The Efficacy of Reverte Oxy-biodegradable Additive Masterbatches

1. Background

The “Reverte” range of oxy-biodegradable additive masterbatches is typified by the BD 92845 grade.

This is a hybrid formulation containing a mixture of a metal ion pro-oxidant system and a micronised cellulosic biodegradation initiator.

It is suitable for inclusion in a broad range of polymers including Polypropylene (PP), high density polyethylene(HDPE), low density polyethylene (LDPE) and linear low density polyethylene (LLDPE). It has also been used in various styrenics and PVC products.

2. Theory

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 initial 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 such as BD 92845 catalyse the initial oxy-degradation of the polymer chains while promoting the growth of microbial colonies to expedite the second biodegradation stage.

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. Oxy-degradation causes the formation of a carbonyl group at the point of every scission.

Measurement of the onset and level of carbonyl group development in the test product is a direct measure of its induced degradation by the metal ion pro-degradant.

Subsequent biodegradation can be shown by studies of microbiological growth or alternatively by the evolution of carbon dioxide.

Polymers are generally reduced to an embrittled state when their carbonyl index is greater than approximately 0.3 to 0.5. This critical value is dependent on the precise grade and type of polymer under consideration.

3. Testing

It is possible to test and measure the initial degradation of samples by ageing them in an appropriate accelerated ageing cabinet. Such cabinets are fitted with UVA and UVB lamps to simulate outdoor sunlight and are generally maintained at an elevated temperature such as 50°C.

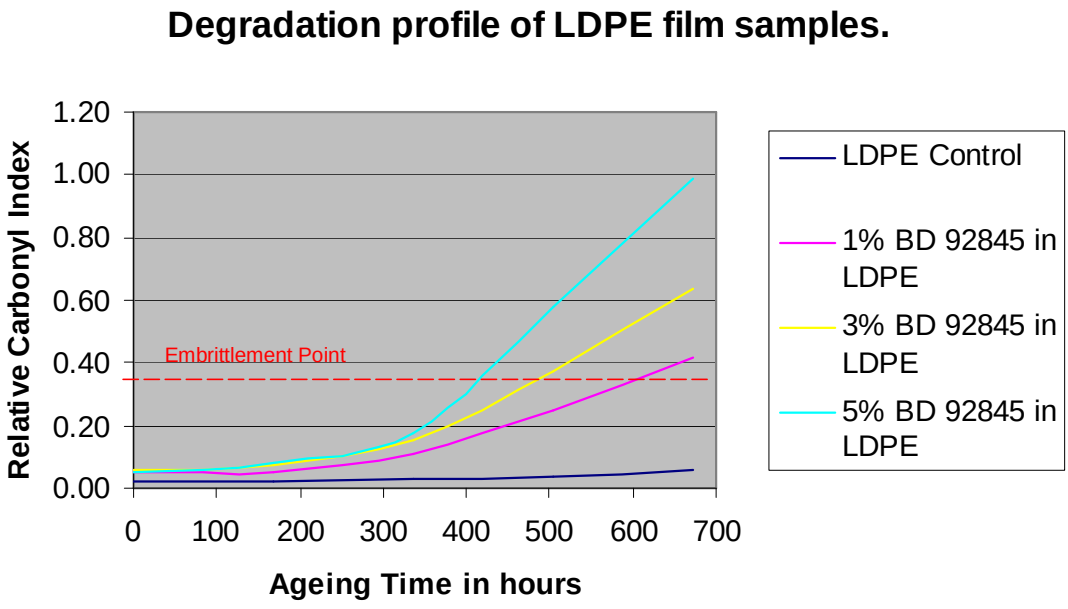
Samples can be removed after fixed time periods and their carbonyl indices determined by Infra-red analysis. In addition the films can be assessed for friability and state of embrittlement.

Following this initial ageing period it is then possible to artificially compost them in a laboratory environment and either empirically assess their biodegradation or measure the rate of evolution of carbon dioxide gas.

Generally the initial embrittlement and microfragmentation stage is regarded as an appropriate "fit for purpose" test as it is well understood that catastrophic physical failure of a plastic film or article is indicative of a drastic reduction in polymer molecular weight.

3. Typical Results

If we inspect some typical results from the accelerated ageing of clear polyethylene films containing Reverte BD 92845 then we see the following :



4. Discussion of results

It can be seen that the sample of PE film without the inclusion of Reverte additive has demonstrated fairly typical behaviour, not developing any significant carbonyl character and not even approaching a point of embrittlement during the test period.

In contrast to this, the specimens containing BD 92845 have demonstrated a highly enhanced rate of decomposition, reaching a state of embrittlement in the test chamber after between 420 and 620 hours.

In addition they all showed the distinct “dwell time” associated with the use of Reverte additives where no polymer breakdown occurs for a measurable period of time.

It is difficult to quantify this in terms of real-time degradation due to the vagaries of natural conditions, but applying Arrhenius principles to these accelerated ageing results indicate that ageing for 12 hour days at a constant temperature of 20 ^{o}C in sunlight should result in a dwell time of around 6 to 7 months followed by degradation to embrittlement and microfragmentation in a further 4 to 12 months.

It should be borne in mind that these are idealised projections and natural climatic conditions of sunlight and soil temperature 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.

5. Expected performance with Reverte additives

As previously stated, it is impossible to give any absolute real-time performance projections because the rate of real-life degradation is wholly dependent on natural conditions and these natural conditions vary and are in turn equally impossible to accurately predict.

In addition, because the Reverte masterbatch is a complex mixture of a photoinitiation package, an oxy-degradation initiator, a scavenging package to give a “dwell time” before degradation is allowed to commence and a biodegradation initiator to speed up the secondary phase of break down by the natural soil-based micro-organisms, the reaction kinetics can be complex and add to the overall unpredictability.

Finally, once the masterbatch is supplied, it is impossible for Wells to control its addition rate in the final product and this is obviously a controlling factor too.

What can be stated, however, is that a polymer with the addition of a Reverte additive such as BD 92845 can be tested and be shown to prematurely degrade in a controlled manner.

5. Expected performance with Reverte additives (continued)

Wells Plastics is prepared to carry out initial “fit-for purpose” testing to demonstrate the breakdown kinetics of submitted film samples and can guarantee that the composition of the masterbatch submitted will not vary so as to affect these kinetics.

However, Wells cannot give any guarantees or indemnifications pertaining to the performance of the final product due to the number of uncontrolled variables present in the manufacturing and disposal chain.

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