

# Biodegradable Film Coated Paper - Drivers for Total Solution in Waste Management & Sustainable Agriculture

Ramani Narayan<sup>1</sup> and Sunder Balakrishnan<sup>2</sup>

Sustainability, industrial ecology, eco-efficiency, and green chemistry are the new principles that are guiding the development of the next generation of plastic and other products and processes. The rationale and drivers for manufacturing eco-efficient, sustainable, and biodegradable/compostable plastic based paper products are discussed on the basis of design principles for the environment, and disposal/waste management infrastructures. 205-BDT410-GFA is a biodegradable film coated paper with superior performance properties, while being biodegradable under composting. Using such a product in packaging and consumer goods applications, and ensuring that they end up in composting systems is an environmentally and ecologically sound approach to waste management.

## INTRODUCTION

New environmental regulations, societal concerns, and a growing environmental awareness throughout the world have triggered the search for new products and processes that are compatible with the environment. Sustainability industrial ecology, eco-efficiency, and green chemistry are the new principles that are guiding the development of the next generation of products and processes. Thus, new products have to be designed and engineered from "conception to reincarnation" incorporating a holistic "life cycle thinking approach". The ecological impact of raw material resources used in the manufacture of a product and the ultimate fate (disposal) of the product when it enters the waste stream has to be factored into the design of the product. The use of annually

renewable resources and the biodegradability or recyclability of the product is becoming an important design criterion. This has opened up new market opportunities for developing biodegradable and biobased products as the next generation of sustainable materials that meets ecological and economic requirements - eco-efficient products (Narayan, 1991, 1992, 1994a, 1998).

Currently, most products are designed with limited consideration to its ecological footprint especially as it relates to its ultimate disposability. Of particular concern are plastics used in single-use disposable packaging and consumer goods. Designing these materials to be biodegradable and ensuring that they end up in an appropriate disposal system is environmentally and ecologically sound. For example, by composting our biodegradable plastic and paper waste along with other "organic" compostable materials like yard, food, and agricultural wastes, we can generate much-needed carbon-rich compost (humic material). Compost amended soil has beneficial effects by

increasing soil organic carbon, increasing water and nutrient retention, reducing chemical inputs, and suppressing plant disease. Composting is increasingly a critical element for maintaining the sustainability of our agriculture system. The attached Figure 1 shows a conceptual schematic for the closed loop use of corn feedstock to prepare starch and protein, process them into biodegradable, single use, disposable packaging and plastic ware for use in fast-food restaurants. The food wastes along with other biowastes are separately collected and composted to generate good, valuable soil amendment that goes back on the farmland to re-initiate the carbon cycle (1-3).

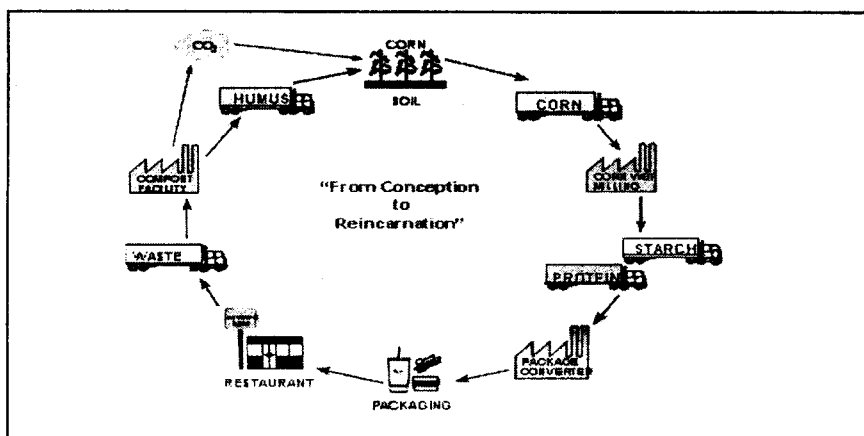
Paper is an inherently biodegradable material under composting conditions. Coating a plastic onto paper (improvement of wet strength, tear properties etc.) destroys the ability of this hybrid product to biodegrade under composting. Thus, in effect, the value of the product is lost in the process. This publication, in addressing the above issues, discusses the performance properties of a new &

<sup>1</sup> Professor of Chemical & Biochemical Engineering,

Department of Chemical Engineering & Materials Science, Michigan State University, East Lansing, MI-48824.

<sup>2</sup> Manager - Technical,

Harita-NTI Ltd., L6, Ambattur Industrial Estate, Ambattur, Chennai-600058



**Figure 1 Conception to reincarnation life Cycle for biodegradable/ biobased materials**

novel proprietary biodegradable film coated paper. Further, the publication also aims at providing a 'total solution' to waste management by integrating product disposal with waste management infrastructure.

## RESULT & DISCUSSIONS

205-BDT410-GFA is a biodegradable film coated paper product (See Figure 2) developed using proprietary resin formulations. This product meets all U. S. and International Standards for Biodegradability, including specifications for compostable plastics as per ASTM D 6400 (USA), DIN54900 (Germany) and EN13432(Europe). It has all of the versatility of standard packaging paper, yet because of the proprietary polymer coating, is also tear resistant, long lasting, flexible, heat sealable and water resistant.

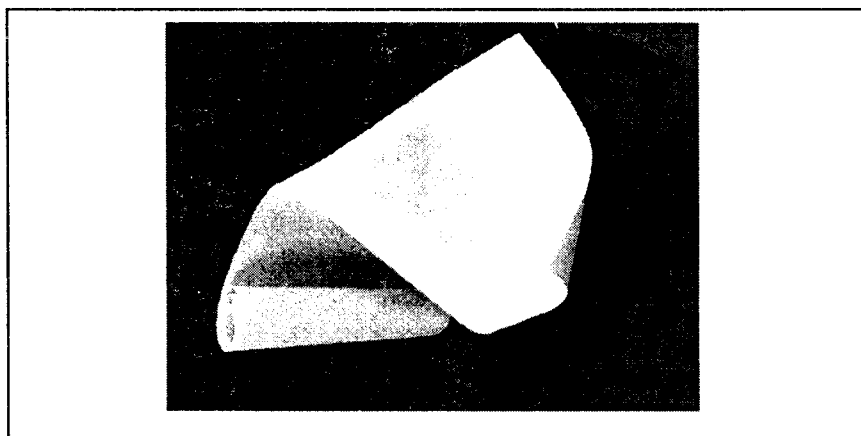
Some key attributes of the product are as follows :

- Paper coated with NTI proprietary

resin in completely compostable

- This is not true for almost all polymer coated papers with equivalent/lesser performance

- Higher tensile, dart, tear and puncture properties.
- Allows use of lower weight paper
- Increased wet strength



**Figure 2 Biodegradable plastic film coated Kraft paper.**

- Heat sealable
- Gluable and printable

Some of the properties are seen in Table1

As seen from the above table, while tensile and tear properties in machine direction are comparable for the products, the biodegradable film coated paper has exceedingly better properties in the transverse direction. Further, as the biodegradable product has a much higher Water Vapor Transmission Rate, these materials are so called "breathable", leading to elimination of odour in certain applications.

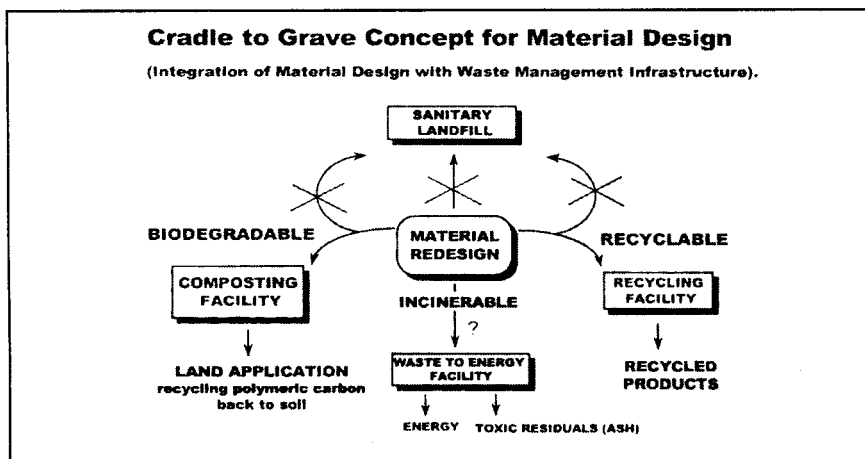
## Integration of Product Design with Disposal Infrastructure

As discussed above, the ultimate disposal of materials in an ecologically sound manner has become an important factor in the design of the material. Making or calling a product biodegradable or recyclable has no meaning whatsoever if the product after

**Table 1**

**Performance property comparison-Biodegradable film coated paper vs. Plastic coated paper**

Sr. No.	Property	Biodegradable film coated paper	Plastic coated paper
1	Tensile strength (MD)-ksi	8.54	8.32
2	Tensile strength (TD)-ksi	5.21	3.91
3	Tear (MD)-lb <sub>f</sub>	0.58	0.57
4	Tear (TD)-lb <sub>f</sub>	1.10	0.98
5	Water Vapor Transmission Rate-g/100in <sup>2</sup> /day; normalized to 1 mill	16.37	0.89



**Figure 3 Cradle to Grave Material Design concepts**

use by the customer does not end up in a disposal infrastructure that utilizes the biodegradability or recyclability features. Recycling makes sense if the recyclable product can be easily collected and sent to a recycling facility to be transformed into the same or new product. Biodegradable products would make sense if the product after use ends up in a disposal infrastructure that utilizes biodegradation. Composting, waste water/sewage treatment facilities, and managed, biologically active landfills (methane/landfill gas for energy) are established biodegradation infrastructures. Therefore, producing biodegradable plastic and products using annually renewable biomass feedstocks that generally end up in biodegradation infrastructures like composting is ecologically sound and promotes sustainability. Materials that cannot be recycled or biodegraded can be incinerated with recovery of energy (waste to energy). Landfills are a poor choice as a repository of plastic and organic waste. Today's sanitary landfills are plastic-lined tombs that retard biodegradation because of little or no moisture and negligible microbial activity. Organic waste such as lawn and yard waste, paper, food, biodegradable plastics, and other inert materials should not be entombed in such landfills. Figure 3 illustrates the cradle to grave material design

concepts.

Composting is an environmentally sound approach to transfer biodegradable waste, including the new biodegradable plastics, into useful soil amendment products. Composting is the accelerated degradation of heterogeneous organic matter by a mixed microbial population in a moist, warm, aerobic environment under controlled conditions. Biodegradation of such natural materials will produce valuable compost as the major product, along with water and carbon dioxide. The  $\text{CO}_2$  produced does not contribute to an increase in greenhouse gases because it is already part of the biological carbon cycle. Composting our biowastes not only provides ecologically sound waste disposal but also provides much needed compost to maintain the productivity of our soil and sustainable agriculture (4,5).

#### **Composting & Sustainable Agriculture**

Soil erosion is a major, worldwide environmental and agricultural problem. Although erosion has occurred throughout the history of agriculture, it has intensified in recent years. Each year, 75 billion metric tons of soil is removed from the land by wind and water erosion. Most is removed from agricultural land. The use of large amounts of fertilizers, pesticides, and irrigation help offset

deleterious effects of erosion but also has the potential to create pollution and health problems, destroy natural habitats, and contribute to high-energy consumption and unsustainable agricultural systems. Erosion is also a major cause of deforestation: since more forests are cut and converted to agricultural production when existing plots become degraded.

Crop yields on severely eroded soil are lower than those on protected solids because erosion reduces soil fertility and water availability. All crops require enormous quantities of water for their growth and the production of fruit. For example, during a single growing season, a hectare of corn (yield,  $7000 \text{ kg ha}^{-1}$ ) transpires about  $4 \times 10^6$  liters of water, and an additional  $2 \times 10^6$  liters  $\text{ha}^{-1}$  concurrently evaporates from the soil.

Organic matter, a necessary component of soil, facilitates the formation of soil aggregates, increases soil porosity, and thereby improves soil structure, and ultimately overall productivity. In addition, organic matter increases water infiltration, facilitates cation exchange, enhances root growth, and stimulates the proliferation of important soil biota. About 95% of the nitrogen and 25 to 50% of the phosphorous in topsoil is contained in organic matter.

Once the organic matter layer is depleted, soil productivity and crop yields decline because of the degraded soil structure and lost availability of nutrients. The erosion typical of conventional agriculture may decrease the diversity and abundance of soil organisms, whereas practices that maintain or add (as in compost addition) soil organic matter content at optimum levels favor the proliferation of soil biota. The application of organic matter may increase earthworm and microorganism biomass as much as fivefold. Soils form slowly: It takes between 200 and 1000 years to form 2.5 cm (1 inch) of topsoil under cropland conditions, and even

longer under pasture and forest conditions.

In the United States, an estimated  $4 \times 10^9$  tons of soil and  $130 \times 10^9$  tons of water are lost from the  $160 \times 10^6$  ha of cropland each year. This translates into an on-site economic loss of more than \$27 billion each year, of which \$20 billion is for replacement of nutrients and \$7 billion for lost water and soil depth. When economic costs of soil loss and degradation and off-site effects are conservatively estimated into the cost/benefit analyses of agriculture, it makes sound economic sense to invest in programs that are effective in reducing widespread erosion.

Compost can provide the much-needed organic matter in soil, and in combination with conventional soil conservation methods, provide an answer to the major environmental and agricultural problem of soil erosion. The benefits of compost-amended soil include:

- increasing organic carbon.
- improving water and nutrient retention.
- reducing the need for additional chemical inputs.
- favoring the proliferation of soil biota, and
- suppressing plant disease.
- increase earthworm and microorganism biomass as much as fivefold.

The feedstock for producing compost is biowastes - produce and grocery, food wastes, agricultural, lawn, yard and paper wastes. Approximately 50% of landfill trash is composed of paper, organic, and food wastes, all of which are partially or fully biodegradable. Thus, composting our biowastes (food, leaves, grass, wood, agricultural) along with new biodegradable plastic packaging and paper waste not only solves the problem of ecologically sound waste disposal but, provides much needed compost to maintain the productivity of our soil and support sustainable agriculture.

## CONCLUSIONS

Biodegradable plastics and biobased products based on annually renewable agricultural and biomass feedstocks can form the basis for a portfolio of sustainable, ecoefficient products that can compete and capture markets currently dominated by products based exclusively on petroleum feedstocks. 205-BDT410-GFA (Biodegradable film coated paper) combines the strengths of plastic (wet strength, tear etc.), without sacrificing the biodegradability of paper. Excellent performance properties & biodegradability, while being cost competitive, make this product a viable alternative to plastic coated paper. Ensuring that such a product ends up in a waste management infrastructure such as composting, is an ecologically sound way to treat and manage waste from a holistic life cycle standpoint.

## REFERENCES

1. Narayan, R. (1989). Environmentally Degradable Plastics, *Kunststoffe*, 79 (10)1022.
2. Narayan, R. (1993). Biodegradation of Polymeric Materials (Anthropogenic Macromolecules) During Composting, In: *Science and Engineering of Composting: Design, Environmental, Microbiological and Utilization Aspects*: Eds. H. A. J. Hoitink and H. M. Keener, Renaissance Publications, Ohio, pp. 339.
3. Narayan, R. (1993) Biodegradable Plastics, In: *Opportunities for Innovation: Biotechnology, National Institute of Standards and Technology (NIST, U. S. Department of Commerce) Monograph; NIST GCR-93-633*, pp. 135.
4. Narayan, R. (1994). Impact of Governmental Policies, Regulations, and Standards Activities on an Emerging Biodegradable Plastics Industry, In: *Biodegradable Plastics and Polymers*, Eds., Y. Doi & K. Fukuda, Elsevier, New York, pp. 261.
5. Narayan, R. (1992). Biomass (Renewable) Resources for Production of Materials, Chemicals, and Fuels -- A Paradigm Shift, *Am. Chem. Soc. Symp. Ser.*, 476,1.