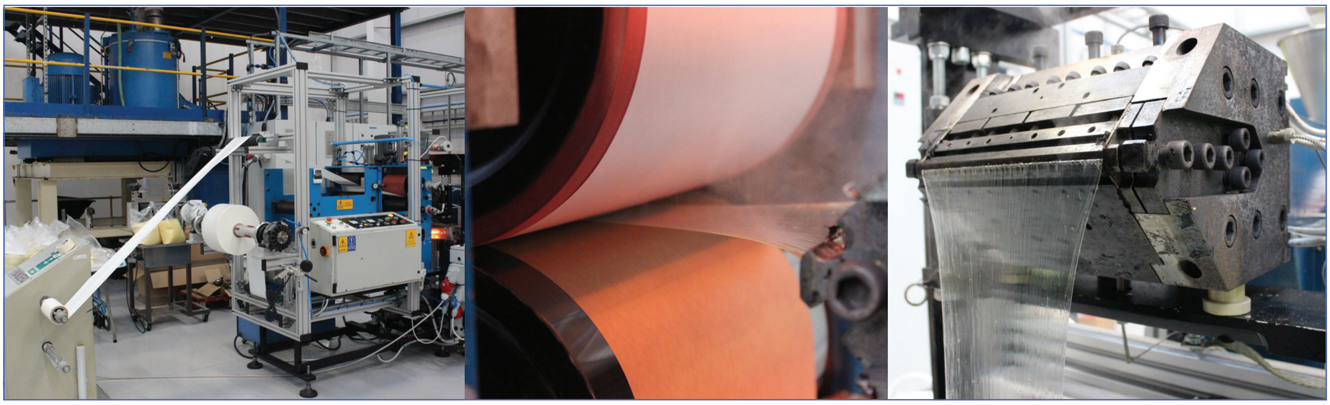

Figure 2. Pilot extrusion coating line showing base-paper unwind and coated paper rewind (left), extrusion die applying a Hydropol polymer to paper (middle) and extrusion die extruding Hydropol polymer curtain (right)

Measurement of flakes

5 litres of repulped stock (1% w/w consistency) were fractionated using a Sommerville fractionator equipped with screen plate with 150µm slots. Flakes retained by the screen after 5 minutes with a flow mains water at 8 l/min were dried in an oven (105°C) to constant weight.

Measurement of adhesive particles (macrostickies)

Macrostickies were recovered by mechanical separation of the coarse screen accepts fraction using a 150µm slotted screen. Test pieces for the measurement of adhesive particles were produced in accordance with ISO 15460-1.[7]

The area of adhesive particles less than 2mm in diameter was recorded and results expressed in mm^2 of the adhesive particle area per kg of sample.

Adhesion test

The adhesion test was carried out on 60gsm handsheets made from the fibre accepts which passed through a 150µm slotted screen. The adhesion test was carried out by checking that the handsheet did not adhere to the surface of two metal discs between which it is pressed at 1.18kPa and 130°C. Adhesiveness was judged to be absent if the sheet completely removed from the supporting metal discs without fibre stand-up or sheet damage.

Evaluation of optical inhomogeneities

Optical inhomogeneities were evaluated by observing the handsheet from both sides and comparing the appearance with references indicated in the method.

Evaluating the results

Test Method MC 501:2017 allows four levels of recyclability (level A+, A, B and C) as well as an evaluation of '*non-recyclable with paper*'. The judgement is based on the assessment shown in *Table 1*.

2.3 Evaluation of impacts from dissolved and colloidal substances

2.3.1 Preparation of test samples

Uncoated Recycled liner - 100gsm (control) or supplemented with Hydropol coated Recycled liner at either 5% or 10 % w/w by weight of fibre were repulped at a consistency of 2.5% w/w, 40°C, pH 7.0 and 30,000 stirrer revolutions for a duration of 10 minutes. These pulps were used as prepared to determine impacts on wet end parameters and dry sheet properties. The pulps were filtered through a 315µm filter and the filtrates analysed for chemical oxygen demand (COD) and micro-colloidal particle number (*Figure 1*).

2.3.2 Assessment of impacts on key wet end parameters

The pH, conductivity and redox of each pulp suspension was measured using a Hach senION meter. Zeta potential and fibre conductivity were measured using an emtec Fibre Potential Analyser. Cationic demand was measured using an emtec Charge Analysing System.

2.3.3 Organic loading and impacts on pulp drainage

The COD of each filtered pulp suspension was measured using the Palintest COD test method.

2.3.4 Assessment of potential for deposition

Micro-colloidal, stickies, and pitch particle number of size ranging from 0.1-100µm were enumerated in 200µl aliquots of each pulp filtrate using a Cyflow Cube 6 (Sysmex) flow cytometer. The unit was configured using olive oil for sticky/hydrophobic particles and a doctor blade pitch to categorise pitch forming moieties. Each sample aliquot was stained with Nile red and excited under blue light (488nm) and detection was initiated by forward scatter above a specific threshold value. The acquired data was processed using a flow cytometry data analysis package (FCS Express).

Evaluation criteria	Recyclable with paper				Non recyclable with paper
	Level A+	Level A	Level B	Level C	Non recyclable with paper
Course reject (%)	<1.5	1.5-10.0	10.1-20.0	20.1-40.0	>40.0
Macrostickies area <2,000μm. (mm^2/kg)	<2,500	2,500-10,000	10,001-20,000	20,001-50,000	>50,000
Fibre flakes (%)*	<5.0	5.0-15.0	15.1-40.0	>40.0	(-)
Adhesiveness	absent	absent	absent	absent	present
Optical inhomogeneities	Level 1	Level 2	Level 3	Level 3	(-)

Table 1. Criteria for evaluating level of recyclability according to Test Method MC501:2017.

***in the case of a clearly identifiable prevalence of non-cellulose based flakes, the fibre flakes result is not assigned and the value is added to the coarse reject value (calculated on the product's weight)**
The parameter with the worst value characterises the class to which the sample belongs. If the sample is classified as 'non recyclable with paper', this material or product is not suitable for waste collection with paper.

Evaluation criteria	Recycled liner (uncoated)	Hydropol coated Recycled liner	Target to achieve Level A+
Coarse reject %	0	0	>1.5
Fibre flakes %	0.96	0.29	<5.0
Macrostickies <2000µm.(mm^2/kg)	0	0	<2,500
Adhesiveness	Absent	Absent	Absent
Optical inhomogeneities	Level 1	Level 1	Level 1

Table 2. Recyclability assessment to Test method MC501:2017. Results are the mean of two tests

Sample	pH	Conductivity (µS/cm)	Redox (ORP mV)	Zeta Potential (mV)	Fibre Conductivity (µS/cm)	Cationic Demand (µeq/L)	COD (mg/l)	Schopper-Reigler Freeness (°SR)
Recycled liner (control)	7.78	233	315	-18.0	407	-235	1,280	50
Recycled liner & 5% Hydropol coated Recycled liner	7.78	230	252	-15.8	308	-225	1,540	34
Recycled liner & 10% Hydropol coated Recycled liner	7.70	233	337	-14.8	401	-270	1,960	34

Table 3. Effects of increasing substitution of Hydropol coated Recycled liner on wet end parameters.

2.3.5 Assessment of dry sheet impacts

Tensile Index (Lloyds LRX Tensile Test), burst index (L&W bursting strength) and Short span compression index (SCT) (L&W Compressive strength) were measured on triplicate test samples which were prepared from 130gsm hand sheets made from each pulp.

2.3.6 Mineralisation within anaerobic digestion and aerobic activated sludge

Anaerobic (Upflow Anaerobic Sludge Blanket-UASB) and aerobic (Mixed Liquor Suspended Solids-MLSS) sludges were obtained from DS Smith Kemsley Mill, UK, and used in the Biomethane potential and Zahn Wellens tests respectively.

Biomethane potential test (anaerobic biodegradability)

UASB granules were stored at mesophilic temperatures for 48 hours to ensure any residual readily biodegradable material within the seed sludge had been exhausted. Hydropol (2,000mg/l) was solubilised in a carbon-free mineral salts media (equivalent to a COD of 3,800g/l O) served as the in-feed to give a COD:mass ratio of 0.05:0.95. This mass ratio was selected to ensure that sufficient gas was produced to analyse the methane quality.

Test mixtures were anaerobically digested for 28 days, during which time the quantity and quality of the biogas produced was measured. Test samples were tested in duplicate and the average methane yield calculated. The reactors were agitated daily to ensure mixing.

Controls containing seed inoculum and mineral salts media only were prepared in duplicate. Methane yields from the controls were subtracted from the test samples to determine the methane yield for the test material only.

Zahn Wellens test (aerobic biodegradability)

MLSS was allowed to settle and the supernatant removed to reduce the possibility of previously partially treated substances from affecting the test. Solubilised Hydropol (2,000mg/l) equivalent to 3,800mg/l O COD was added to MLSS to achieve a ratio of 1g/l MLSS:1g/l of COD within a carbon-free mineral salts media. Duplicate negative controls were prepared which contained MLSS and mineral salts media only. A positive control comprising MLSS and mineral salts media together with glycol was prepared to verify the viability of the MLSS. The COD of this control should be reduced by 70% after 14 days of the test to demonstrate the viability of the MLSS.

All vessels were aerated and mixed throughout the test and kept in subdued light. pH was maintained at 6.5 to 8.0. The biodegradation process was monitored by determination of COD in filtered samples at daily intervals. The ratio of eliminated COD corrected for the control after each time interval, to the initial COD value was expressed as the percentage biodegradation at the sampling time. The percentage biodegradation was plotted against time.

3. Results

3.1 Repulpability and recyclability assessment

Repulpability and recyclability assessments of Recycled liner and Hydropol coated Recycled liner to UNI 11743 as evaluated according to Test Method MC 501:2017 are shown in *Table 2*. Uncoated and Hydropol extrusion coated Recycled liner achieved Level A+ for each of the assessed parameters. Hydropol did not impact on key process impacts as evidenced by an absence of coarse rejects, low % fibre flakes and an absence of macrostickies. The Hydropol coating did not impact paper sheet quality parameters as evidenced by an absence of adhesiveness and optical inhomogeneities.

3.2 Impacts on wet end parameters

The effects of substitution of Hydropol coated Recycled liner at 5 or 10% of furnish on wet end parameters are shown in *Table 3*. pH, conductivity, redox, fibre conductivity and cationic demand remained largely unchanged regardless of the extent of substitution. Zeta potential magnitude was noted to decrease. This change would indicate a modification to the charge balance between the water and solid phase - one possible explanation being cationic interaction with the fibre surface, either by neutralisation or ad/absorption. The degree of surface charge modification observed was considered insufficient to warrant further investigation.

Sample	Vol ul	Total	Stickies	Nat Extractives	Pitch	Stickies %	Nat Ext %	Pitch %
Recycled liner-control	25	125,815	464	2,499	4,836	0.37	1.99	3.84
5% substitution	25	118,272	202	849	3,446	0.16	0.67	2.74
5% substitution rep	25	115,709	192	962	3,454	0.15	0.76	2.75
10% substitution	25	100,995	158	894	3,162	0.13	0.71	2.51
10% substitution rep	25	95,438	165	906	3,197	0.13	0.72	2.54

Table 4. Effects of increasing substitution of Hydropol-coated Recycled liner on micro-colloid, sticky, natural extractives and pitch particle numbers.

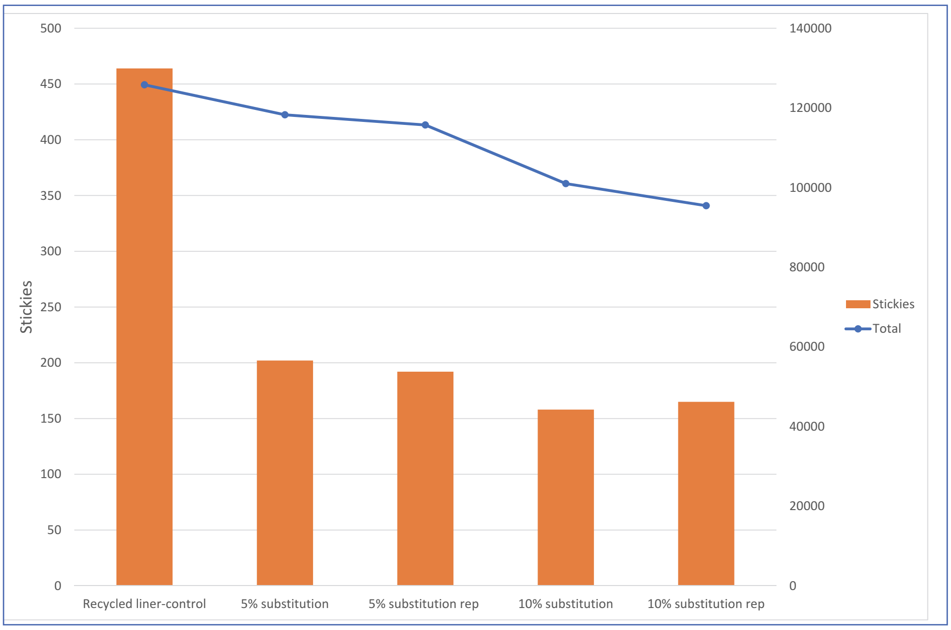

Figure 3. Impacts of substitution of Hydropol coated Recycled liner at 5 and 10% w/w on total micro-colloid and stickies particle count.

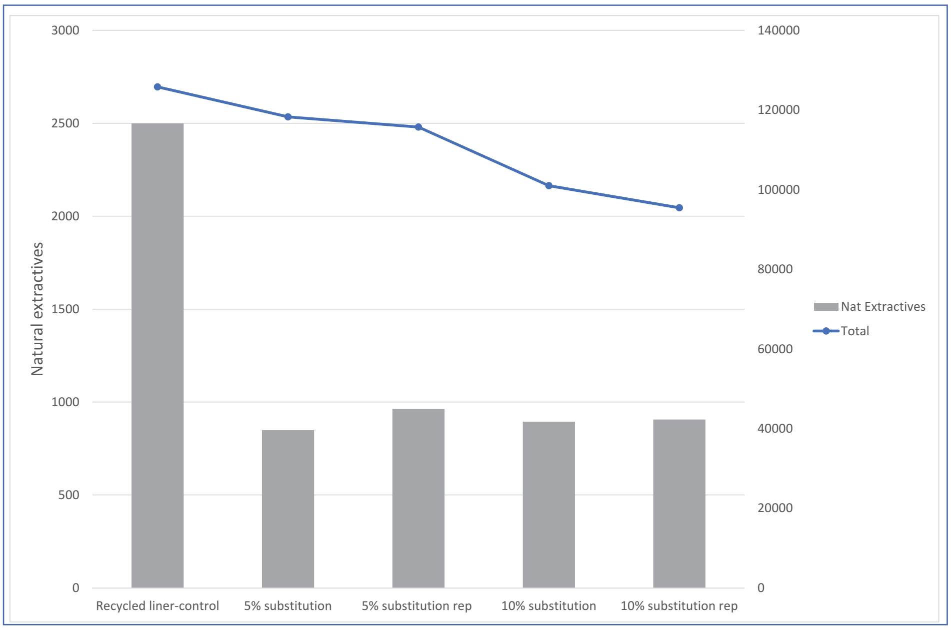

Figure 4. Impacts of substitution of Hydropol coated Recycled liner at 5 and 10% w/w on total micro-colloid and natural extractives particle count.

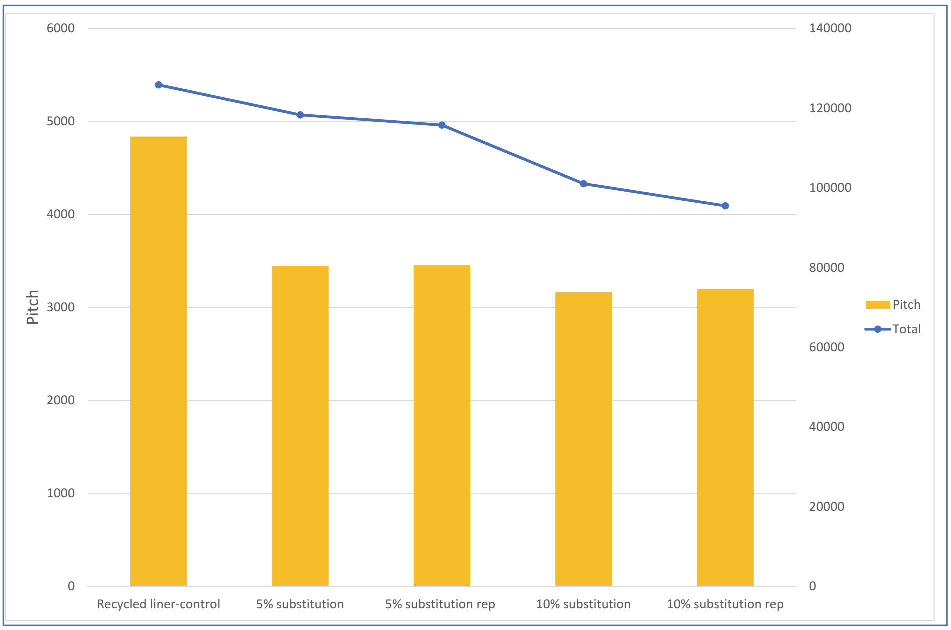

Figure 5. Impacts of substitution of Hydropol coated Recycled liner at 5 and 10% w/w on total micro-colloid and pitch particle count.

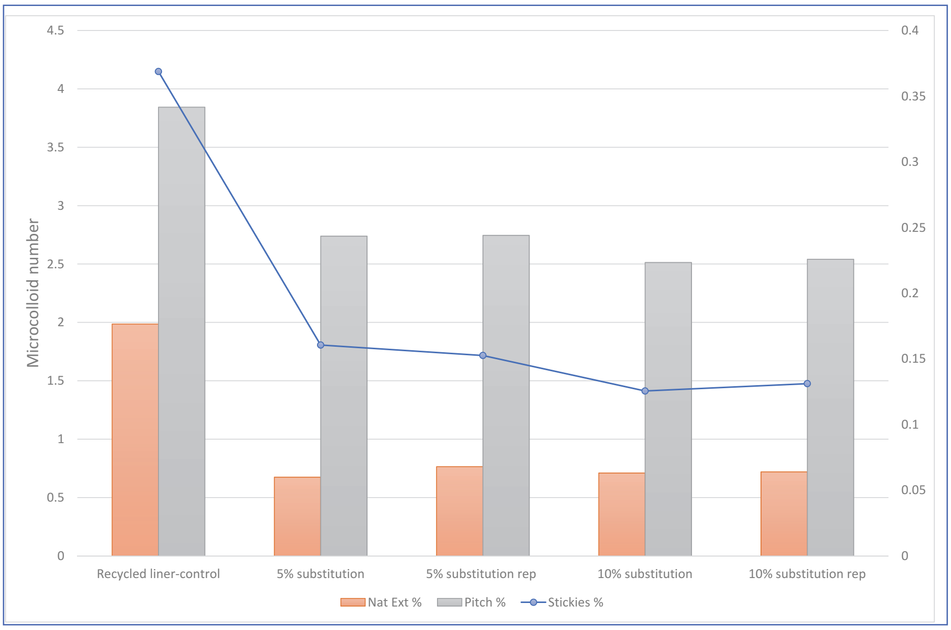

Figure 6. Impacts of substitution of Hydropol coated Recycled liner at 5 and 10% w/w on % stickies, natural extractives and pitch (expressed as % of micro-colloidal particle number).

3.3 Organic loading and impacts on pulp drainage

Substitution with Hydropol coated Recycled liner at 5 and 10% increased COD by 260mg/l (20% increase) and 680mg/l (53% increase) when compared to the uncoated paper control (*Table 3*). The increased organic load in the pulp filtrate is expected and is indicative of dissolution of the Hydropol coating. Substitution with Hydropol coated Recycled liner resulted in a faster draining pulp.

3.4 Potential for deposition

The effects of substitution of Hydropol coated Recycled Liner at 5 or 10% of furnish on micro-colloid, sticky, natural extractive and pitch particle number are shown in *Table 4* and *Figures 3 to 6*. The total micro-colloidal count associated with filtrate from repulped uncoated Recycled liner was noted to be highest and decreased by ~22% following 10% substitution with Hydropol coated Recycled liner. Particles identifying at stickies, pitch and natural extractives were also noted to decrease with increasing substitution of Hydropol coated Recycled liner.

3.5 Dry sheet impacts

The effects of substitution of Hydropol coated Recycled liner at 5 or 10% of furnish on Tensile Index, Burst Index and SCT are shown in *Table 5* and *Figures 7 to 9*. Increasing substitution of Hydropol coated Recycled liner did not impact on any of the measured sheet physical properties.

3.6 Mineralisation within anaerobic digestion and aerobic activated sludge

The results for BMP tests are shown in *Table 6* and *Figure 10*.

Sample	Tensile Index (N/gsm)	% increase compared to control	Burst Index (kPa/gsm)	% increase compared to control	Short-span compression Index (kN/gsm)	% increase compared to control
Recycled liner (control)	0.4489	–	0.0129	–	1.192	–
Recycled liner & 5% Hydropol coated Recycled liner	0.4345	-3.21	0.0133	2.63	1.254	5.24
Recycled liner & 10% Hydropol coated Recycled liner	0.4494	0.1	0.0132	1.89	1.130	-5.19

Table 5. *Effects of increasing substitution of Hydropol-coated Recycled liner on Tensile Index, Burst Index and SCT*

Sample	COD (mg/l)	Volume of sample added (ml)	CH4 produced (ml)	Methane yield (L.CH4/kg.COD applied)	% COD destruction
Hydropol	3,800	207	94	120	34.3

Table 6. Feedstock parameters and methane yield.

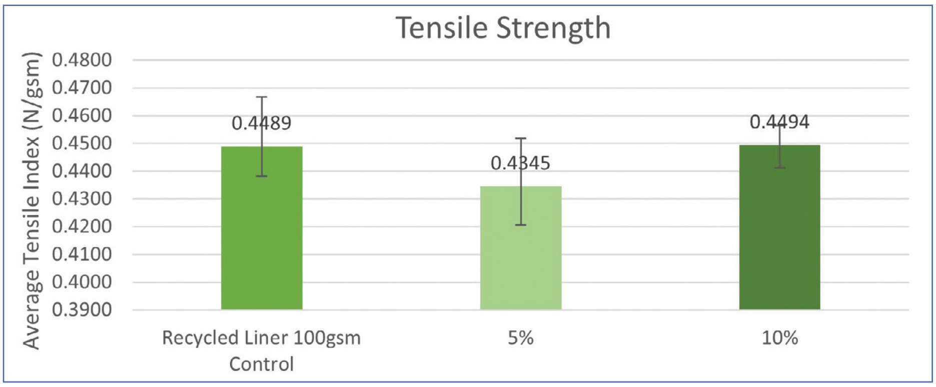

Figure 7. Impacts of substitution of Hydropol coated Recycled liner at 5 and 10% w/w on Tensile Strength.

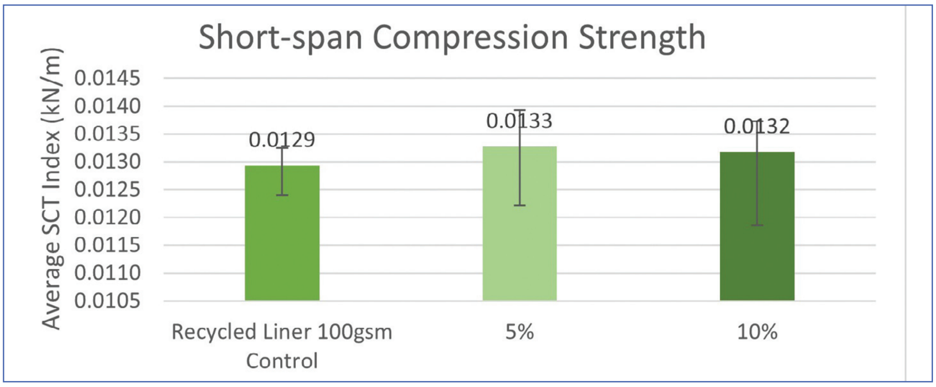

Figure 8. Impacts of substitution of Hydropol coated Recycled liner at 5 and 10% w/w on SCT.

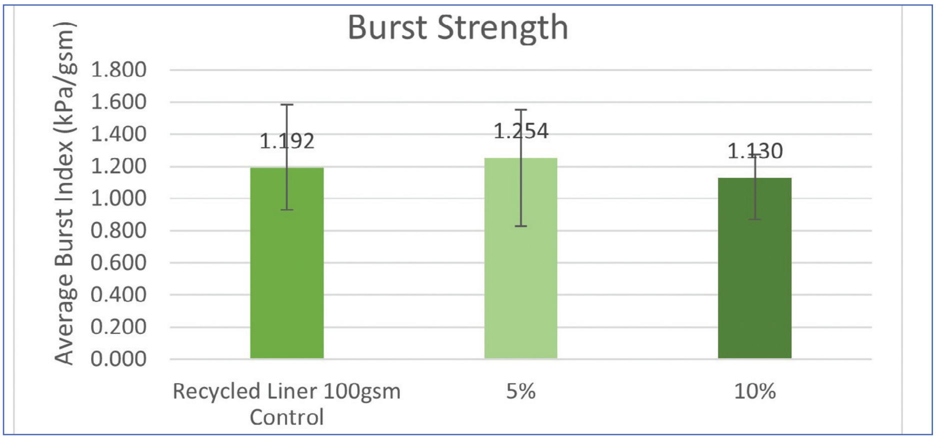

Figure 9. Impacts of substitution of Hydropol coated Recycled liner at 5 and 10% w/w on Burst Strength.

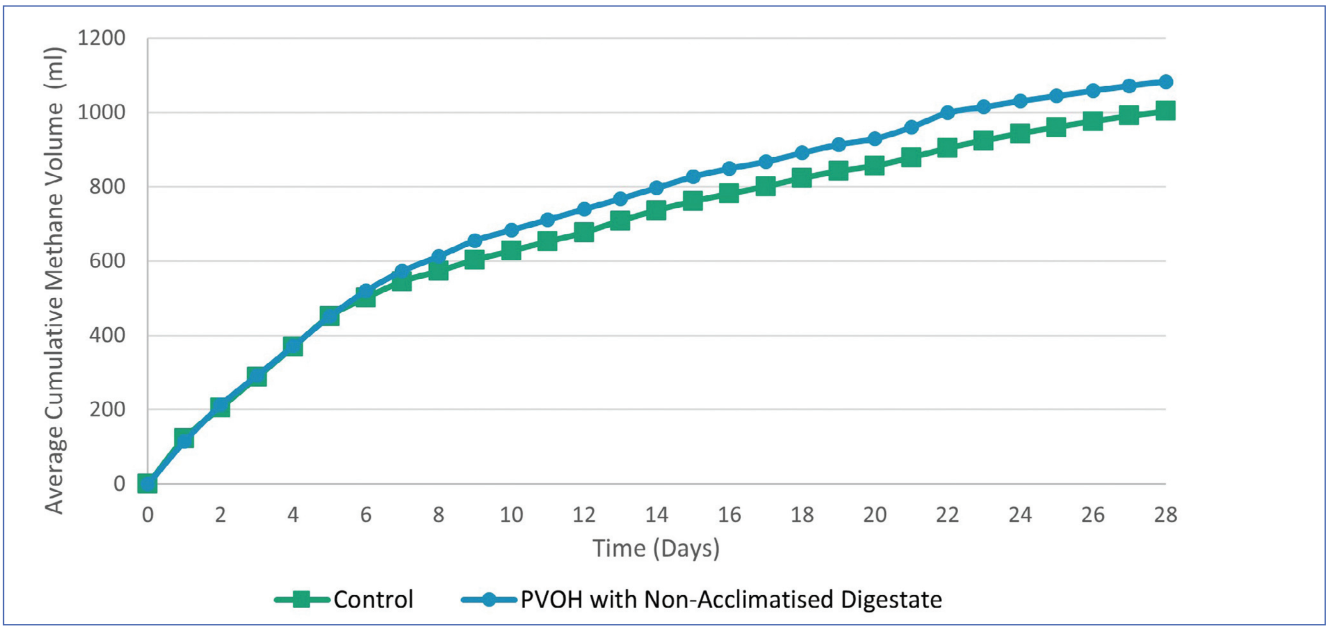

Figure 10. Methane evolution profile for Hydropol

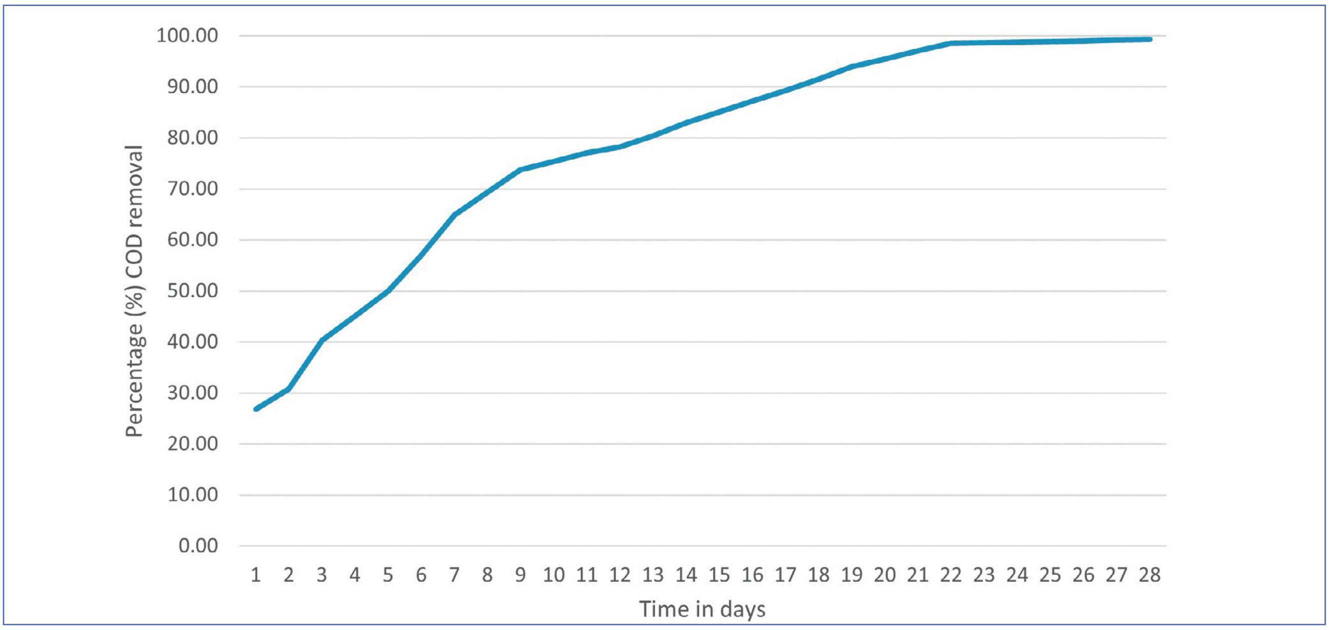

Figure 11 *Percentage soluble COD removal curve for Hydropol*

The methane evolution profile for Hydropol during the BMP test indicates that no methane was produced over days 0-5, suggesting the UASB microflora took time to acclimatise *(Figure 10)*. From day five, the Hydropol was steadily converted to methane over the 28 day test period; tailing off towards the end of the test period indicating the methane evolution was complete.

The results for the Zahn Wellen test are shown in *Figure 11*. Soluble COD removal was 78.3% by day nine. COD destruction then slowed until day twelve when it slowed even further with an eventual COD reduction of 99.3%.

4. Conclusions

Bio-digestible barrier coatings which solubilise under the typical repulping conditions deployed by high volume recycling mills offer a route to design functional yet sustainable paper and board packaging which is compatible with mills thereby increasing paper recycling rates and fibre yield. Since soluble coatings enter mill process waters and are discharged for effluent treatment as part of their intended use their potential impacts need to be quantified. A testing strategy was designed to quantify these potential impacts. The strategy combined repulpability and recyclability tests described in the Italian National Recyclability Standard UNI 11743 together with testing to evaluate the potential impacts arising from solubilisation, namely impacts on wet end chemistry, deposition potential, increases to organic load in process waters, impacts on paper sheet physical properties and mineralisation across anaerobic and aerobic activated sludge treatments.

Repulpability and recyclability tests of Hydropol coated Recycled liner to UNI 11743 revealed an absence of coarse rejects and low flake content and an absence of macrostickies with an area <2,000µm (mm^2/kg). The handsheet quality was not impacted negatively. Hydropol coated paper was judged '*Level A+ Recyclable with paper'*.

The effects of fibre substitution with 5 or 10% Hydropol-coated Recycled liner on wet end chemistry parameters, potential for deposition, organic loading of process waters, effects on dry sheet strength were investigated using accepted test methods. These substitution rates would likely represent the highest levels of Hydropol coated paper that a recycling mill might receive. Substitution of the uncoated fibre furnish with Hydropol coated Recycled liner at 5 and 10% w/w on fibre didn't affect key wet end parameters or dry sheet properties when compared to the uncoated control. Micro-colloidal particles and particles identified as stickies (0.1-100µm) associated with pulp substituted with Hydropol coated Recycled liner at 5 and 10% w/w on fibre were observed to be lower than those observed for uncoated paper itself. These results suggest that the Hydropol extrusion coating has low deposition potential. Organic loading of the process water increased by 20% and 53% with 5 and 10% substitution respectively. The increased organic load in the pulp filtrate is expected and is indicative of dissolution of the Hydropol coating. The decrease in °SR value from 50 to 34 with substitution with Hydropol coated Recycled Liner indicates increased pulp drainage. Such a result, if substantiated by further testing and evaluation at mill scale, could lead to a drier sheet entering the press and dryer sections which would lead to energy savings.

Biomethane potential (anaerobic biodegradability) and Zahn Wellens (aerobic biodegradability) tests reveal ~34% and 99.3% mineralisation respectively with Hydropol loading rates which equated to over 25% substitution of the fibre furnish with Hydropol coated papers. Pilot scale testing would be required to determine whether this level of biodegradability would be replicated under the process conditions of a full-scale process and whether this could be treated without any other impacts upon the process.

The laboratory results align with result obtained by P&G for PVOH mineralisation assessments of PVOH coatings used with their Tide Pod range of laundry detergent pods.[8] Henkel also carried out an in-depth environmental safety assessment of PVOH associated with its liquid laundry detergent.[9]

An extensive set of aquatic toxicological and biodegradation information was collated to develop scenarios on detergent use and to assess the risk associated with the raw material use in the respective scenarios. Dual tests which examined Total Organic Carbon and mineralisation to CO_2 qualified PVOH as inherently biodegradable and that a significant proportion would be removed from sewage during biological treatment. The REACH regulations[10] classify persistent substances as those that display a half-life of 60 days or more in aquatic environments. Since PVOH is inherently biodegradable it was concluded that PVOH is not persistent and does not accumulate in aquatic environments. Acute toxicity data against algae and *Daphnia magna* revealed low toxicity. When extrapolated, it was concluded that chronic effects would not be expected for a range of end-use scenarios. Henkel concluded for all scenarios addressed, that the use of PVOH with its liquid laundry detergent was safe.

Taken together, the results of the laboratory tests together with supporting literature provides evidence to suggest that Hydropol is compatible with the processes used by high volume recycling mills and would likely enable high fibre recovery whilst reducing insoluble single-use plastics which are ejected and sent to landill or waste to energy. The results obtained in the study provide packaging designers with evidence to meet CEPI's Paperbased Packaging Recyclability Guideline, namely:

1. *Ensure that the paper fraction of the packaging breaks down into single fibres when pulped within a specified timeframe*
2. *Give preference to polymers and other sealing agents that can be dealt with efficiently by the papermill process and effluent treatment systems and do not compromise the finished product, the production process or the environment whilst being recycled.*

The tests applied and results obtained provide useful guidance for coating manufacturers wanting to demonstrate the compatibility of their coatings with the processes used and products made by high volume recycling mills.

Nick Thompson, Materials Development Director, DS Smith Group R&D commented, "It's clear that materials used in paper-based packaging have to be designed into the packaging with recycling in mind from the start. This is why DS Smith developed circular design principles; to ensure repulpability, recyclability and no negative impact on the end of life of the materials used. It seems like the Aquapak Hydropol product during recycling, has now been shown to help fibre separation and can itself be eliminated from the process with no negative impact and with no need for finding an outlet for unwanted waste material, such as difficult to recycle plastics."

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Stop Press

Nigel Malone, Operations Manager at Simpson Clough Paper Mill, Union Papertech Ltd., has retired after 20 years at the site in Heywood, near Bury. Nigel started his career with Robert Fletcher and Sons Limited in the early 1980s – in fact, his first Paper qualification was achieved in June 1981, "Skills and Knowledge Associated with the Paper and Paper Products Industry", just before his seventeenth birthday. Nigel moved to Simpson Clough Mill, then a part of the JR Crompton Group, in 2001, with the mill transferring to the Purico Group in 2006. He rose to the position of Operations Manager for Simpson Clough in 2009, a position he occupied until his decision to retire in October 2021 after more than 40 years of service to the Paper Industry. Matthew Miller, Managing Director of Union Papertech Ltd., commented, "Nigel has been absolutely central to the operation at Union Papertech Ltd. for many years, and he leaves a huge legacy. There are very few people who can claim to be at the heart of a business to the extent that Nigel Malone has been for Union Papertech. He leaves behind a team of people who have enjoyed and benefited from working with him and are all sorry to see him go." Sam Cropper will replace Nigel as the new Head of Operations.

Metsä Tissue, the tissue paper business of the forest industry group Metsä Group, is planning to invest in a new tissue mill in the UK. The plan consists of 240,000 tonnes of tissue paper production capacity, built in several phases during the upcoming decade. The plans are part of the company's Future Mill programme to drive world class environmental performance in tissue production. The production of the planned UK mill would be based on using sustainable fresh fibre pulp, and the first phase of the investment would be ready during 2025 to serve the professional and consumer tissue markets in the UK and Ireland. "Over the past couple of years, we have been developing a Future Mill concept in relation to our planned tissue mill expansion in Mariestad, Sweden. Our studies show that we will be able to utilise more efficient and better technology than today, which will make us more competitive and more environmentally efficient. We see great opportunities for growth in the UK market and are planning to supply the market locally based on our Future Mill concept", says Esa Kaikkonen, CEO, Metsä Tissue. The mill concept is planned to be based on best available technologies, with a world class environmental performance. As the next step, the location of the mill is planned to be selected during the first half of 2022. The locations currently under investigation are Newark and Hull.