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Final Report

End Markets for recycled detectable black PET plastics

A technical report that investigates the changes required for UK plastics recyclers to sort detectable black plastic APET and CPET into unique polymer and colour streams and whether detectable black plastics impact the purity and quality of their current product streams. It also identifies potential end markets for coloured PET containing detectable black APET and CPET.

Project code: IMT003-002
Research date: Aug 2012 – March 2013 **Date:** July 2013

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nextek

Front cover photography:
Top LHS, Manufacture of detectable black CPET trays. Top RHS, Sorting trials at ECO Plastics
Bottom LHS, Fibre trials with up to 20% black CPET regrind. Bottom RHS, Black APET trays made with 7.5% and 15% black CPET regrind.

Executive summary

Introduction

This project builds on the previous WRAP projects 'Development of NIR Detectable Black Plastic Packaging' and 'Masking strength of NIR detectable black colourants'[1]. The initial project demonstrated the potential for detectable black colourants to be used for black plastic packaging that enabled sorting by polymer type; and the second project showed that the detectable black colourants were suitable for use with coloured jazz regrind from in-house production scrap.

Novel NIR detectable black colourants were developed with a satisfactory appearance in APET, CPET and PP food trays, to enable the packaging to be sorted by polymer type using existing NIR sorting systems used commercially in plastics recycling facilities. The use of NIR detectable black colourants in packaging would then enable the plastic to be identified and recycled to produce high quality materials, in the same way other colour packaging is currently recycled. This would divert black packaging currently pigmented with carbon black (and unable to be detected by existing NIR sorting technology) from landfill, potentially allowing the recycled materials to be used in place of virgin plastic to manufacture new items.

A brief questionnaire was provided to the key recyclers to gain insight into any issues or positive aspects that they had with the introduction of detectable black plastics. All respondents indicated they had significant concerns with two aspects related to the use of detectable black PET, both of which have been addressed by this project. The two concerns were:

- Possible contamination of existing clear and coloured jazz rPET / CPET products, with the potential for small amounts of black to impact on the colour specification of the clear rPET stream, reducing its value:
- The need to remove black from the coloured jazz stream to meet existing colour specifications and prevent material contamination from CPET would be an additional processing cost and yield losses to both clear and jazz products. The additional cost associated with removing detectable black from both clear and coloured products could only be offset if there was a market and application of high value for the separated stream of black rPET.

A more detailed investigation of the impacts of the presence of detectable black plastics on the recycling of packaging materials was required. In particular for PET it was important to investigate the impact of the addition of black to the coloured rPET recycling stream on existing products, and that applications for black recycled PET were available.

The other large application for these colourants is in black PP packaging. The sorting of black packaging made from PP is less critical than PET since the mixed coloured PP fraction is often directed to dark applications and these colourants will assist. The production of specific colours in recycled PP may require additional colour sorting; however, the higher value for the sorted products will help offset the investment.

There were two primary objectives for this work:

- Ensure that UK plastics sorters are able to sort detectable black plastic (particularly PET) into the correct polymer and colour streams and that the presence of detectable black plastic does not adversely affect the purity and quality of the sorted products.

[1] http://www.wrap.org.uk/content/recyclability-black-plastic-packaging-0

- Identify and develop end markets for coloured jazz rPET containing detectable black APET and CPET to show whether these applications are viable with the presence of an increased amount of black PET and black CPET.

Preliminary bench scale trials with all of the key sorting equipment manufacturers unanimously showed that detectable black CPET products could be correctly identified and sorted as PET and also detected as coloured and sorted into the coloured jazz rPET stream.

Re-processor sorting trials were conducted at Closed Loop Recycling, ECO Plastics and Poly Recycling (Switzerland). All three large-scale trials produced positive results and confirmed the bench scale trials conducted by the equipment suppliers. Detectable black CPET trays were successfully sorted in to the PET stream and then to the coloured PET stream at high efficiencies so that there was negligible contamination of the clear rPET stream and minimal losses of detectable black CPET trays to the landfill fraction.

The testing and trials have shown that, while the detectable black CPET was readily identified and sorted at high efficiency in existing facilities, the concerns of contamination will likely remain until there has been some further on-going experience in the recycling facilities to validate the results of this study and confirm that the detectable black materials can be reliably sorted to avoid contamination of existing products.

The tests and trials also showed that CPET has a sufficiently different NIR signature when compared to PET bottles and APET trays and it could be identified and sorted into its own unique CPET stream independent of the coloured APET fraction. This attribute could enable closed loop recycling of detectable black CPET trays back into black CPET applications.

Market development trials showed that the detectable black CPET could be used at 15-20% percentages in both textile fibre and APET sheet products without any impact on product quality. It could not be used in green PET strapping due to the impact on the colour specification, however black PET strapping is a potential application in the future. The presence of black CPET in the mixed colour PET stream will not interfere with the current green strapping application because this coloured PET fraction is currently sorted to remove dark and opaque PET materials.

Conclusions

The key conclusions that emerged from this study were;

- Bench scale testing by the major suppliers of NIR sorting equipment manufacturers BT-Wolfgang Binder GmbH (Redwave), MSS, Pellenc, RTT-Steinert (Unisort), Sesotec (S+S), Tomra (Titech) and Unisensor showed that they were all able to positively identify and separate CPET trays made with detectable black colourant.
- Commercial sorting trials conducted at Closed Loop Recycling, Poly Recycling and ECO Plastics validated the results of the bench scale testing showing that detectable black CPET trays and flake were able to be separated from the clear rPET stream and sorted into the coloured jazz rPET stream.
- Bench and commercial scale trials showed that detectable black CPET can be identified and separated from clear and coloured APET, into a unique separate stream of recycled material.
- Detectable black CPET is unsuitable for green PET strapping applications due to the impact of the colour; however, it could be used in the smaller black PET strapping market.
- Detectable black CPET can be used in fibre and APET tray applications at levels of 15% and 20%respectively without impacting processing conditions or physical properties.
- Concern amongst recyclers that the presence of detectable black packaging would result in additional processing costs and a reduced value for jazz recycled materials that contain black plastics have been addressed by the results of this investigation. The results show that the detectable black CPET would not contaminate the clear rPET stream and that the

coloured jazz rPET fraction, that would contain black CPET, still remains suitable for existing applications of fibre and black APET trays.

Recommendations

Based on the results of this study, it is recommended that detectable black colourants be proposed as a viable option to carbon black pigments in the manufacture of black packaging such as APET, CPET, PE and PP packaging. The additional cost of detectable black colourants has been considered in earlier studies and it is anticipated that this cost difference compared to carbon black will reduce over time as demand and volume increases.

If producers of detectable black packaging were encouraged to buy recycled black packaging (which would be only detectable black articles), recyclers would be provided with a new market into which they can sell the new product and begin to recover any cost for additional sorting. Converters of products like black trays would have the opportunity to buy back the recycled detectable black packaging so they might recoup some of the additional costs of the detectable black colourant invested into the packaging.

A further consideration specifically for detectable black CPET is that this material could then be used back into CPET packaging so that closed-loop recycling of black CPET could be feasible for the first time.

It is recommended that a coordinated programme is delivered that disseminates the information in this report to recycling plant operators as well as the respective NIR equipment suppliers.

For the avoidance of doubt no direct comparison of individual equipment, technology or process performance should be drawn from the information published throughout this report. For all equipment, technology or processes tested, the equipment, technology or process may have been tested under different conditions and using different methodologies and therefore may not be comparable.

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Glossary of Terms

APET	Amorphous form of Polyethylene terephthalate
CPET	Crystallised form of Polyethylene terephthalate
CO_2	Carbon Dioxide
Food Contact Polymer or Packaging	That which has been used in contact with food or has been tested and approved for use in contact with foods in compliance with the requirements of EU Regulation 10/2011.
Jazz	Mixed colour
HDPE	High-density polyethylene.
MFR or MFI	Melt Flow Rate or Melt Flow Index; a rheological test method providing an assessment of ease of flow within subsequent melt processing equipment. Also an indicator of molecular weight.
MRF	Material Recovery Facility
NIR	Near infra-red
PCR	Post-consumer recyclate
PE	Polyethylene
PET	Polyethylene terephthalate
PP	Polypropylene
PRF	Plastic Recovery Facility
rHDPE	Recycled high density polyethylene
rPET	Recycled polyethylene terephthalate
rPP	Recycled polypropylene
UK	United Kingdom

Acknowledgements

WRAP and Nextek would like to thank Colour Tone Masterbatch for the supply of the detectable black colourant, Faerch Plast for their extensive support in the manufacture of the black CPET and APET processing trials. A big thanks to all of the sorting equipment suppliers BT-Wolfgang Binder GmbH (Redwave), MSS, Pellenc, RTT-Steinert (Unisort), Sesotec (S+S), Tomra (Titech) and Unisensor for their considerable efforts and professionalism in conducting trials with the detectable black plastics. A further thanks to the recycling businesses Closed Loop Recycling, Poly Recycling, and ECO Plastics that were able to provide valuable line time for trials to show sorting efficiencies in actual recycling situations and to Centexbel and Interstrap for their dedication to the application trials for PET fibre and PET strapping respectively.

1.0 Introduction and Overview

This project builds on the previous WRAP projects 'Development of NIR Detectable Black Plastic Packaging' and 'Masking strength of NIR detectable black colourants'[2]. The initial project demonstrated the potential for detectable black colourants to be used for black plastic packaging to enable it to be sorted by polymer type and the second project was able to show that the detectable black colourants were suitable for use with coloured jazz regrind from in-house production scrap.

Black plastic packaging is usually coloured with carbon black pigment, which is low cost, has high tint strength or opacity, can be used in food contact packaging, and provides a contrasting background that allows the colours in the food to stand out. However, plastic packaging items produced with carbon black currently cannot be identified with automated sorting systems used in plastics recycling and consequently almost all post-consumer black plastic packaging ends up in landfill.

Novel NIR detectable black colourants were developed and shown to look satisfactory in APET, CPET and PP food trays, and they enabled the packs to be sorted by polymer using NIR sorting systems used commercially in plastics recycling facilities. The use of NIR detectable black colourants in packaging would therefore enable the plastic to be identified and recycled to increase the recovery of high quality materials in the same way other colour packaging is currently recycled. This would divert black plastic packaging from landfill potentially allowing it to be used in place of virgin plastic to make new items delivering savings in CO_2 and contributing to the achievement of UK plastic packaging recycling targets.

A more detailed investigation of the impacts of the presence of detectable black plastics on the recycling of packaging materials was required. In particular for PET it was required to ensure that the addition of black to the coloured rPET recycling stream would not have a negative effect on existing products, and that applications for black recycled PET were available. A series of trials with NIR equipment suppliers were conducted to determine if detectable black plastics could be effectively sorted by all recyclers regardless of equipment selection, and trial with recyclers were completed to validate the process under commercial conditions. The opinions of commercial plastics recyclers were researched to determine their ideas and concerns regarding the presence of black rPET in the coloured jazz rPET stream and any potential impact this might have on specifications and applications.

Trials were also conducted to assess the performance of regrind made from detectable black CPET trays in a number of applications that are large users of recycled coloured rPET. Fibre, APET and strapping trials were completed with up to 20% of the detectable black CPET regrind material.

The other large application for these colourants is in black PP packaging. The sorting of black packaging made from PP is less critical than PET since the mixed coloured PP fraction is often directed to dark applications and these colourants will assist. The production of specific colours in recycled PP may require additional colour sorting however the higher value for the sorted products will help offset the investment. Consequently this study has focussed only on the impact on the detectable black coloured packaging on the coloured jazz PET fraction where many of the products might be sensitive to the presence of dark colourants.

2.0 Project Objectives

There were two primary objectives for this work:

- Ensure that UK plastics sorters are able to sort detectable black plastic (particularly PET) into the correct polymer and colour streams and that the presence of detectable black plastic does not adversely affect the purity and quality of the streams they are sorted into.

[2] http://www.wrap.org.uk/content/recyclability-black-plastic-packaging-0

- Identify and develop end markets for coloured jazz rPET containing detectable black APET and CPET to show whether these applications are viable with the presence of an increased amount of black PET and black CPET.

3.0 Project Methodology

3.1 Manufacture of detectable black plastic trays

Detectable black colourant was sourced from Colour Tone Masterbatch, a UK supplier who has participated in previous projects with detectable black plastic. This was supplied to Faerch Plast, an extrusion and thermoforming company to manufacture CPET trays and regrind flake for further trials.

3.2 Identification and Sorting Trials

Sorting trials were initially conducted within the test laboratories of the sorting equipment suppliers and subsequently with the recycling companies to evaluate if high performance sorting of the black packaging could be readily achieved or if it would potentially create problems. The aims of the sorting trials were to:

1. Establish communication with all the main sorting equipment manufacturers and recyclers regarding the need for specifically tested sorting solutions for the recently developed detectable black plastics, which are expected to enter packaging markets in the near future. Conduct trials to sort detectable black CPET into the jazz PET stream, and evaluate the separation of CPET into its own unique stream so detectable black CPET articles could be recycled into a closed loop back into CPET packaging.
2. Conduct detection trials on CPET trays at equipment manufacturers' facilities and recyclers to identify any key adjustments to software and hardware required on the standard NIR sorting equipment. Investigate how these adjustments can be made available to recyclers and reprocessors and be readily applied to existing MRF and PRF sorting facilities.
3. Determine the sorting accuracy of black CPET from clear PET for each sorting system.
4. Determine the separation accuracy of black CPET via a positive CPET sort from PET.
5. Conduct an assessment to show the purity and yield of sorted black and clear PET streams when detectable black packaging had been sorted with other mixed plastics by systems from the main sorting manufacturers. Also provide details of any identified sorting limitations or challenges.

3.2.1 Bench scale trials with sorting equipment suppliers

Currently, reprocessors in the UK use NIR sorting machinery for large objects (like bottles and trays) and laser/NIR (for flake sorting) from BT-Wolfgang Binder GmbH (Redwave), MSS, Pellenc, RTT-Steinert (Unisort), Sesotec (S+S), Tomra (Titech) and Unisensor. The methodology to accomplish the first objective of this project was to work with the main NIR auto sorting equipment suppliers. This included an evaluation of detectable black CPET plastics trays and flake to establish the sorting efficiency in identifying detectable black trays and flake as PET with no modification or minor software adjustments. A second aspect of the bench scale trials was to conduct colour sort tests to positively identify detectable black PET trays and flake as coloured PET at the second and subsequent sorting stages of the recycling process so they were also then removed from a clear PET stream.

To accomplish this, trays and flake samples were sent to the equipment manufacturers. After testing was completed, the equipment suppliers reported results and developed any required software modifications to optimise the sorting efficiency of their systems.

3.2.2 Industrial scale sorting trials at Recyclers

Industrial scale sorting trials were then organised with UK reprocessors to achieve real life detectable black plastic sorting solutions, which could be implemented at all UK PET plastics sorting plants. Sorting trials on detectable black CPET and trays were conducted at Closed Loop Recycling (CLR), and ECO Plastics in the UK, and Poly Recycling in Switzerland, so that four of the sorting equipment suppliers could be evaluated.

Samples of trays were taken to each recycler and specific numbers of trays were placed into the recycle stream to assess sorting efficiencies. Representatives from the relevant sorting equipment supplier attended the trials. The results of both PET identification and colour separation were quantified by counting the trays diverted to PET or landfill and coloured or clear PET streams, as well as recording the data from the sorting equipment.

3.3 Application trials with converters

Markets for coloured PET are typically in the strapping, fibre and sheet extrusion/thermoforming markets. The impact of the detectable black plastics on these markets was evaluated in a series of trials:

1. A trial with PET strapping manufacturer, Interstrap, measured the impact of black CPET regrind on strapping, coloured rPET is typically used in large quantities and is not known to cause any processing issues in strapping manufacture. Dark colours, including black, are not usually present due to prior sorting steps.
2. A fibre spinning trial at Centexbel in Belgium who have pilot scale fibre spinning equipment that was used to produce PET fibre with black CPET regrind added to virgin PET. The impact of a range of levels of the black CPET on fibre processing and physical properties was measured in a series of trials.
3. A sheet extrusion and thermoforming trial at Faerch Plast making black APET products with black CPET regrind and inhouse rPET that produced food grade APET trays. This trial assessed the acceptability of detectable black CPET flake in black APET thermoformed products.

4.0 Manufacture of detectable black trays

Detectable black masterbatch IRR Black 95559 from Colour Tone Masterbatches was used in earlier trials then further developed to IRR black 95591 to provide improved opacity and meet colour requirements. An initial sample of 95591 was used at Faerch Plast to conduct a small trial to produce CPET trays that were supplied to sorting equipment manufacturers for bench scale testing. An additional 100kg of 95591 detectable black colourant was used at Faerch Plast to conduct a larger three tonne CPET extrusion and thermoforming trial to evaluate processing behaviour over an extended period and to provide trays for trials with recyclers and regrind for application trials. Faerch Plast reported that processing conditions did not require adjustment and the product met all of the usual quality and performance requirements. Two hundred kilograms of CPET trays were reserved for use with trials at recyclers.

Regrind was manufactured from crystallised trays to ensure there was an adequate level of crystallinity in the shredded material so that it was able to be dried under typical commercial conditions without clumping that can often happen with amorphous PET and which leads to bridging and blockages. Approximately eight hundred kilograms of regrind was shipped to Interstrap for strapping trials. Faerch Plast used five hundred kilograms for its own APET trials and a further one thousand one hundred kilograms was available for fibre manufacture and any other production trials including flake sorting evaluations.

5.0 Equipment Suppliers; NIR and colour sorting trials.

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Bench scale trials using detectable black CPET trays manufactured at Faerch Plast were performed at the major sorting equipment manufacturers; BT-Wolfgang Binder (Redwave), MSS, Pellenc, RTT Steinert (Unisort), Sesotec (S+S), and Tomra (Titech). The first two aims of these tests was to investigate if detectable black articles could be recovered into the PET stream and not lost to landfill and if they could be sorted and removed from the high value clear PET that might otherwise be contaminated.

Equipment suppliers were guided only in the objective of the trials and they each utilised different methods to conduct the trial and evaluations. Some equipment suppliers used a static test with only the detectable black CPET trays; other suppliers conducted a dynamic identification and sorting trial by mixing the detectable black CPET trays with other materials and using both positive identification to eject PET and negative sorting to drop only PET. All suppliers confirmed that their equipment was able to identify the detectable black trays as PET and also as coloured PET with minimal or no adjustment to the software programmes. The suppliers indicated that the NIR PET signal from the detectable black CPET tray material was strong and distinctly PET in character and that it was expected that earlier models of their equipment should in principle be able to identify the black CPET trays; however, some evaluation and optimisation was recommended to ensure the best possible efficiency.

Most suppliers utilised their software system to create a new "CPET class" of material to optimise the identification and sorting process. Creating a new class of material for the NIR detection system to identify is a straight forward process that can be accomplished by most operators. Using these software modifications all systems were able to identify detectable black CPET trays and sort them into the PET stream at an efficiency of 95% or better.

Colour sorters were able to separate the detectable black CPET trays from clear PET in either positive sort mode selecting coloured PET or in negative sort mode selecting clear PET with efficiencies of at least 95%. There were minimal yield losses of just 0.1% of clear material when using a positive sort mode for coloured PET.

A third objective of these trials was to determine if the NIR detection equipment could also identify the trays as CPET, distinct from APET, so that a separation of detectable black CPET packaging into its own stream would be feasible. This capability would make it possible to close the loop on the detectable black CPET packaging so that it could be recycled back into new CPET products. Bench scale trials with the equipment suppliers confirmed that by creating a "CPET class" there was sufficient difference in the NIR signal to enable CPET material to be identified distinctly from APET materials, so that detectable black CPET materials could be isolated into a unique stream at efficiencies of at least 95% in a single step. This would enable CPET material to be removed from APET material if there were any concerns or any potential impact on applications from having a mixture of APET and CPET materials.

6.0 Equipment suppliers colour flake sorting trials

Equipment suppliers that manufacture flake sorting equipment, i.e. Sesotec (S+S), Titech and Unisensor were requested to conduct bench scale trials to remove any detectable black flake from the clear PET flake stream. The black CPET flake supplied (from Faerch Plast) was tray regrind, made for in house re-extrusion, and was small in size, approximately 2-6mm. In comparison, ground recycled material at reprocessors typically presented to flake sorters is approximately 10-15mm. Some suppliers prepared their own flake samples by cutting up trays to a more typical 10mm flake size and trials were conducted with these handmade flake samples. Subsequent trials at reprocessors used larger flake size with results that are presented in Section 7.

Similar to the bench scale trials with trays, the equipment manufacturers created a "CPET class" in their software systems to optimise identification and sorting efficiencies of the detectable black CPET flake. Some adjustment of sensitivity was possible to maximise the removal of the black flake or minimise yield losses of clear PET. The trials demonstrated that the detectable black CPET flake could be removed at efficiencies of better than 99%.

Flake sorters are typically used as a final polish stage to reduce (low) concentrations of contamination to very low levels to provide a high quality material for applications such as clear rPET for bottles. The bench scale trials have showed that flake sorting is equally effective at the identification and removal of detectable black CPET as it is with other coloured materials to prevent contamination of the clear rPET stream.

7.0 Plastic Reprocessors sorting trials

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7.1 Closed Loop Recycling (CLR)

7.1.1 Tray sorting Pellenc Unit

Closed Loop Recycling operates a Pellenc NIR bottle sorter on the mixed plastic line to positively identify PET, and HDPE and negatively sort the other plastics in a three way split. A colour sorter then operates in series, to split the PET stream into clear and coloured PET fractions. During a scheduled maintenance period, trials were arranged and detectable black CPET trays were passed through the Pellenc system to validate the results obtained from the bench scale testing and confirm whether the detectable black CPET trays could be readily identifiable as PET by the NIR sorters and the subsequent colour sorter would remove the tray into the coloured rPET stream. Due to the down time the regular flow of in feed material was not available for the trial and so black trays were sorted through the process as a single material.

One tray was passed through the unit to evaluate identification. This test spectrum was similar to PET with segments that identify the tray as CPET and this was added into the software on the unit as a specific material type. Trays were then manually placed on the sorting belt by hand at regular intervals and sorted to PET and non-PET streams using otherwise standard operating conditions and with no other software adjustment. Results were quantified by counting the trays that had been positively identified and ejected into the PET stream by the NIR sorter and also any trays that remained in the clear PET stream after the colour sorter.

All 49 trays were identified and sorted into the PET stream with a 100% recovery rate. Review of the Pellenc unit also confirmed that 36 of the 49 trays were identified as the CPET grade previously added to the units menu. It is likely that further optimisation would improve the CPET identification percentage if identification and sorting to a separate stream was required at this stage of the process.

The 49 black trays then passed through the visible colour sorter unit and on which no adjustment was made. All 49 trays were correctly identified as coloured PET and ejected from the clear PET fraction in the same manner as coloured PET material is ejected under normal production conditions.

Figure 1: Closed Loop Recycling tray sorting trial

7.1.2 Tray sorting S+S unit

Closed Loop Recycling also operate an S+S NIR/colour sorter on another line to separate coloured PET and other plastics to purify the clear rPET stream. This is a single unit that identifies and ejects both non-PET and all coloured material (including coloured PET) into a single stream, providing a negative sort on clear PET and results in detectable black trays being sorted with coloured PET from clear PET in one step.

Due to the test being conducted during a maintenance period, the regular flow of in feed material was not available for the trial and so black trays were sorted through the process as a single material. Trays were placed on the sorting belt by hand at regular intervals and sorted to clear PET and a reject stream with all other materials using standard S+S conditions and no software adjustment. Results were quantified by counting the trays that remained in the clear PET stream after the colour sorter.

The in-feed belt to the S+S sorter was relatively short and manually placing trays on to the moving belt was causing some trays to bounce and they may have still been moving relative to the belt when passing under the detector. If trays are not static on the belt the detection, identification and ejection can be affected and sorting efficiency reduced. It was not possible to see if trays were static when they reached the detectors, however the two runs provided identical results, effectively sorting 88 trays with a very high efficiency of 91%, without any adjustment or optimisation for the detectable black trays.

7.1.3 Flake sorting

Closed loop recycling operate an S+S colour flake sorter as part of their process to purify clear PET flake. S+S had successfully demonstrated in bench-scale trials that the small regrind flake <4mm was able to be detected and sorted from clear PET flake, however this small size regrind flake was considered difficult to sort with high efficiency in an industrial situation. Trays were cut into square 10mm pieces so that a more typical flake size could be evaluated in the CLR trial.

Exactly one hundred 10mm flakes were mixed with 10kg of clear PET flake representing a concentration of approximately 0.5% by weight. The flake blend was fed into the S+S colour sorter running under standard conditions, without any software adjustment, and the recovered and rejected fractions collected for evaluation. Of the 100 black PET pieces, 93 were correctly ejected, with only 1 piece going through to recovery and 6 pieces not exiting the sorter, which are likely to have been trapped in the loading mechanism or exit chute.

Table 1: Closed Loop Recycling black flake sorting trial results.

Composition	Input (kg /No.)	Recover (% /No.)	Eject (% / No.)	Lost (% / No.)
Clear rPET	10kg	99%	1.0%	NA
Black CPET Flakes	0.1kg / 100	0.1% / 1	93% / 93	0.6% / 6

Figure 2: 10mm black CPET flake

This small in-situ trial at Closed Loop Recycling confirms the previous testing done by S+S that the detectable black CPET flakes are readily identified by colour sorting and are efficiently separated from clear rPET flake along with other coloured material under commercial reprocessors operating conditions.

7.2 Sorting trial at ECO Plastics

A sorting trial was conducted with ECO Plastics and TITECH to determine the sorting efficiency of the detectable black plastics from clear PET. ECO Plastics operate a large and automated sorting and recycling facility in the UK with a relatively complex and integrated system of conveyors and sorting units. A schematic of the small part of the plant that was used for trials is shown in Fig. 3 below.

There were three specific technical objectives for the trials to determine how the detectable black CPET trays are sorted in the plant and what fractions they are sorted to:

1. To quantify the proportion of black CPET trays identified as PET at the first NIR detector. (The black trays stay with PET bottles and APET trays).
2. To quantify the proportion of black trays identified as coloured PET at the second (colour) detector. (Trays are intended to be removed from the clear PET stream). These first 2 steps would be done in a single pass.
3. To quantify the proportion of black CPET trays that can be identified by NIR separately to APET trays and bottles and are sorted into a CPET stream as achieved in the laboratory trials. (TITECH made a software adjustment to the sorter to differentiate between the two materials and additional trays and clear PET was run through the line to conduct the trial).

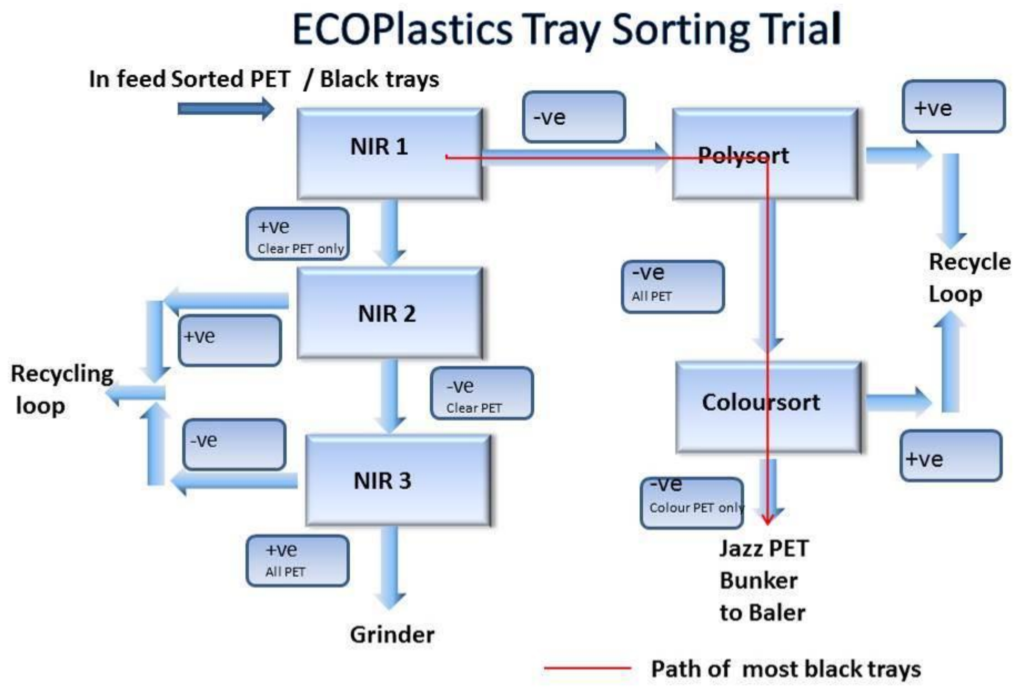


Figure 3: Schematic of sorting process at ECO Plastics for objectives 1 and 2.

Objectives 1 and 2 were conducted in a single run using the sorting line for pre-sorted PET bottle in-feed. Running at normal production speeds of 6,000 kg/hr for a 20-30 min time period, over one thousand trays were manually fed onto the conveyor to provide an average detectable black tray concentration of about 1% in the in-feed material. This represented a higher concentration of black articles in the in-feed stream than is usually seen in production at ECO Plastics and was considered sufficiently rigorous for the trial.

The clear rPET stream, the drop conveyor from the first NIR sort, the recovery loop and the residue streams were continuously monitored to observe any black trays. It was expected that a majority of black trays would be sorted as coloured rPET and be directed to the coloured jazz rPET fraction so that any black trays in the clear rPET stream or the residual mixed plastic stream would be easily seen and recorded. This same trial was run twice under the same conditions to validate results. Over the course of the two trials, sorting over 2,300 trays, only 1 tray was observed in the residue (mixed plastic) fraction in the first trial and no trays were detected in the clear rPET stream in either trial.

Results below in Table 2 show that the detectable black trays were successfully sorted into the coloured jazz fraction at a high efficiency, with no contamination of the clear rPET stream and only 0.05%, or 1 tray, being lost to the residue or mixed plastic fraction. Although a high level of sorting efficiency was expected based on the bench scale testing, the ability of the process to completely exclude black trays from the clear rPET stream was an affirmation of the design of the ECO Plastics system, the ease of identification of the detectable black CPET trays and the performance of the optical sorting units.

Table 2: Quantitative results of objective 1 and 2 sorting trials

Trial	Trays Input (kg / No.)	Recovery to colour / jazz PET (% / No.)	Contamination to clear rPET (% / No.)	Lost to residue mix plastics (% / No.)
Trial #1	17.5kg / 1171	99.95%/ 1170	0%/ 0	0.05% / 1
Trial #2	17.5kg / 1171	100 %/ 1171	0%/ 0	0% / 0

Figure 4: Coloured jazz fraction including sorted black trays

The complete absence of any black trays in the clear rPET stream was a notable outcome from the trial, and should provide some reassurance that the inclusion of detectable black PET products will not result in any significant contamination of the clear rPET stream.

A further trial was conducted on the separate recovery line which had only one NIR sorting unit to complete objective 3, the sorting of detectable black CPET trays from APET and other PET by NIR. This was based on the signal being distinguishable from clear APET, coloured APET and other PET products. It was demonstrated during the bench scale trial at TITECH that while the detectable black CPET trays had a clear and distinctive PET signal, there were distinguishing features of the spectrum that would enable a new classification to be programmed into the NIR sorting units so that the detectable CPET trays could be uniquely identified and sorted as CPET, separate from APET material. TITECH technical staff made the programming adjustments to the single sorting unit, and added CPET as a new classification so it could be positively identified and ejected, non-CPET materials such as the bottles would be in the drop fraction.

Clear and coloured PET bottles were collected and mixed with black trays at a 1:1 ratio, so that there were 100 bottles and 100 trays, 200 articles in total. These were spread on a stationary belt 6m long and 1 m wide, prior to the acceleration belt and the sorting unit itself. Conveyers were then started, and the sample sorted into either CPET or non-CPET fractions in a single pass and collected in bins for inspection.

Figure 5: NIR sorting classification to CPET (LHS) and non-CPET (RHS) after single pass.

Only two CPET trays were not identified or effectively ejected and dropped into the non-CPET fraction. As has been observed in other trials if the articles are still moving relative to the acceleration belt, the timing between identification and ejection can be affected, resulting in correct identification but a missed ejection. This is a common occurrence when belts first start moving and the inertia of the articles take a few seconds to come to equilibrium. It may be that some of the very first trays were not static on the acceleration belt as it started up, which caused a missed timing of the ejection.

Table 3: Results from NIR CPET identification sorting trial

Trays Input (kg / No.)	**Recover to CPET (% / No.)**	**Lost to Non-CPET (% / No.)**
1.5kg / 100	98% / 98	2% / 2

The trial results are very positive evidence that detectable black CPET trays could be sorted by NIR into a separate fraction from a mixed plastic or sorted PET stream once a classification for CPET has been programmed. The capability of a recycling plant to isolate CPET may provide an additional product that can be sold at a favourable value to compensate for the cost of the additional sorting process.

Only 1 single tray from the 2,300 trays used in both trials, was sorted into the residue stream, confirming that detectable black trays will not be lost to low value mixed plastics residue stream or landfill. This will improve overall yields and reduce landfill costs.

7.3 Poly Recycling

Poly Recycling in Switzerland conducted quantitative online sorting trials on MSS NIR sorting units with the detectable black CPET trays to measure how efficiently the CPET trays were separated compared to other products. The trial involved measuring the number of trays that were successfully identified by the MSS bottle sorting equipment. No modification or software adjustment was made to the sorting unit and trays were presented in a number of conditions to ensure accuracy of the results (Table 4).

Table 4: CPET tray sorting results at Poly Recycling

CPET Tray		Input	Recover to PET	Not identified
Gloss (inside) side up		100	100	0
Matt (outside) side up		100	99	1
Crushed Matt side up		100	97	3

Results clearly show that the detectable black CPET trays are readily identified and sorted at high efficiency regardless of the orientation on the belt. Although the detectable black CPET trays are monolayer, because of the matt grey appearance on the outside of the tray, operators considered that this might affect results and so tested identification results on both the inside (gloss) and outside (matt grey) of the CPET trays. Sorting of trays that had been crushed to simulate the condition in which they would usually appear, was also evaluated. Results show a small decrease in efficiency of identification; however, the detectable black trays continue to be identified and sorted at very high efficiencies of 97%.

8.0 Feedback from recyclers on detectable black plastics

A questionnaire was sent to recyclers to gain their views and an understanding of the impact that detectable black plastics may have on their operations and products. While an increase in the recovery of black plastics would reduce material going to landfill, concern had been expressed regarding the impact on processing costs and quality of existing products and materials if they included black plastics or the black plastic was not adequately removed. At the time of the questionnaire recyclers were informed that the detectable black plastics could be sorted from existing clear and coloured streams; however, the sorting trials at recyclers had not been completed and no quantitative results were available. A copy of the questionnaire is listed in Appendix 1 and the summary of the responses and some quotes from them are provided below.

Can you indicate the amount of coloured rPET that you would process/sell?

Can you also estimate the percent of black plastics in the input/coloured PET stream.

A large recycler that processed mixed plastic materials had several hundred tonnes per month of coloured rPET or other materials. Because of the current carbon black pigment, black materials are not sorted and black plastics are not represented in these coloured jazz streams.

“The black would be a separate quality as black is limiting our current applications. We might use 1000 tonne of black in the future”

To whom or to what applications do you sell the coloured rPET.

Depending on the destination / application, the presence of small or large amounts of black rPET may impact on the performance of the coloured rPET material.

All recyclers are selling only to UK and EU customers, strapping applications was a common market as well as fibre and other packaging applications including sheet and compounders. Each application has a separate specification and quality requirement, for example strapping generally required predominantly green rPET.

“Needs to be a separate quality for all applications”

Is the coloured rPET sold as baled bottles, flake or washed flake?

The level of reprocessing may impact on what applications the coloured rPET is being used for.

Coloured material was sold at all stages of processing from baled bottles/packaging, washed flake and pelletised material, according the reprocessors own capabilities and market application requirements. Typically baled material is simply the rejects from sorting clear rPET, while flakes and pelletised materials were often further processed for a specific application and specification.

Is there a colour or other specification for the grade / composition / quality of the coloured rPET

A colour or other specification for coloured rPET may limit the percentage of black PET

All of the recyclers who process coloured materials indicated that they supply to customers specification of Intrinsic Viscosity (IV), colour and purity. The presence of black in the coloured stream would impact on the colour specification and need to be removed to meet current specifications. Generally black was not a desirable colour in the jazz stream for most specifications and applications.

“None of our customers have any interest in black recycled PET”

“Customer provides specification – food grade, colour, IV, being the priority part of the spec”

Can you comment on any issues with sorting detectable black plastics into the coloured PET stream that you consider would have a positive or negative impact on recycling plastics materials and their applications?

Trials and evaluations have been conducted to ensure detectable black plastics can be detectable as PET and are colour-sorted so they are removed from the clear PET stream, similar to existing coloured PET articles.

Recyclers raised concern with regard to an increased presence of black being included into the coloured plastic stream, the potential contamination of the clear rPET stream, increased operating and capital costs for sorting or removing the detectable black plastics and the demand / value of a separate black fraction. It was commented that while detectable black would add volume to the coloured fraction, the need to separate it in most instances would negate the improved yield unless there was a market of equal value for the black fraction.

“The modifications required to current sorting facilities would negate any positives in doing this”

“It would be a disaster if the black PET (typically cPET) were to be included with other coloured PET, certainly in terms of colour but likely polymer properties”

Clearly the recyclers had strong concerns regarding the introduction of detectable black plastics and the potential impact on existing processes and products, as might be expected with the introduction of any new material to the recycling stream. Testing and trials have shown that the detectable black can be effectively and efficiently sorted from clear rPET with existing equipment and processes and this should not present any additional cost to recyclers. For some applications, like green PET strapping, coloured jazz rPET material may require additional processing and perhaps capital costs. The question then raised by recyclers is whether there are applications and markets for this new additional stream of material that are of sufficient value to offset the operational and capital costs they will likely incur.

9.0 Market Development trials

9.1 Strapping

PET Strapping is widely used for a range of applications, it provides a grade that is significantly stronger than PP strapping and is often more easily used than steel strapping materials. PET strapping itself can use high IV grades of PET for high tensile applications or lower IV grades for "standard" applications, typically made using 100% rPET it is a major consumer of coloured jazz recycled PET. Trials have been conducted to determine if the presence of detectable black CPET material in the coloured PET recycling stream has any impact on the manufacture, specification performance and application of PET strapping using recycled PET.

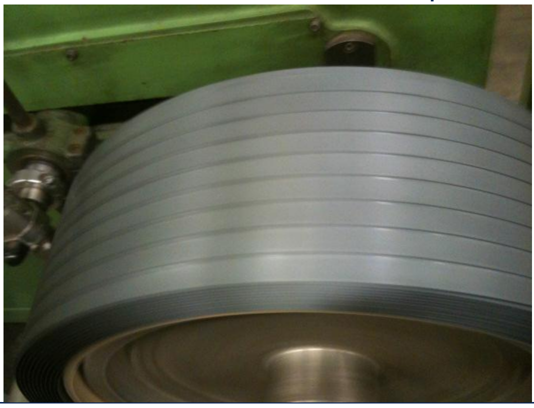
PET strapping manufactured by a number of suppliers is predominantly green in colour, and has a colour specification as part of its quality standard. To manufacture PET strapping producers use jazz rPET that is produced to a colour specification to ensure the final green strapping product is consistent. In particular the coloured jazz rPET is sorted to remove dark and opaque colours which have the greatest impact on the final colour of the strapping product.

Interstrap received CPET regrind from Faerch Plast to conduct the PET trapping trial. They evaluated the detectable black CPET in green strapping and determined that at levels of as low as 1%, the black would have a negative impact on the final green colour of the product and that it would be outside the current specifications.

Knowing that a standard green strapping could not be made using any significant level of detectable black CPET, a trial was run using 100% detectable black CPET material to evaluate processing and physical properties. A silvery-grey colour strapping product was successfully manufactured without breakage or any other operational issues under standard conditions. It is thought the silvery grey colour is the result of an increased level of crystallinity that may be induced by the nucleators in the CPET and stress whitening that results from the orientation and drawing process that strengthens the strapping.

Extruded wide thick black tapes

Tapes thin and narrow as they are drawn



Stress whitening impacts on final colour

Standard green PET strapping

Figure 6: Strapping made at Interstrap using 100% detectable black CPET

Interstrap manufactured strapping from 100% detectable black CPET which was tested using standard quality control methods for tensile strength and also the strength of the weld.

Table 5: Tensile and weld test results for CPET strapping.

Material	Tensile strength	Weld strength
Standard Green APET	475N (minimum)	Min 80% of tensile strength
CPET black (100%)	381N (80% of minimum)	317N (83%)

The results show that the use of 100% CPET results in a tensile strength lower than the standard product. This suggests that a blend may need to be used rather than using the 100% CPET. The weld strength of the strapping met the requirement of retaining at least 80% of the tensile strength, suggesting that a blend with APET would also be satisfactory provided there was a market for this colour.

To meet the colour specification for green strapping applications the detectable black CPET would need to be removed just as dark and opaque rPET materials are currently removed from the coloured jazz rPET stream.

There are some smaller volumes of black grades of PET strapping made and there are also other developments in the strapping market that in the future could use coloured jazz rPET which contained significant amounts of detectable black CPET.

9.2 Fibre

The PET fibre market is a major consumer of recycled PET globally and is able to use coloured rPET in coloured fibre applications for clothing, carpet, upholstery, tyres, ropes and a broad range of other industrial applications. The spinning and drawing of PET fibre is a technical process requiring specific material properties to achieve the required fibre strength and toughness. Fibre applications commonly used coloured jazz rPET that is specified and selected for the manufacture of products that will not be impacted by a coloured fibre because it will be subsequently dyed or otherwise coloured to make black products.

Trials were conducted to assess if the presence of CPET material at a range of concentrations had an impact on the processing and physical properties of the fibre.

Centexbel supports the Belgian textile industry in the development of novel and quality products by offering specialised textile tests, analyses, technological and environmental advice. Based in Gent, Belgium it has a pilot scale fibre spinning line that enabled a wide range of CPET concentrations to be evaluated under production conditions. Centexbel was supplied with CPET regrind from Faerch Plast, which was blended with virgin PET at a range of concentrations and each blend made into a yarn which was then tested according to EN ISO 2062(2009). Full experimental details and results are listed in Appendix 2.

Table 6: Fibre test results for CPET blends.

Composition (%virgin / %CPET)	**Modulus** (chord 1-3%)(N/tex)	**Tenacity at Break** (N/tex)	**Elongation at break** (%)
100 / 0	1.21	0.124	58.7
98 / 2	1.29	0.126	79.1
95 / 5	1.26	0.127	68.0
90 / 10	1.42	0.133	77.5
80 / 20	1.63	0.141	70.9

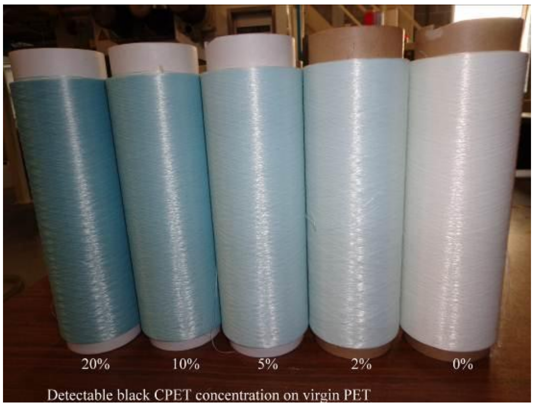


Figure 7: Centexbel fibre spinning trial bobbins produced

The test results show a slight trend of increasing Modulus and Tenacity without impacting on elongation with increasing CPET concentrations. While the increase is small it highlights that there was no negative impact on physical properties, and coloured rPET containing CPET could be readily used.

Centexbel's comments on the processing of all concentrations of CPET up to 20% were that there were no significant differences observed, other than the increased colouration that can be seen in Fig 7 with an increased concentration of the detectable black CPET.

These results showed that detectable black CPET products can be included in the coloured rPET stream at significant levels of at least 20% and can be processed without any negative impact.

With the remaining material and time available additional trials were conducted with 0% and 10% CPET concentration to vary the melt draw ratio / cold draw ratio, which required an in increased spinning speed. These variables were not tested for physical properties but processed without issue, further highlighting that CPET is not impacting on fibre processing properties and performance. The full results are in Appendix 2.

These trial results show that the presence of detectable black CPET will not have any impact on the processing or physical performance of fibres and fibre processors can continue to use coloured jazz rPET when it contains detectable black CPET at levels of up to 20%. At increased levels of detectable black CPET there may be some light colour fibre products that would no longer be suitable, and the coloured jazz rPET would need to be used at reduced levels. Recyclers will be able to continue to sell coloured jazz rPET which has levels of detectable black CPET of at least 20% into fibre applications and will not need to conduct any further sorting or separation to isolate the CPET. Fibre applications offer an on-going opportunity for the sale of coloured jazz rPET, while the amounts of detectable black CPET in the market are relatively small, and use for dark fibre colours can continue when levels have increased significantly.

9.3 APET Sheet extrusion & thermoforming

Faerch Plast produced the detectable black CPET trays and regrind that has been used in sorting evaluations and application trials in this project and also produced black APET products. Although CPET is not usually used in APET applications, it was considered that black APET packaging may be a suitable application for recycled detectable black CPET trays. A trial was conducted to assess the Extrusion and Thermoforming process and physical performance of APET trays made with regrind from detectable black CPET.

Figure 8: Images of detectable black CPET extruded to sheet and thermoformed into APET tray

The APET sheet uses virgin PET on the two external surface layers, and a blend of internal regrind and rPET in a core layer, often referred to as an A/B/A structure. Detectable black CPET regrind was added at 7.5% and 15% addition rate into the core layer and 800kg of each of the two grades of sheet were made. Both percentages of black CPET extruded under standard conditions using vacuum vented extrusion without pre-drying. Each grade of sheet was then thermoformed into 300 APET meat trays under standard operating and process conditions. Faerch Plast evaluated the trays for the full range of tray parameters and reported that trays meet all required specifications and were suitable for commercial use. The trial trays were retained and the remaining sheet material was approved for production based on the tray evaluation results, confirming that detectable black CPET products could be recycled into black APET products, utilising at least 15% recycled regrind content.

Some black APET products use coloured jazz rPET, most commonly in an A/B/A structure with virgin PET external cap layers. These results show that the presence of detectable black CPET in the coloured jazz stream would not have an impact on the processing of performance of those products, and manufacturers could continue to use rPET as part of their structure.

Recyclers would be able to continue to sell coloured jazz rPET which had levels of detectable black CPET of at least 15% into this application and would not need to conduct any further sorting or separation to isolate the CPET. Black APET applications offer an immediate opportunity for the sale of coloured jazz rPET, while the amounts of detectable black CPET in the market are relatively small, and the application is sufficiently robust to continue when levels have increased, at which point the volume would be sufficient to consider producing a separate black CPET stream to close the loop back into CPET trays. Being primarily a monolayer structure and its use in higher temperature food applications food grade decontamination would be required.

10.0 Conclusions

Detectable black plastic packaging can be introduced into the UK market with minimal risk to existing product streams such as clear rPET and coloured rPET and the applications these products are sold into. The project results clearly indicate that detectable black CPET products can be readily detected and sorted at high efficiency by existing automated sorting equipment and commercial sorting installations with minimal, if any, software or process adjustment.

For packaging manufacturers these results show that products using detectable black colourant can be marketed with the knowledge that when collected for recycling their products will be able to be correctly identified and sorted by the recyclers and unlike products using carbon black pigments, by using detectable black colourant their products will not end up in landfill.

Recyclers can now be confident that products using detectable black colourant in the recycling stream can be correctly identified and sorted into the coloured jazz rPET stream in the same way other colours are sorted using existing equipment and processes so the detectable black packaging will not contaminate the clear rPET fraction and will not have a negative impact on most applications for the mixed coloured PET.

Applications such as PET fibre and APET trays were able to use detectable black CPET at significant levels without adversely affecting physical properties or the manufacturing process conditions. For green PET strapping the coloured specification was affected at levels as low as 1% detectable black CPET making this product unsuitable; however, there is a smaller market for black PET strapping where rPET containing detectable black CPET could be used, and potential for other applications to be developed.

All of the NIR sorters that were tested were also able to identify detectable black CPET as a separate material distinct from the APET used in bottles and other trays, so that recyclers could isolate a unique stream containing only CPET. This would enable recyclers to market a new product that could be decontaminated back to food grade for reuse in CPET trays closing the loop on this application.

The equipment configuration from different suppliers and existing recyclers installations varies significantly in process methodology, with positive and negative PET sorting, combination and sequential sorting by materials and colour so that a large number of options for sorting mixed plastic materials could be achieved.

The inclusion of a detectable black CPET into the mixed plastics stream was in effect an addition of a new colour of PET in to the jazz rPET stream and this will impact the specification of that fraction. This change presents recyclers with the opportunity to grow or develop new markets for this additional material such as fibre, black PET strapping, APET and CPET by further sorting into black or CPET fractions or as a darker coloured jazz specification.

11.0 Recommendations

Based on the results of this study, it is recommended that detectable black colourants be proposed as a viable option to carbon black pigments in the manufacture of black packaging such as APET, CPET, PE and PP packaging. The additional cost of detectable black colourants has been considered in earlier studies and it is anticipated that this cost difference compared to carbon black will reduce over time as demand and volume increases.

A further consideration specifically for detectable black CPET is that this material could then be used back into CPET packaging so that closed-loop recycling of black CPET could be feasible for the first time.

If producers of detectable black packaging were encouraged to buy recycled black packaging (which would be only detectable black articles), recyclers would be provided with a new market into which they can sell the new product and begin to recover any cost for additional sorting. With a fully closed loop process converters of products like black trays would have the opportunity to buy back the recycled detectable black packaging so they might recoup some of the additional costs of the detectable black colourant invested into the packaging.

It is recommended that a coordinated programme is delivered that disseminates the information in this report to recycling plant operators as well as the respective NIR equipment suppliers.

For the avoidance of doubt no direct comparison of individual equipment, technology or process performance should be drawn from the information published throughout this report. For all equipment, technology or processes tested, the equipment, technology or process may have been tested under different conditions and using different methodologies and therefore may not be comparable.

Appendix 1 – Questionnaire

Questionnaire on Detectable black plastics in coloured PET recycle stream.

Background:
Thank you for taking the time to complete this brief questionnaire. Nextek Limited is performing this survey for a WRAP project, which seeks to demonstrate the performance and impact of detectable black PET articles in the recycling stream. The purpose is to develop strategies and actions to start diverting black plastics away from landfill. Project work has shown that the detectable black PET can be sorted into the coloured PET stream with high efficiency in existing auto sorting recycling facilities.
Information supplied is kept confidential, anonymous and used only for this project.

Questions	Response / Answers
1. Can you indicate the amount of coloured rPET that you would process/sell? Can you also estimate of the percent of black plastics in the input/coloured PET stream.	Eg.tonne / month, tonne/year
2. To whom or to what applications do you sell the coloured rPET. Depending on the destination / application, the presence of small or large amounts of black rPET may impact on the performance of the coloured rPET material.	Eg. UK or EU or international traders. And to which application would it be used? Fibre, Strapping, Packaging and Extrusion manufacturers, other
3.Is the coloured rPET sold as baled bottles, flake or washed flake? The level of reprocessing may impact on what applications the coloured rPET is being used for.	Eg.Unprocessed bottles baled and sold directly from colour bottle sorter. Bottles are shredded or further processed to remove caps / labels etc.
4. Is there a colour or other specification for the grade / composition / quality of the coloured rPET A colour or other specification for coloured rPET may limit the percentage of black PET.	Eg.Customer provides a specification as a minimum quality standard. There is an in-house specification to ensure yields and quality.
5. Can you comment on any issues with sorting detectable black plastics into the coloured PET stream that you consider would have a positive or negative impact on recycling plastics materials and their applications? Trials and evaluations have been conducted to ensure detectable black plastics can be detectable as PET and are colour-sorted so they are removed from the clear PET stream, similar to existing coloured PET articles.	Eg.Inclusion of black rPET will improve yields of coloured rPET, reduce volume of lower value mixed plastics or landfill costs. Eg. Presence of black in the coloured or jazz stream will reduce its value and use in some applications

Please attach documents, photos, etc that you think may help to better understand what the impact of detectable black plastics may have on recycling and the use of the recycled materials. – THANK YOU.

Appendix 2 - Centexbel Fibre Trial.

Company: Nextek

Title
Spinnability of CPET

Required tests:
Spinability of different concentrations of CPET in virgin PET

Materials:
PET Invista RT20
CPET

Date of the trials: 05/02/2013

Head of the technology platform: Veerle Herrygers

1 EXTRUSION

For the evaluation of spinnability of the CPET material, the following testes were performed:
Series 1 – sample TA-NEXTEK-280 to TA-NEXTEK-284:

- Production of a bobbin at a reference material, 4 dtex/ fil
- Evaluation of the maximum drawability by increasing the speed of the dual godets (last step in drawing)
- Evaluation of the minimum titer by decreasing the spinpump velocity
- Steadily increasing the concentration of CPET in the yarn

Step 2 – sample TA-NEXTEK-285-290

- Production of bobbins of 0% and 10% cPET at different ratio's of melt draw ratio/cold draw ratio
- (To do this, the overall spinning speed had to be increased)

In all tests performed, no significant differences between the virgin PET and the PET with varying concentrations of CPET could be observed. An overview of the results is given in the table below. The samples that were made have received a T-nr for further testing. The correspondance between the extrusion trials and the T-nrs are given in the last column of the table.

Bobbin	**Concentration cPET**	**Winding speed**	**Melt draw ratio**	**Cold draw ratio**	**Maximum speed dual godets**	**Minimum spinpump velocity**	**T-nr**
TA-NEXTEK-280	0%	1235	191	2.5	2200-2300	2.5	T1302022
TA-NEXTEK-281	2%	1225	191	2.5	2300-2300	2.5	T1302023
TA-NEXTEK-282	5%	1225	191	2.5	2400-2300	2.5	T1302024
TA-NEXTEK-283	10%	1225	191	2.5	2200-2200	2.5	T1302025
TA-NEXTEK-284	20%	1225	191	2.5	2100-2200	2.5	T1302026
TA-NEXTEK-285	10%	1770	191	2.5	-	-	T1302027
TA-NEXTEK-286	10%	1765	119	4.0	-	-	T1302028
TA-NEXTEK-287	10%	1765	265	1.8	-	-	T1302029
TA-NEXTEK-288	0%	1765	191	2.5	-	-	T1302030
TA-NEXTEK-289	0%	1745	119	4.0	-	-	T1302031
TA-NEXTEK-280	0%	1745	265	1.8	-	-	T1302032

2 DETAILED REPORTS

Test	1	2	3
Materials Used	100% PET	98% RT20 +	95% RT 20 +
	RT 20	2% CPET	5% CPET
Moisture content	RT20 : 61,1 ppm	CPET : 92,5 ppm	
Drying procedure	x cycli 30' 120°C+30' vacuum	7 days in vacuumoven 120 °C	
Sample ID	TA-NEXTEK-280	TA-NEXTEK-281	TA-NEXTEK-282
Temp. gradient Extruder °C	250-260-270-280	250-260-270-280	250-260-270-280
Extruder pressure (bar)	50	50	50
Temperature spinnerette (°C)	280	280	280
Spinerrette type	72 R	72 R	72 R
Spinpump (RPM)	5	5	5
Velocity extruder (rpm)	26	26	26
temperature cooling air (°C)	no cooling air	no cooling air	no cooling air
Spin Finish type + conc	Fasafin KB 88 (10%)	Fasafin KB 88 (10%)	Fasafin KB 88 (10%)
SF kiss roll (RPM)	8	8	8
slow godet (m/min - °C)	500 (80°C)	500 (80°C)	500 (80°C)
fast godet (m/min - °C)	850 (100°C)	850 (100°C)	850 (100°C)
dual godet (m/min - °C)	1250 (100°C)	1250 (100°C)	1250 (100°C)
winders godet (m/min)	1300 (60°C)	1300 (60°C)	1300 (60°C)
Winder (m/min)	1235	1225	1225
V&V	490	490	490
start filament fractures(m/min)	2200 - 2300	2300-2300	2300/2200
fractures at dual godets (m/min)	2200 - 2300	2300-2300	2400/2300
Mininum spinpump titer	2.5	2.5	2.5
materials (filaments, bobbins)	1 bobbin (7000m)	1 bobbin (7000m)	1 bobbin (7000m)
remarks	Minimum spinpump velocity: 2,5 rpm - At 2 rpm:fractures on slow end fast godet - melting drops at spinerrette - INTERLACER : 7,4 bar	Minimum spinpump velocity: 2,5 rpm - At 2 rpm: fractures on slow end fast godet - meltfractures - INTERLACER : 7,4 bar	Minimum spinpump velocity: 2,5 rpm - At 2 rpm: fractures on slow end fast godet - melt fractures - INTERLACER : 7,4 bar

Test	4	5	6
Materials Used	90% RT20 +	80% RT20 +	90% RT20 +
	10% CPET	20% CPET	10% CPET
Moisture content			
Drying procedure			
Sample ID	TA-NEXTEK-283	TA-NEXTEK-284	TA-NEXTEK-285
Temp. gradient Extruder °C	250-260-270-280	250-260-270-280	250-260-270-280
Extruder pressure (bar)	50	50	50
Temperature spinnerette (°C)	280	280	280
Spinerrette type	72 R	72 R	72 R
Spinpump (RPM)	5	5	7,2
Velocity extruder (rpm)	25	25	34
temperature cooling air (°C)	no cooling air	no cooling air	no cooling air
Spin Finish type + conc	Fasafin KB 88 (10%)	Fasafin KB 88 (10%)	Fasafin KB 88 (10%)
SF kiss roll (RPM)	8	8	8
slow godet (m/min - °C)	500 (80°C)	500 (80°C)	720(80°C)
fast godet (m/min - °C)	850 (100°C)	850 (100°C)	1200(100°C)
dual godet (m/min - °C)	1250 (100°C)	1250 (100°C)	1800(100°C)
winders godet (m/min)	1300 (60°C)	1300 (60°C)	1875(60°C)
Winder (m/min)	1225	1225	1770
V&V	490	490	490
start filament fractures(m/min)	2200/2200	2100/2200	/
fractures at dual godets (m/min)	2200/2200	2100/2200	/
Mininum spinpump titer	2.5	2.5	/
materials (filaments, bobbins)	1 bobbin (7000m)	1 bobbin (7000m)	1 bobbin (7000m)
titer (tex)	/	/	/
remarks	Minimum spinpump velocity: 2,5 rpm - At 2 rpm: fractures on slow end fast godet - INTERLACER : 7,4 bar	Minimum spinpump velocity: 2,5 rpm - meltfractures - INTERLACER : 7,4 bar	no fractures

Test	7	8	9
Materials Used	90% RT20 +	90% RT20 +	100% PET
	10% CPET	10% CPET	RT 20
Moisture content	/	/	/
Drying procedure	/	/	/
Sample ID	TA-NEXTEK-286	TA-NEXTEK-287	TA-NEXTEK-288
Temp. gradient Extruder °C	250-260-270-280	250-260-270-280	250-260-270-280
Extruder pressure (bar)	50	50	50
Temperature spinnerette (°C)	280	280	280
Spinerrette type	72 R	72 R	72 R
Spinpump (RPM)	7,2	7,2	7,2
Velocity extruder (rpm)	33	33	34
temperature cooling air (°C)	no cooling air	no cooling air	no cooling air
Spin Finish type + conc	Fasafin KB 88 (10%)	Fasafin KB 88 (10%)	Fasafin KB 88 (10%)
SF kiss roll (RPM)	8	8	8
slow godet (m/min - °C)	450(80°C)	1000(80°C)	720(80°C)
fast godet (m/min - °C)	900(100°C)	1300(100°C)	1200(100°C)
dual godet (m/min - °C)	1800(100°C)	1800(100°C)	1800(100°C)
winders godet (m/min)	1875(60°C)	1875(60°C)	1875(60°C)
Winder (m/min)	1765	1765	1765
V&V	490	490	490
start filament fractures(m/min)	/	/	/
fractures at dual godets (m/min)	/	/	/
Mininum spinpump titer	/	/	/
materials (filaments, bobbins)	1 bobbin (7000m)	1 bobbin (7000m)	1 bobbin (7000m)
titer (tex)	/	/	/
remarks	no fractures	no fractures	no fractures

Test	10	11
Materials Used	100% PET	100% PET
	RT 20	RT 20
Moisture content	/	/
Drying procedure	/	/
Sample ID	TA-NEXTEK-289	TA-NEXTEK-290
Temp. gradient Extruder °C	250-260-270-280	250-260-270-280
Extruder pressure (bar)	50	50
Temperature spinnerette (°C)	280	280
Spinerrette type	72 R	72 R
Spinpump (RPM)	7,2	7,2
Velocity extruder (rpm)	33	33
temperature cooling air (°C)	no cooling air	no cooling air
Spin Finish type + conc	Fasafin KB 88 (10%)	Fasafin KB 88 (10%)
SF kiss roll (RPM)	8	8
slow godet (m/min - °C)	450(80°C)	1000(80°C)
fast godet (m/min - °C)	900(100°C)	1300(100°C)
dual godet (m/min - °C)	1800(100°C)	1800(100°C)
winders godet (m/min)	1855(60°C)	1855(60°C)
Winder (m/min)	1745	1745
V&V	490	490
start filament fractures(m/min)	/	/
fractures at dual godets (m/min)	/	/
Mininum spinpump titer	/	/
/materials (filaments, bobbins)	1 bobbin (7000m)	1 bobbin (7000m)
titer (tex)	/	/
remarks	no fractures	no fractures

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Through our consultant

Your notice of	**Your reference**	**Date**
04-02-2013		20-02-2013

Analysis Report 13.00578.01

Required tests :

Centexbel	**Pilot line extrusion**
EN ISO 2062 (2009)	**Determination of the tensile strength and elongation of yarns**

Identification number	Information given by the client	Date of receipt
T1301748	PET Invista RT20	04-02-2013
T1301749	CPET	04-02-2013
T1302022	TA-NEXTEK - 280	08-02-2013
T1302023	TA-NEXTEK - 281	08-02-2013
T1302024	TA-NEXTEK - 282	08-02-2013
T1302025	TA-NEXTEK - 283	08-02-2013
T1302026	TA-NEXTEK - 284	08-02-2013

Veerle Herrygers

Order responsible

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The results of the analysis cover the received samples. Centexbel is not responsible for the representativeness of the samples.
In assessing compliance with the specifications, we did not take into account the uncertainty on the test results.

VAT BE 0459.218.289 **Fin. Acc. 210-0472965-45** **IBAN BE44 2100 4729 6545**

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Reference: **T1301748 - PET Invista RT20**
T1301749 - CPET

Pilot line extrusion

The report of the trials is given as attachment to this report.

Annex 1	Annex.1_report13.00578.01.pdf

Performed in the technological platform under the responsibility of Veerle Herrygers

Reference: **T1302022 - TA-NEXTEK - 280**
T1302023 - TA-NEXTEK - 281
T1302024 - TA-NEXTEK - 282
T1302025 - TA-NEXTEK - 283
T1302026 - TA-NEXTEK - 284

Determination of the tensile strength and elongation of yarns

Date of ending the test 19-02-2013
Standard used EN ISO 2062 (2009)

Deviation from the standard -
Conditioning 20°C, relative humidity 65%
Method A
Apparatus Instron, type CRE, class 0,5
Rate 250 mm/min
Pretension 0,5 cN/tex
Gauge length 250 mm
Number of bobbins 1
Number of measurements/bobbin 20

Reference			
	Modulus (chord 1%-3%) (N/tex)	Tenacity at breakage (N/tex)	Elongation at breakage (%)
T1302022	1.21	0.124	58.7
T1302023	1.29	0.126	79.1
T1302024	1.26	0.127	68.0
T1302025	1.42	0.133	77.5
T1302026	1.63	0.141	70.9

Annex 2 The individual results

Performed in the physical lab Ghent under the responsibility of Filip Ghekiere

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