Summary Report

Increasing the recyclability of Black Polypropylene packaging

The impact of increased levels of black polypropylene (PP) in the Jazz PP stream

This research demonstrates that using NIR detectable black pigment in the manufacture of black polypropylene plastic packaging could greatly enhance its opportunity for access to secondary markets and recycling into new product at end of life.

Project code: PMP011
Research date: 2018
Date: October 2018

WRAP's vision is a world in which resources are used sustainably.

Our mission is to accelerate the move to a sustainable resource-efficient economy through re-inventing how we design, produce and sell products; re-thinking how we use and consume products; and re-defining what is possible through re-use and recycling.

Find out more at www.wrap.org.uk

Written by: WRAP

Front cover photography: Stack of black pots

Contents

Figures

Glossary

Carbon Black – standard pigment used to turn polymers Black
Detectable – visible to NIR sorting equipment according to Polymer Type
Homogeneous – blended material that exhibits uniform technical properties throughout
Injection Moulding – the mechanical process used to mould plastic into products
Jazz – A mix of different colours within a single Polymer stream
Masterbatch – A concentrated mixture of pigments used for colouring plastic
Melt filtered pellet – Plastic chips (pellets) that have been produced through a re-melting process that homogenises technical properties and filters waste plastic to remove any remaining contaminants. Considered suitable for use as feedstock for new plastic products
NIR sorting –Process using Near Infra-red camera equipment to separate mixed plastics into separate polymer streams
Pigment – colourant added to polymers to create coloured plastic
Plaques – small squares of moulded plastic used as representative samples for evaluation of colour and surface finish
PP – Polypropylene
PP recycling stream – infrastructure through which Polypropylene is collected, sorted and recycled into new product
PTT – Pots, Tubs and Trays
Regrind – small chips made from clean rigid plastic products
Reprocessor – facility where waste plastics are converted to either washed flake, regrind or melt filtered pellet
Washed flake – small, thin chips created from dirty plastic that has been cleaned through a washing process

Acknowledgements

Biffa Polymers - Supplier of base washed PP flake material
Chase Plastics Ltd – Reprocessor site
Dart Products Europe – Carried out colour measurement
Imerys – Supplier of base washed PP flake material
RPC – Suppliers of black PP (detectable and conventional). Producers of plaques for colour comparison and paint pots

1.0 Summary

Black Plastic Packaging is perceived by many to be a major problem. It is viewed as being not recyclable because Near Infra-Red (NIR) sorting systems, used in sorting plants to detect and separate individual polymers streams, are effectively blind to plastic items made using Carbon Black pigment.

There are however, alternative Black pigments available that will enable conventional NIR detectors to successfully recognise and effectively sort Black plastic items according to polymer type. In 2011, WRAP published a report 'Development of NIR Detectable Black Plastic Packaging' which described the development of a solution that enabled the mechanical recycling of black plastic packaging that hitherto was destined only for landfill or energy recovery (http://www.wrap.org.uk/content/recyclability-black-plastic-packaging-0)

Despite this breakthrough, widespread adoption of detectable Black pigments in the manufacture of plastic packaging failed to take off. This was in part due to the additional cost of such detectable pigments but also because there remained the perception that there was no end market for Black plastic and that, if it became detectable, it would contaminate and potentially devalue the existing secondary markets for PET, PP and PE rigid packaging. Renewed focus on the 'problem' of Black plastic has now prompted WRAP to look again at this issue.

This trial, commissioned by WRAP and conducted by Recoup, demonstrates the minimal effect that an increasing % of 'detectable' Black PP packaging waste entering the current PP recycling stream would have upon existing end markets for PP packaging waste collected at kerbside.

It is estimated that if manufacturers of Black Polypropylene packaging were to switch to the use of detectable Black pigment, the amount of additional Polypropylene that would be recovered from the domestic waste stream for recycling would rise by up to 6.5%.

1.1 Key facts

- It is estimated that 162kT of polypropylene pot/tub/tray packaging is placed on the market each year[1] (2018 Pack Flow report), of which 85k tonnes is consumer. WRAP estimates that around 6.5% of the consumer PP packaging is black.
- Black plastics account for around 3.7% of all plastics currently being collected by local authorities[2]
- End markets for all the PP packaging currently being collected for recycling already exist.
- Dark colours and black products already represent the majority of the end market applications for recycled PP.

[1] *Plastic Packaging Flow Data Report, WRAP 2018*
[2] *Composition of Plastic Collected via Kerbside in MRFs and PRFs, WRAP 2018*

- No additional equipment would be required at sorting plants to capture Black PP packaging for recycling if use of detectable pigment was adopted by manufacturers.

1.2 Key conclusions

- Creating the ability to detect Black PP packaging at sorting plants and divert it into the PP recycling stream would increase PP recycling rates.
- The capture of Black Polypropylene packaging for recycling, at percentages representative of what is currently placed on the market, will not significantly affect the colour or quality of the Jazz recyclate generated from PP packaging collected at kerbside.
- The presence of Black PP at levels up to 10% has no discernible effect on the subsequent re-use in products such as paint containers.

2.0 Methodology

The purpose of this project was to demonstrate the changes that occur in the technical properties (particularly colour) of PP recyclate derived from kerbside collections through progressive inclusion of a percentage of Black PP packaging in line with compositional analysis of PP packaging placed on the market and currently collected for recycling.

High level methodology:

1. **A supply of washed PP flake representative of current kerbside** collected PP packaging waste
2. **A cross check sample of washed PP flake** from an alternative source to confirm that the washed PP flake procured is truly representative of UK waste stream
3. A supply of **conventional Carbon Black PP** packaging in regrind format
4. A supply of **'detectable Black PP packaging** in regrind format for comparative assessment
5. A reprocessor site capable of **accurate blending and compounding** of PP regrind to melt filtered pellet
6. A laboratory capable of **colour measurement and production of Plaques** from the melt filtered PP pellet produced during reprocessor site trials.
7. A PP injection moulding site capable of manufacturing **finished mouldings with an industry standard percentage of recycled PP** produced during reprocessor site trials.

Figure 1: Washed jazz PP flake from two UK sources of post-consumer material

2.1 Reprocessor process steps

The trial process steps (outlined below) ensured that the reprocessor trials effectively bracketed all likely percentages of Black PP that may enter the PP packaging recycling supply chain should detectable Black pigment become widely adopted.

Not only that but, should technologies not involving the use of detectable pigment be developed for sorting Black PP by polymer type, by using conventional Carbon Black in all the percentage trials we are still able to demonstrate that minimal changes in technical and colour properties occur at all likely addition rates.

1. Cross blend washed flake representative of the current kerbside collected PP packaging waste to ensure homogeneity.

Figure 2: Material mixer at Chase Plastics

2. Produce a control sample of melt filtered pellet from the cross blended washed PP flake alone.

Figure 3: PP strands (control sample)

Figure 4: PP pellet (control sample)

3. Cross blend by weight 95% homogenous flake and 5% of the Carbon Black PP regrind and produce a melt filtered pellet.

Figure 5: Pellet from 95% homogenous flake and 5% of the Carbon Black PP

4. Cross blend by weight 90% homogenous flake and 10% of the Carbon Black PP regrind and produce a melt filtered pellet.

Figure 6: Pellet from 90% homogenous flake and 10% of the Carbon Black PP

5. Cross blend by weight 85% homogenous flake and 15% of the Carbon Black PP regrind and produce a melt filtered pellet.
6. Cross blend by weight 80% homogenous flake and 20% of the Carbon Black PP regrind and produce a melt filtered pellet.
7. Cross blend by weight 95% homogenous flake and 5% of the 'Detectable' Black PP regrind and produce a melt filtered pellet.

Figure 7: Pellet from 95% homogenous flake and 5% of the Detectable Black PP

8. Cross blend by weight 90% homogenous flake and 10% of the 'Detectable' Black PP regrind and produce a melt filtered pellet.
9. 5 Kg samples of all 7 production runs were taken for colour testing and the production of comparative plaques
10. 125 Kgs from each production run was packaged up for despatch to the injection moulding site ready for the manufacture of mouldings containing industry standard recycled content.

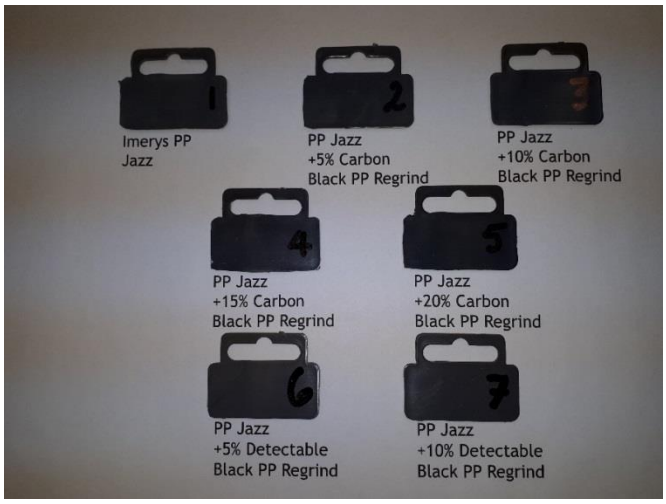
Figure 8: All samples packaged up ready for manufacture

2.2 Production of plaques, colour testing and manufacturing trials.

The most critical technical variation that an increasing percentage of Black in the PP Jazz stream will bring about is a darkening of the base colour. It is therefore important to demonstrate, for each of the percentage additions tested, how far exactly from the control sample each percentage addition of Black deviates.

1. Plaques were produced from the samples drawn from the reprocessor production runs including the control sample and each of the respective % Back addition rates.

Figure 9: Plaques from the control, and all samples with Carbon and Detectable Black



It is evident from a close inspection of the plaques that **no significant change in colour occurs until levels >10% Black are present in the mix. Such a level would comfortably exceed the current percentage of Black PP in the total quantity of PP packaging placed on the market.**

Each plaque was then evaluated for colour change. Two assessments were made for each plaque produced. Conclusions are that increasing Black content makes the product darker, slightly more Red with a minimal shift to Yellow.

Figure 10: Colour measurement from the control and all samples

Plaque number	% Black	Black Type	Lightness value	Red to Green Axis	Yellow to Blue Axis
1	0		46.54	0.05	0.19
1	0		44.5	0.02	-0.21
2	5	Carbon	40.77	-0.42	-1.01
2	5	Carbon	40.4	-0.33	-1.21
3	10	Carbon	35.71	-0.33	-2.02

3	10	Carbon	37.84	-0.28	-1.64
4	15	Carbon	35.18	-0.38	-1.95
4	15	Carbon	34.81	-0.36	-2.16
5	20	Carbon	33.71	-0.32	-2.18
5	20	Carbon	35.48	-0.33	-2.02
6	5	Detectable	39.44	-0.28	-0.97
6	5	Detectable	35.19	-0.34	-1.83
7	10	Detectable	42.06	-0.24	-1.26
7	10	Detectable	41.87	-0.33	-1.24

2. In order to determine exactly what these changes in colour might represent in a practical sense, paint container bodies were then moulded with a standard 25% inclusion of PP recyclate to virgin PP polymer.
3. Three mouldings were produced.
   a. A standard paint container using 25% reprocessor Jazz PP control sample but with an industry standard addition rate of carbon black masterbatch (middle of picture).
   b. A paint container using 25% reprocessor Jazz PP with 5% Carbon Black regrind addition rate (left of picture)
   c. A paint container using 25% reprocessor Jazz PP with 5% Detectable Black regrind addition rate (right of picture)

A close inspection of the paint containers indicates that, for any given level of Black pigment used, **Detectable Black pigment has less darkening effect on the final colour of product than the use of an equivalent Carbon Black pigment** as seen below.

Figure 11: Paint containers from left to right: 1) 5% carbon black regrind 2) RPC (manufacturers of paint pots) standard with masterbatch 3) 5% detectable black

3.0 Conclusion

- The capture of Black Polypropylene packaging for recycling, at **percentages representative of what is currently placed on the market, will not significantly affect the colour or quality** of the Jazz recyclate generated from PP packaging collected at kerbside.
- **The presence of Black PP at levels up to 10% has no discernible effect** on the subsequent re-use in products such as paint containers.
- If detectable pigment is adopted as the means to separate Black Plastics (in this case PP) by polymer type, sorting plants would **at most** need only to tweak the settings of their detection equipment[3].
- It is recommended, however, that manufacturers conduct appropriate assessment of the effect that increased levels of Black packaging in the PP recycling stream may have upon **specific products**

Testimonials

"When processing Black Polypropylene regrind mixed with PP jazz flake, there was no discernible difference in extrusion and pelletising performance with addition rates between 5% and 20% black material. Chase Plastics would happily process recovered Polypropylene containing black material at these addition rates." Stephen Chase (MD Chase Plastics Limited)

"The injection moulding of recycled Polypropylene containing Black material did not show any significant processing differences that would prevent recovered Black material being included in the recycling mix." Andy Bloor (RPC Superfos)

[3] *Based on evidence from previous trials: http://www.wrap.org.uk/content/recyclability-black-plastic-packaging-0*