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Bio-Tec Environmental LLC Technology for Biodegradable Polymers – EcoPure

Note: This report is not meant to be comparison of EcoPure and EPI's TDPA™ technology, since the TDPA™ oxobiodegradable additives are well established as being authentic degraders of polyolefins. Rather it is an attempt to determine whether the EcoPure additives offer real and viable competitive options to produce biodegradable plastics from inert commodity plastics.

Objective:

To assess the technical strength and claims from Bio-Tec of their EcoPure additive technology to convert conventional commodity plastics into biodegradable analogs.

In order to evaluate the claims of EcoPure, a wide ranging literature search has been completed and generous support has been given by the Biodegradable Plastics Institute (BPI), through Mr. Steve Mojo who supplied their complete dossier on this technology. The report is written in a logical evaluation progression from a technology patent application; to evaluation of testing evidence in support of their technology claims; to applications that appear to be underway; and a brief contrasting with EPI's TDPA™ and other technologies. These steps all lead to an answer to the objective stated above. I will also comment on the technical presentation that Bio-Tec has published on their website.

Patent Application:

Bio-Tec has a US Patent Application number 20080103232, filed in October 2007 titled: "Chemical Additives to make Polymeric Materials Biodegradable". The essence of the patent can be summed up in the following bullet points:

- The additives claimed include a broad mix selected from many organic molecules, synthetic polymers, and natural monomeric and polymeric products, swelling agents, and encapsulated microbial material. Some examples are sugars, furanones, glutaric acid, other simple carboxylic acids in the C₅ to C₁₈ chain length range, cellulose and derivatives, and amino acids such as glutamic acid, etc.
- Some of the polymers claimed to be biodegradable by this technology as mentioned in the patent application are DVB (polydivinylbenzene), EVA (polyethylene- co-vinylacetate), PE (polyethylene), PP (polypropylene), PS (polystyrene), PET (polyethyleneterephthalate), polyesters in general, PVC

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(polyvinylchloride), nylons, polycarbonates, polyamides. Maleic acid copolymers and acrylics. Quite a formidable list *if* biodegradation can be achieved.

- The technology purportedly works by intimate blending of up to a few percent of the additive with a commodity plastic of choice. The special characteristic of the additive is that it allows enzyme attachment to the plastic that promotes surface biodegradation and the degradation products “open” up the plastic matrix which allows further penetration into the interior where biodegradation spreads to all the plastic. Similar claims have been seen before for the additives such as starch, simple fatty acids and a host of others – ALL were eventually shown to be fallacious and no base plastic was biodegraded.
- Some of the testing protocols used in the patent which claimed to validate the patent, are all from outsourced testing or else from simple spectral analysis of surface erosion relative to virgin plastic material. This of course, is not acceptable and has been dismissed before as indicated for starch additives mentioned. *These tests validate nothing!*

It is quiet surprising given the technically impoverished nature of the patent that anyone has deemed the technology of commercial value and proceeded to try to implement it in any shape or form. However, as we see later, some have fallen for the technology and continue to espouse the technical propaganda.

Biodegradation Testing Results:

As already alluded to, testing of the EcoPure additive technology has not been “rigorous” by any means, and in fact, borders on being incompetent or completely naïve. Claims have been made for long term biodegradation without substantiation, at least as far as publicly available data. The two approaches taken by Bio-Tec to establish biodegradation have been plastic surface evaluation after exposure to a given environment such as landfill, compost and soil and gas production in a bioreactor using ASTM Standard Method D 5511.

Surface analysis on plastics, such as PE, PP, PS, PET and PVC, done with infra red or, better, scanning electron spectroscopy. The results from the additive-containing plastics show some surface erosion over several months, as one would expect, but the virgin materials are less marked. The surface erosion is likely the additive removal by enzymes. How the claim “accelerated biodegradation” can be used, is a stretch beyond credibility and there can be little validity attached to the claims.

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Gas Evolution: On the commendable side for Bio-Tec, they have had external testing done for biodegradation using ASTM D 5511-02 protocol at Northeast Laboratories Inc. in Berlin, Connecticut.

- **NOTE:** this anaerobic test is not an indicator of the landfill fate of plastics, since most landfills are NOT as reactive as bioreactors – which are in limited supply in North America (20 or so exist) and results are likely to be more positive than would be observed in commercial landfill. Care must be exercised in extrapolation to a real world situation – best to do the real world test.

As far as can be determined, the tests were run as recommended by ASTM. The results for PVC, using only weight loss – why not gas evolution is surprising! - Indicate about 1-2% biodegradation over 42 days! Hardly a convincing conclusion – even the testing laboratory indicates more work needs to be done.

Further biodegradation testing using D 5511-02, by the same laboratory using gas evolution, methane and carbon dioxide, has given very mixed results. One set of data indicates PP biodegrades 45% in 90 days! EVA biodegrades 7% in 90 days, and SBS/SEBS biodegrades 5.5% in 90 days. The PP result appears to be in error and should have been reproduced with the calculation checked since it is so far out of line! However, the Laboratory Director, quite shockingly, reports that these results are very good and indicate that in the real world fast biodegradation should occur! WOW!!!!

- **NOTE:** I had an independent evaluation by a landfill expert and he expressed total disbelief in the data for PP and recommended many repeats for such an unusual and unanticipated result.

Commercialization:

Obviously, there is a very well orchestrated publicity campaign ongoing to get EcoPure established in the marketplace. Several recent articles in Plastics News indicate companies such as Casey Containers are interested in further commercial utilization of EcoPure. Also Brooks, a running shoe manufacturer is producing “biodegradable” EVA shoe mid-soles with this technology. A BIO-TEC Newsletter indicates progress by ENSO Bottles to produce “biodegradable” PET bottles and others are interested in PS cup “biodegradation”. All of these are questionable uses, if biodegradability is the goal. Testing does not support claims and hence the use of EcoPure technology in these applications.

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Propaganda:

The video developed by Bio-Tec and seen on their web page is a charming collection of sense, nonsense and speculation. This is repeated in all of the home page articles and the grasp of the significance of biodegradation is there but extrapolations to their additives are outrageous. How any end-user can buy into the propaganda is amazing. Surely there will be an exposure and someone is heading for censure, fines or both.

Contrast with EPI and Other Technologies:

EPI's TDPA™ technology is based on additives for a two stage biodegradation of polyolefins which has been well substantiated to function by oxidation and subsequent biodegradation, as claimed in academic as well as, standard testing methodology. Work continues in collaboration with the ASTM to establish acceptable specification for TDPA™ and similar additives.

EcoPure additives apparently function in a fashion similar to that of many early offerings in this field. Enzymes promote the organic additive hydrobiodegradation which then synergistically promotes plastic biodegradation; though it is difficult to rule out some oxidation occurring. Hence, it may be a hybrid technology, but, since no testing of any reliability has been completed it is not easy to say how it works. Indeed, leading questions that need to be answered by Bio-Tec are:

Does it work?

How does it work?

How effectively does it work?

At this point, no conclusive evidence is available for answering any of these questions as far as my readings go. In discussions with Steve Mojo, he tells me that BPI has a similar jaundiced view of the technology.

Graham Swift

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