Evaluation of the Oxo-Biodegradable Characteristics of Bag Samples Supplied by Extra Packaging

1. Background

Extra Packaging is interested in evaluating Wells' "Reverte" oxo -biodegradable masterbatches for use in their products.

The Reverte grade BD 92845 has been recommended as being potentially suitable for their application. This are formulation contains a mixture of a metal ion pro-oxidant, a photoinitiated initial degradation inhibition package and a secondary biodegradation initiator.

BD 92845 is a polyolefin based masterbatch and is suitable for inclusion in a broad range of polymers including high density polyethylene (HDPE), low density polyethylene (LDPE), linear low density polyethylene (LLDPE) and polypropylene (PP).

This formulation has been developed to give thin section PE films maintained at 20°C a controlled in-house shelf life of approximately 18 months, a further dwell time of around 3 to 6 months after pholoinitiation and then a rapid breakdown of film properties resulting in acute embrittlement, normally after a further 15 to 18 months.

Extra Packaging has supplied a sample of a PP non-woven substrate coated with a thin PE film, both layers contacting 1% of Reverte. This was submitted for an evaluation of its oxo-biodegradable properties.

2. Sample Identification

3. Method

The high molecular weight of commercial grades of polymers render them too hydrophobic and, therefore, very resistant to direct microbial attack.

A reduction of the polymer chain length from its filial value of around 250,000 to a value between 4,000 and 10,000 increases its intrinsic microbial accessibility and enables subsequent biodigestion.

Reverte products initially catalyse the oxo-degradation of the polymer chains and then promote the growth of microbial colonies to expedite the second biodegradation stage.

3. Method (Cont'd)

The initial chain scission (degradation) of the polymer chain causes a serial reduction in polymer molecular weight which ultimately results in acute embrittlement, microfragmentation and biodigestion. Oxo-degradation causes the formation of a carbonyl group at the point of every scission. Measurement of the onset and level of this carbonyl group development in the test fan is a direct measure of its induced degradation by the metal ion pro-degradant within the Reverte masterbatch.

Polyolefins are generally reduced to an embrittled state when the carbonyl index is greater than approximately 0.1 to 0.4 depending on the type, grade, pigmentation and thickness of the product under consideration.

The various samples were aged in a UV ageing cabinet with UVA and UVB lamps to simulate gentle outdoor sunlight. The temperature of the cabinet was maintained at 50°C.

Wells' standard PE film without any Reverte addition was also aged alongside the test sample as an internal control.

It should be noted that the level of UV exposure generated in the ageing cabinet is very low and should not be compared with the levels generated, for example, in QUV ageing experiments.

In effect, the UV exposure level is around 26kLy per year in the cabinet. To put this in perspective, to simulate a full year's outdoor exposure in the UK the samples would have to be in the cabinet for around 3 to 4 years, to match a year in mainland Europe they would have to be in the cabinet for around 4 to 5 years and a year in Florida, USA would be simulated by 9 to 10 years in the cabinet.

As the samples within this set of experiments have only spent around 6 weeks in the cabinet, we can see that the actual UV exposure is very slight and that tie acceleration of the ageing process should be largely attributed to the higher temperature (50°C) following the photo-triggering stage of the breakdown reaction.

Samples were removed after fixed time periods and their carbonyl indices determined by Infra-red analysis. In addition the films were empirically assessed for friability and state of embrittlement. The carbonyl index at the point at which the film was embrittled was noted and presented as 100% embrittlement. The remaining Carbonyl indices were calculated as a percentage of this and presented as "Degree of Embrittlement".

In addition. Arrhenius principles were applied to the results obtained at 50°C, transposing them into the real-time results that would be expected at 20°C.

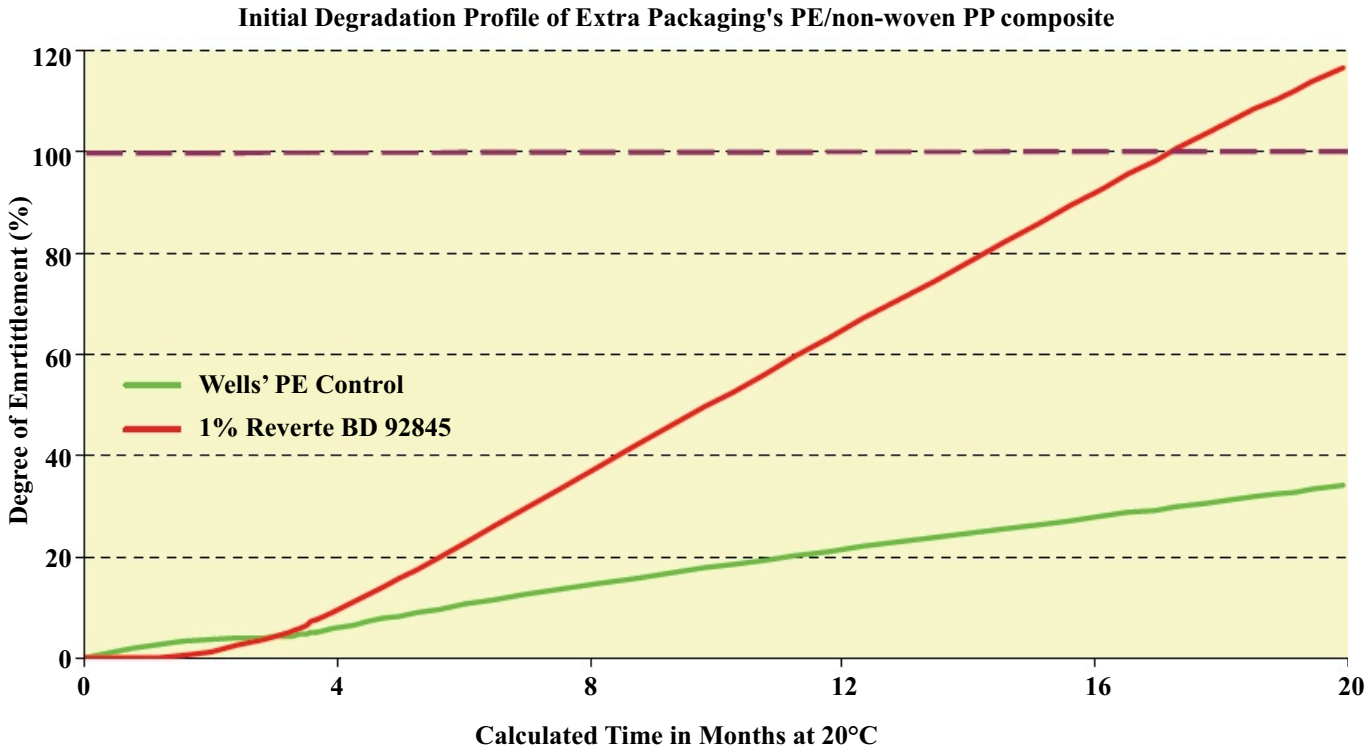
4. Results

4.1 Degree of Embrittleness

	Degree of Embrittleness (%)							
Accelerated Ageing time (hours at 50°C)	**0**	**72**	**144**	**168**	**240**	**432**	**792**	**912**
Calculated Time (months at 20°C)	**0.0**	**1.6**	**3.1**	**3.7**	**5.2**	**9.4**	**17.3**	**19.9**
Wells' PE Control	0.0	3.2	4.4	5.0	8.8	17.2	30.0	34.0
1% Reverte BD 92845	0.0	0.2	4.7	7.6	17.6	46.9	100.7	116.7

Photographs of test specimens after the accelerated ageing period may be found in appendix 1.

4.2 Graph of Results



5. Discussion of results

It is always difficult to precisely quantify results obtained in terms of real-time degradation due to the vagaries of natural conditions. However, the Arrhenius principles that we have applied to the accelerated ageing results enable us to present the results that would be expected from ageing in a real environment at a constant temperature of 20°C in sunlight.

The Wells' PE control sample demonstrated fairly typical behavior, not reaching a point of embrittlement during the test period and reaching a level of embrittlement of around 34% after the 912 hour accelerated ageing period (calculated to ~20 months at 20°C).

In marked contrast to this result, the sample containing Reverte additive demonstrated a greatly enhanced degradation profile. The sample gave a marked "dwell time" of around 137 accelerated ageing hours (calculated to around 3 months at 20°C) during which no enhanced degradation was evident, followed by a rapid degradation in physical properties reaching a point of embrittlement after around 823 accelerated ageing hours (~18 months at 20°C).

It can be seen that this "dwell time" exhibited by the Reverte containing products gives a greatly enhanced window of confidence in the use of oxo-biodegradable additive technology as no induced degradation was evident for the first time period of the product's calculated lifetime following its photo-triggering. This photo-initiation property incorporated into the Reverte additive control package means that within this testing timeframe the breakdown reaction doesn't significantly commence before the product is discarded. In effect, without any photo-triggering, products will exhibit an 18 to 24 month shelf life before the initial dwell time and subsequent breakdown commences.

5. Discussion of results (Cont'd)

The complex reaction control package contained within the Reverte product gives an enhanced level of confidence when compared with alternative additives, particularly with respect to "fit-for-purpose" product lifetimes.

Finally it should be noted that even when a control film may have degraded through normal UV/oxidative attack, this doesn't mean that the chain scission will continue in a uniform and controlled manner until the chains are short enough for microbial digestion.

This is what the use of Reverte additives does and it is this, together with the secondary phase biodegradation promoter, which speeds up and facilitates the ultimate biodegradation of the plastic following the initial oxo-breakdown.

It should be re-stated fiat these are idealized real-time projections based on accurate accelerated laboratory ageing and, as previously stated, natural climatic conditions of sunlight, soil temperature, etc. do vary. These extrapolated results have, therefore, been prepared in good faith, but any potential user would have to carry out his own empirical observations to ensure that the product was fit for his purpose in the precise ageing regime employed.

6. Conclusion

The addition of Reverte masterbatch to the product submitted has been shown to be very effective in introducing excellent oxo-biodegradable characteristics, giving a good fit-for-purpose dwell time after photoinitiation followed by a rapid development of embrittlement.

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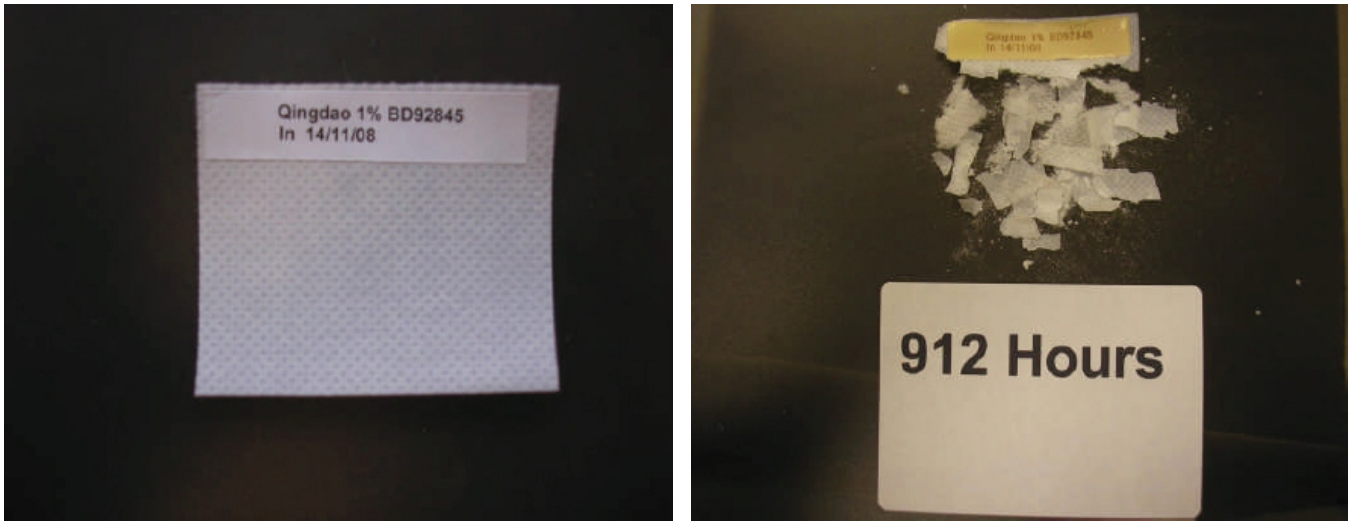
Appendix 1

Photographs of Extra Packaging-supplied samples before and after ageing



The photographs were taken before and after the accelerated ageing process, wherein the samples had been subjected to a 912 hour period of accelerated ageing at 50°C (equivalent to around 20 months of real-time ageing at 20°C).

The Reverte sample on the right has lost most of its significant physical properties, and is exhibiting extreme friability, breaking up when handled.

These observations are commensurate with the measurements taken and contained within the body of this report.