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5 December 2013

Review requested by the Oxo-biodegradable Plastics Association, of

A Report [1] by the Transfercenter für Kunststoffttecknik GmbH ("TCKT") dated 12 November 2013 on behalf of European Plastic Converters ("EuPC")

Roediger Agencies is an analytical laboratory, specialising in troubleshooting and research of polymers and chemical and physical testing of polymers. The company is owned and managed by Dr. A.H.A. Roediger (Ph.D., Chem.), a polymer scientist experienced in polymeric applications.[2]

Situated in the buildings of the Institute for Polymer Science at the University of Stellenbosch, we are in touch with ground-breaking polymer research and technology. We have access to a wide range of advanced analytical, thermal, and mechanical equipment. This allows extensive and complete investigation of problematic or research materials, and enables us to blend practical and technical knowledge with relevant data.

In 2012 we conducted a detailed series of tests to ascertain whether oxo-biodegradable plastic bags could be recycled with conventional plastic bags in a post-consumer waste stream without the need for separation, and on 21st May 2012[3] we reported the following Conclusion "**We are able to confirm that plastic products made with oxo-biodegradable technology may be recycled without any significant detriment to the newly formed recycled product."**

Since that date work has been done by Birgit Hornitschek of TCKT and we have been asked to examine and comment upon her report dated 12 November 2013. It is said that the report has been peer-reviewed by Dr. Wolfgang Stadlbauer, who is associated with TCKT.

We have also been asked to comment on a statement made by EuPC on the basis of this report.

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[1] http://www.plasticsconverters.eu/uploads/FINAL%20Impact%20of%20Degradable%20Plastic%20Carrier%20Bags%20on%20mechanical%20recycling.pdf
[2] See Annex 1
[3] http://www.biodeg.org/files/uploaded/ROEDIGER%20REPORT%2021%20May%202012.pdf

It needs to be clearly understood at the outset that there are two very different types of biodegradable plastic products:

a. "Compostable" - (also loosely known as "bio-based plastics" or "bioplastics") and designed according to EN13432 to biodegrade in industrial composting, and
b. Oxo-biodegradable - made from petroleum-derived polymers such as PE and PP, containing special ingredients (which do not include "heavy-metals") designed according to ASTM D6954 to degrade and biodegrade in the open environment leaving no harmful residues.

Executive Summary

1. The TCKT report makes it clear that "compostable" plastics cannot be safely recycled together with oil-based plastics in a post-consumer waste stream.
2. We have no reason to change our 2012 opinion, and we consider **that plastic products made with oxo-biodegradable technology may be recycled together with conventional oil-based polymers without the need for separation and without any significant detriment to the newly-formed recycled product.**

The TCKT Report

The Introduction to the TCKT report says that "four mixtures of non-biobased degradable plastic bags and one virgin-LDPE recycling material were tested…." This is fundamentally incorrect as only one mixture containing non-biobased material was tested. Figure 1 on page 5, shows that DEG 1, 3 and 4 are all bio-based and compostable. Only DEG 2 was non-biobased and degradable, but it is not clear what it is.

The tests of DEG 1, 3 and 4 confirm that "bio-based and compostable" plastics cannot be recycled together with conventional oil-based plastics in a post-consumer waste stream. This is a serious problem with "bio-based and compostable" plastics in countries who wish to recycle their post-consumer plastic waste, and it is therefore vital to be clear when considering recycling of biodegradable plastic, whether the subject is "bio-based and compostable" or oxo-biodegradable.

We have been asked to consider the recycling of oxo-biodegradable plastic, and DEG 1, 3 and 4 are of no further relevance to our enquiry.

Oxo-biodegradation is defined by CEN (the European Standards Organisation) in TR15351 as "degradation resulting from oxidative and cell-mediated phenomena, either simultaneously or successively." Whilst described in the TCKT report as "oxo-fragmentable," and sometimes described in non-scientific literature as "oxo-degradable" this describes only the first or oxidative degradation phase. These descriptions should not be used for material which degrades by the process of oxo-biodegradation defined by CEN, and the correct description is "oxo-biodegradable."

Oxo-biodegradation of polymer material has been studied in depth in many scientific studies, most recently at the Technical Research Institute of Sweden and the Swedish University of Agricultural Sciences. An independently peer-reviewed report of the work was published in Vol 96 of the journal of Polymer Degradation & Stability (2011) at page 919-928. It shows 91% biodegradation in a soil environment within 24 months, when tested in accordance with ISO 17556.

Review

In general, the TCKT Report is confused. The results measured are inconsistent, and show few or no trends that could indicate that the presence of oxo-biodegradable recycled material weakens the physical properties of recycled blown-film.

The following are serious failings from a scientific point of view

- DEG2 is not properly described. It is not therefore known what type of polymer was used, how old the sample was, nor which additive had been included in the polymer, nor at what concentration within the polymer.
- There is no explanation as to how the author assessed whether the collected material was biodegradable. No x.r.f. examination was conducted. She has not described how DEG 1 - 4 were developed and what materials they are. It is not even known whether DEG2 is oxo-biodegradable.
- Films were tested that are assumed to contain prodegradant additive, but they are not compared to formulations of the same materials that do not contain pro-degradant additive. If there is any effect on physical properties it must therefore be questioned whether is caused by the pro-degradant additive, or by the polymer from which the film sample is made, or by materials other than pro-degradant additives within or upon the film.
- No mention is made of how the addition of biodegradable material to DEG 2 pellets was made. Were flakes added to in-house reground pellets, or were they separately pelletised and then added?
- There is no explanation as to why in the case of DEG 2 (Fig. 7 page 11), duplicate runs of only the 5% formulation were made and not with the other additives DEG 1 and 4, nor with any other percentage loadings of DEG.
- On page 14 it is suggested that a colour-change of the blown-film occurs with an increasing amount of DEG. There is no scientific significance here. Increasing the amount of DEG does not change the colour of a compound, but if the bags containing DEG were highly pigmented this could cause a colour change. This would apply whether the feedstock was oxo-biodegradable or conventional. There was no analysis of the composition or concentration of pigments in the collected bags.
- Regarding the results cited in Table 2 (page 18): no standard deviations of results are given, so it is difficult to judge how representative the results actually are and how valuable the tabulated results are.
- As the conclusions of the report do not distinguish between bio-based and non bio-based, they are meaningless.

Analysis of data presented

In general, the data does not show any trend with increasing amounts of DEG material added or even any consistency in duplicate experimental runs. It is therefore virtually impossible to reach a logical conclusion upon which any decisions could be made regarding the use of biodegradable plastic bags in the production of recyclates.

Figure 3, gives melt-pressures for the recycling of five batches of in-house LDPE waste. Although the highs and lows in each experiment are given, the overall results indicate that the in-house waste, on which all

future blends are based, is very inconsistent in processing parameters. This in-house base material could not therefore be used to achieve usable physical data to reach a conclusion in the experiments. Specifically, a variation in melt pressure from 130 to 150 bar is shown on the base material, which shows an 18.5% variation in physical parameters. Simply stated, if there is a 18,5% variation in the base material, then no better spread in results could be achieved in subsequent formulations.

Figure 6 - The reduction in melt pressure of the blown film extrusion line indicates that the polymer used in the collected biodegradable bags is totally different to the in-house LDPE used.

Figure 7 - Melt pressure is generally stable and motor-load actually increases. One graph represents the melt back-pressure inside the extruder barrel, and the second graph represents the motor-loading. What is strange is that when adding 5% DEG2 the back-pressure goes higher while at 10% and 50% it goes back to the same value as for 2%. There's no logic in this graph. The report says that even when they were running straight virgin polymer they had variations (as per Figures 3 and 4). Since the concentration of the DEG is the same in both compounds, results indicate that it is not the DEG that leads to varying results but some other factor.

The photographs of blown film mean very little and may be due to the incompatibility of the polymers used, or pigmentation.

Table 2 shows inconsistent results, from which neither logical deductions nor any policy decision can be made. The varying tensile-strengths may be due to the type of polymer blends, and hence would have no bearing on the biodegradable additive. In fact, the addition of 2% and 5% material essentially has no effect on the strengths. The inconsistent tensile strength for the 10% addition requires explanation before one can deduce that it is the prodegradant additive that causes the effect. The trend of the tabulated elongation-results is totally inconsistent and needs to be explained prior to any deduction being made. The varying film thickness of the various compounds shows that the film-blowing process has not been adjusted to produce consistent products from each formulation. Similarly, the results of the tear resistance as well as the puncture impact show absolutely no trend with the increase in concentration of the biodegradable bags in each compound.

Conclusion

Having carefully studied the TCKT report, we have no reason to change the conclusion of our report of 21st May 2012, that **plastic products made with oxo-biodegradable technology may be recycled together with conventional oil-based polymers without any significant detriment to the newly formed recycled product.** Separate collection is not therefore necessary.

With regard to bio-based plastics, we agree that if recycled together with non bio-based plastics they would cause a significant detriment to the newly formed recycled product.

Comment on EuPC press statement of 18th November 2013

EuPC said "the results show that even in quantities as low as 2%, degradable plastic films cause significant, detrimental impacts to the quality of plastic recyclates. These impacts are not only detrimental in terms of mechanical properties of the recycled material, but also involve visual impacts on the newly produced film." This may be correct in relation to bio-based, compostable or bioplastics, but it is incorrect for oxo-biodegradable plastics.

Yours faithfully,

Dr. AHA Roediger

Annex 1

Dr. A.H.A. Roediger

Profile

- Ph.D. in Polymer/Organic Chemistry from the University of Stellenbosch.
- Expert witness on Plastics, Paints and Rubbers in court.
- Rewarding consultant to the technical industry.
- NRF advisor on Polymer Thrust for Uniqwa.
- Considered a specialist in the plastics industry.
- Has been working and researching oxo-biodegradeable compounds since 2008.
- Examiner for MSc Kibret Mequanint at University of Stellenbosch
- Examiner for MSc Corinne Greyling at University of Stellenbosch

University Education

1984	Ph.D in Polymer Chemistry from the University of Stellenbosch
1977	M.Sc in Polymer Chemistry from the University of Stellenbosch Graduated Cum Laude
1975	B.Sc (Hons) in Chemistry from the University of Natal, Pietermaritzburg
1974	Graduated B.Sc majoring in Chemistry from the University of Natal, Pietermaritzburg

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