Sustainable Manufacturing in Plastics Processing

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An overview of oxodegradable technology

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Enhanced oxo-degradation of Polymers

• The basic technology behind the concept is certainly not new!
• Pioneering work was carried out by, for example, Gerald Scott (1973), Dan Gilead (1985), Gerry Griffin (1987) and others.
• This work led to the development of polymer based oxo-biodegradable masterbatches containing pro-oxidants and reaction enhancers/modifiers.
• These products have been in the commercial arena for at least 20 years and have found uses in many areas.
• Applications are predominately in the polyolefin film industry but there are other applications in a variety of sectors.
Myths surrounding the Technology

• A broad variety of misinformation, disinformation and myth surrounds the oxobiodegradable technology.

• Anti-claims include:
  1. Products are dangerous / contain toxic heavy metals / are unsafe.
  2. OBD films merely fragment into smaller pieces of plastic which remain in the environment with no further change.
  3. Subsequent biodegradation (mineralisation) does not occur.

• Much of this can be dispelled once the science is better understood and results scrutinised.
Technology 1

Initial Polymer Breakdown
Degradation of Polymers

- The natural degradation of polyolefins, such as polyethylene and polypropylene occurs relatively haphazardly and at a low rate.
- The breakdown is generally instigated by exposure to heat and/or UV light, but subsequent microbial biodigestion remains very, very slow due to the polymer’s high molecular weight and intrinsic hydrophobicity.
- However, microbial digestion (biodegradation) can commence when the polymer’s molecular weight is sufficiently reduced by initial degradation.
- Oxo-biodegradable additives have been developed to enhance, accelerate and control this breakdown process.
The Breakdown of Polyolefins through oxo-degradation.

eg POLYETHYLENE \([\text{CH}_2 - \text{CH}_2]_n\)

Typical molecular weight 150,000 to 250,000

Chain scission can be achieved through free radical initiated catalytic oxidation by certain metal ions:

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\text{R}^-/\text{M}^+/\text{O}_2 \rightarrow \text{R}^\text{O} + \text{M}^+ \]

Oxidative degradation causes chain scission. A carbonyl group is formed at each break point. The carbonyl level can be measured to chart the reaction kinetics and Arrhenius principles used to estimate real-life performance.

The Metal ion catalyst is regenerated allowing the reaction to continue and chain lengths to become progressively smaller.

When the MW is reduced to below 10,000 then microbial attack can occur.
Results indicate that embrittlement has occurred after the equivalent of 12 months at 20°C.
Technology 1

So what does the initial breakdown look like?
Technology 2

Molecular Weight reduction
Molecular Weight Reduction

HDPE check-out bag – After heat/UV exposure in an ageing cabinet at 50°C.

The sample’s MWt has been reduced from its initial 170,000 to <5,000 during the test period.

Source: Independent testing to ASTM 6954 by RAPRA UK

PE Carrier bag + 1% Reverte
Technology 3

Biodegradation
Biodegradation of Tier 1 preoxidised check-out bags

Biodegradation results from Tier 1 preoxidised HDPE bags.

Source: Independent testing to a modified ASTM D 5338 method by Biosystems Atlanta

Mineralisation was achieved after only 10 weeks of biometry.
Biodegradation of pre-oxidised PE Film containing oxobiodegradable additive.

>77% mineralisation was achieved after only 7.5 weeks of biometry.
• The major suppliers of OBD additives all claim food contact suitability and can be individually contacted for appropriate verification and certification.

• Major food contact specification bodies include the European Community (through EC directives including 2002/72/EC and its subsequent amendments) and, in America, the FDA (through their positive listings and “Chapter” suitability).

• Suppliers also claim specific compliance with the European directive 94/62/EC pertaining to the presence of toxic heavy metals and the American equivalent, CONEG. We can all be contacted for certification of our claims.

• All of these data give confidence in the suitability of oxobiodegradable additives for food use and their general lack of toxicological contraindications.
Specific examples of the use of OBD additives
Example 1 – Check-out bags

• Supermarket check-out bags are an important OBD application.
• Some countries and country regions have legislated for the use of OBD additives in carrier bags, eg UAE, Mexico and Argentina, amongst others.
• OBD additives are used throughout the world for this application.
Example 2 – Bubble Wrap

Bubble wrap and other similar forms of packaging are often used as short term, one-trip packaging and so are well suited to oxobiodegradable technology.
Example 3 – Food Netting

Fruit netting is an application that requires much longer product lifetimes and so the oxobiodegradable additive must be formulated accordingly.
Example 4 – Refuse bags

Polyethylene rubbish bags containing OBD Additive are formulated to degrade after their useful life has been completed.
Example 5 – Food Bags

Produce bags containing OBD additive are used in supermarkets. Food contact suitability is important in this application.
Example 6 – Agrimulch film

Example of Field covered with OBD Film

The film fragments under the first stage of the oxo-biodegradation pathway.

OBD additive has been used in many different crop types including tobacco, maize, potatoes and peanuts.

It is then biodegraded to form CO$_2$, H$_2$O and biomass.
• Oxobiodegradable additives are not a new concept but they have been technically refined over the years to increase their application suitability.
• The “myths” regarding toxicity, mere fragmentation into smaller plastic shards and no subsequent biodegradation have been shown to be ill-founded.
• In fact OBD films have been shown to comply with the demanding ASTM D 6954 standard with very rapid biodegradation following controlled oxidation.
• OBD products are not recommended for applications that require an EN 13432 / ASTM D 6400 type of composting property, but they do have a strong market niche in many significant areas such as check-out bags, food packaging, agricultural films and many other sectors.
• Oxobiodegradable additives have become an important product of choice in a broad variety of plastics products and their continuing growth is a testament to their proven efficacy in the right applications.
Thank you for your attention!

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