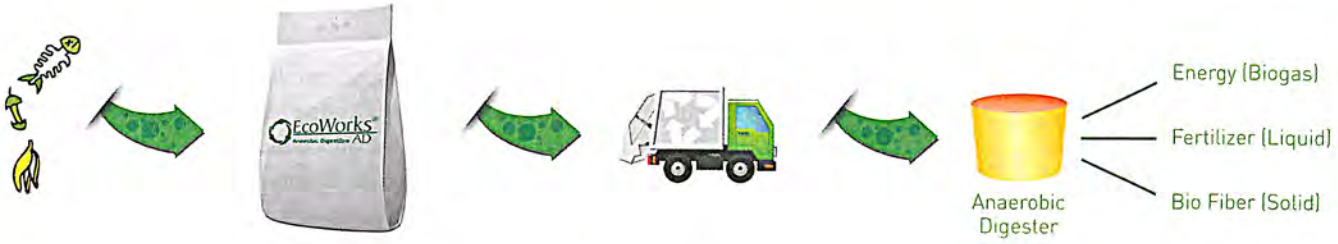

Good for AD

Versatile bioplastic product enabling increased use of Anaerobic Digestion

By
Robert Kean
Biodegradable Technologies Manager
Cortec Corporation
St. Paul, Minnesota, USA

Anaerobic Digestion is a well known process by which organic wastes are decomposed in the absence of oxygen by anaerobic micro-organisms; often resulting in the production of significant amounts of methane gas. Anaerobic Digestion is most commonly used in wastewater and sewage treatment and in the treatment of animal manure waste. Over the past decade, there has been a strongly growing interest in Anaerobic Digestion as sustainable and environmentally friendly way to process biodegradable wastes and as a means to produce renewable energy. Anaerobic Digestion compatible waste bags will enable increased use of this technology.

Anaerobic Digestion Basics

Anaerobic Digestion can be implemented in a wide variety of configurations. Key variables include: temperature (mesophilic ~20-45°C, or thermophilic ~49-70°C), number of chambers/stages, batch or continuous process, solids content in process (high solids 'dry' at 25-40% solids, high solids 'wet' at ~15-25% solids, or low solids at less than 15% solids), biogas use (burned on site or purified for sale), feedstock(s), and output streams/treatments. Like many technologies, Anaerobic Digestion benefits from economies of scale; but small or medium size installations can be economically feasible in specific situations. Anaerobic Digestion systems can be designed for very efficient land use, for facilities in urban setting. If properly designed and operated, they produce no harmful emissions and minimal unpleasant odors.

The outputs of Anaerobic Digestion usually include biogas, fibrous solid/sludge, and process liquor. The latter two may be combined in a slurry. The biogas is typically 50-75% methane. It can be combusted as-is or scrubbed/purified for sale as natural gas. The biogas typically contains 25-50% carbon dioxide and small quantities of other gases; including hydrogen sulfide (up to about 3%, which can be removed by scrubbing). The solid/sludge can be used in the same way as compost as a soil improver, or it can be composted after Anaerobic Digestion to increase the breakdown of lignin and cellulose. The process liquor is typically nutrient rich and can be used as a fertilizer. However, if liquor volume is excessive (e.g. with a large low-solids installation), process liquor may be discharged or re-used following additional treatment (primarily to remove nutrients and dissolved solids).

Anaerobic Digestion is an excellent technology for treatment of (and energy recovery from) animal manure and numerous facilities have been constructed exclusively for this purpose. However, other biodegradable feedstocks produce significantly higher biogas yields. Favorable feedstocks include: food waste, paper, yard waste (grass/leaves), and crop residue. The biogas

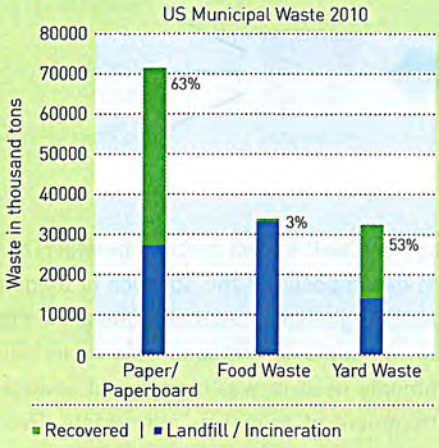

Figure 1: Recent historic recovery of municipal organic waste via recycling or compost in the USA

yield can be highly variable based on feedstock and operating conditions. However, a typical yield for food scraps may be about 265 m^3/t and almost 1000 m^3/t for fat and grease. This compares with biogas yields in the range of about 25 (cow) to about 80 (chicken) m^3/t for manure [1]. Grass clippings and yard waste would likely be in the range of 150-200. Except for materials high in lignin (e.g. wood waste), most natural organic materials are readily degraded with Anaerobic Digestion. Somewhat surprisingly, most compostable bioplastics do not degrade quickly in Anaerobic Digestion, especially at lower temperatures.

A study [2] using life cycle assessments (LCA) has shown that Anaerobic Digestion of municipal organic waste is clearly superior to both composting and incineration. A key contributor to the improved LCA is the energy recovered with Anaerobic Digestion (as biogas), compared with the energy input required for turning/aeration of compost. Incineration also recovers energy, but this benefit is offset by greater emissions (of CO_2 and other gaseous combustion products) and the ash waste which may be concentrated in toxic heavy metals. Most (non-recyclable) municipal organic waste now goes to land fill or incineration, with minor amounts diverted to home or industrial composting. Data from the US, for 2010 (Figure 1) show that only about 3% of food waste was recovered (through composting). Recovery of yard waste was considerably better (at about 57%). In comparison, about 63% of paper and paper board was recovered through recycling. Thus, municipal organic waste (especially food waste) is a large, favorable, and mostly untapped source of raw materials for Anaerobic Digestion. Implementation of Anaerobic Digestion would show numerous environmental benefits over current disposal methods and provide a clean source for renewable energy. Based on these benefits, many communities are now exploring Anaerobic Digestion as a preferable option. One concern in many countries is the collection infrastructure and logistics, including the availability, cost, and performance of waste bags.

PHA Advantages for Anaerobic Digestion

EcoWorks® AD, by Cortec Corporation, St. Paul, Minnesota, USA, first described in a previous issue of this magazine , is ideally suited for expanding the use of Anaerobic Digestion for disposal of municipal organic waste. EcoWorks AD is made from Mirel™ P5001 PHA (polyhydroxyalkanoate), which degrades rapidly and completely in Anaerobic Digestion (demonstrated by ASTM D5511). This means that debagging of waste is not necessary for feeding of materials into the Anaerobic Digestion system, and it is compatible with a wide range of operating conditions (high or low solids, high or low temperature). EcoWorks AD has good mechanical properties, including high tear and impact strength (table 1). Unlike some other compostable/ degradable bags (especially paper bags and some starch bioplastic blends), EcoWorks AD does not become weak or sticky when it gets wet. EcoWorks AD can be made in a range of sizes and thicknesses, to accommodate commercial (e.g. large bags for restaurant or food service waste collection) or residential (e.g. counter top food scrap bins, yard waste bags) applications.

[1] Yeatman C.: Biogas Experiences and Ethanol Prospects, Oxford Farming Conference, 2007, pp. 1-12.
[2] Edelmann W, Baier U, Engeli H.: Environmental aspects of the anaerobic digestion of the organic fraction of municipal solid wastes and of solid agricultural wastes, Water Sci Technol. 2005;52(1-2):203-8.
[3] Darby, Debra: Innovation with a Marine Focus: New Film Products for Marine and Anaerobic Digestion, bioplastics MAGAZINE, 05/11, 2006 pp. 32-33

Property		Test Method	Units	Typical Value
Caliper		ASTM D6988	µm	44.45
Breaking Factor	MD TD	ASTM D882-02	kN/m	0.70 0.63
Tensile Strength at Break	MD TD	ASTM D882-02	MPa	15.98 13.94
Elongation at Break	MD TD	ASTM D882-02	%	594.26 567.84
Yield Strength	MD CD	ASTM D882-02	MPa	8.85 11.43
Tear Strength	MD CD	ASTM D1922-06a	mN	4332.75 3044.37
Dart Drop Impact Resistance		ASTM D1709-04, Test Method A	grams	147.29
Puncture Resistance		MIL-STD-3010, TM 2065	N	6.65

* Typical properties represent average laboratory values and are not intended as specifications but as guides only.

Table 1: Typical Properties Eco Works AD

Further environmental benefits of EcoWorks AD include:

- Suitable for use in home compost. EcoWorks AD will degrade at the lower temperature (even ambient temperatures) of home compost bins compared to commercial compost facilities.
- It will biodegrade in marine (ASTM D7081), soil, and fresh water environments; reducing long term effects of inappropriate disposal (litter). Its ability to biodegrade in marine environments provides coastal areas with a technological 'safety net' for coastal and marine preservation.
- It contains 77% biobased carbon content (ASTM D6866) and has been awarded USDA Biopreferred designation for Waste Bags
- Meets ASTM D6400 standard for compostable plastics. In municipal composting facilities, EcoWorks AD breaks down faster than most other compostable bioplastics, allowing faster composting cycles and/or less "plastic" residue visible in the compost product.

The combination of mechanical and degradation properties of EcoWorks AD create the opportunity for a more environmentally friendly plastic shopping bag. If provided by retailers, consumers would use the bag to transport their merchandise home. Then the bag could be used to collect home waste for disposal via Anaerobic Digestion, home composting, or collection for municipal composting.

EcoWorks AD represents a collaborative development between Cortec and Telles. With the recent termination of the Telles joint venture, the ownership of the Mirel brand and technology has reverted to Metabolix. Cortec is working with Metabolix to continue development and production of EcoWorks AD. The product expands Cortec's portfolio of bioplastic products while growing the market for the Mirel brand bioplastic. Cortec is now manufacturing EcoWorks AD bags and film, along with the companion brand EcoOcean™, at its Advanced Films division in Cambridge Minnesota, USA. Plans are underway to also manufacture the product at the EcoCortec subsidiary in Beli Manaster, Croatia in the future. EcoWorks AD is targeted to be price competitive with other compostable bioplastics, yet provides the superior benefits described above.

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