SUSTAINABLE BIOMATERIALS COLLABORATIVE

Guidelines for Sustainable Bioplastics

Version 1.0 :: May 2009

Developed by

The Sustainable Biomaterials Collaborative

www.sustainablebiomaterials.org

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The Sustainable Biomaterials Collaborative works with sustainable agriculture, environmental health, clean production, recycling, and other public interest organizations working together to spur the introduction and use of sustainable biomaterials in the marketplace.

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Refer to www.sustainablebiomaterials.org for the most up-to-date version of this document and other reference materials on sustainable biomaterials. This is a living document that will be revised as the industry and our understanding of opportunities and challenges evolve. We welcome your feedback and input.

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Introduction

This guidance document proposes goals and a roadmap for improving the sustainability of bioplastics – defined for this document as plastics in which 100% of the carbon is derived from renewable agricultural and forestry resources. While these Guidelines focus on biobased plastic replacements for fossil-fuel-based plastics, many of the principles apply to other biobased materials as well.

The word "sustainability" in this document encompasses issues of environment, health, and social and economic justice, as well as material resource sustainability across the entire life cycle of bioplastics (from the production of their feedstocks to the management of the bioplastic product after its intended use).

This document represents the collective wisdom of a wide range of organizations that are engaged in addressing the potential benefits and challenges of bioplastics. Individuals and their organizations that have contributed to the development of this document are listed at the beginning of this document.

This is a working draft. It will continue to be revised as our understanding of the emerging industry evolves. Refer to www.sustainablebiomaterials.org for the most up-to-date version.

Principles: The goal of this document is to encourage the development and use of bioplastics that are healthy and sustainable. To be truly sustainable requires attention to a number of key principles:

- Reduce the amount of material, product and packaging used
- Eliminate single-use products that can be neither recycled nor composted
- Avoid fossil-fuel-based materials in favor of materials and products derived from renewable feedstocks
- Address sustainability across the life cycle of the material: the growing of the feedstock, manufacturing of the polymer and final product, using the product and reclaiming the material at the end of its original use.
- Define sustainability to include issues of environment, health, and social and economic justice.
- Design and use products that are reusable, recyclable or compostable.
- Encourage agricultural systems that are sustainable for farmers, the environment, farm workers' and communities.
- Support small- to mid-sized family owned and operated farms.
- Do not use genetically modified organisms in agricultural feedstock production.
- Use chemicals that meet the 12 Principles of Green Chemistry.[1]
- Avoid engineered nanomaterials and chemicals that have not been tested for environmental and public health effects across the life cycle.
- Decentralize production and buy local to reduce the environmental footprint of production, transportation, and consumption.

Problem statement: Fossil-fuel-derived plastics are non-renewable, often threaten public health, have devastating impacts on marine life, and increase reliance on imported fossil-fuel-based feedstocks. Overall recycling of fossil-fuel-based plastics remains at a very low level. Virgin fossil-fuel-based plastics inevitably must be entirely replaced with sustainable, biobased, renewable materials.

The development of bioplastics holds great promise to mitigate many of these sustainability problems, offering the potential of renewability, biodegradation, and a path away from harmful additives. They are not, however, an automatic panacea. Modern industrial agriculture creates a host of health, environmental, and social and economic justice issues including the use of genetically modified organisms (GMOs) in the field, toxic pesticides, high fossil fuel energy use, and destruction of family farms. Increased demand for agricultural products for energy and materials may well exacerbate problems posed by modern agriculture while increasing pressure on ecologically sensitive land and raising food security concerns.

Manufacture, use and discard of products made from bioplastics can also result in hazardous emissions, particularly if the bioplastic is mixed with fossil-fuel-based chemicals. While many bioplastic products are certified compostable, challenges remain to develop the education and outreach, the collection services, and the composting infrastructure to ensure products are actually composted at the end of their intended use. At the same time, some bioplastic products may be recyclable but similarly lack the necessary infrastructure, while posing concerns for existing recycling systems.

Bioplastics must be developed with clear sustainability goals and guideposts to avoid the pitfalls and realize the promise of this technology. Additionally, the current excessive consumption of materials and products will overburden the earth's capacity, whether the materials are fossil-fuel-based or biobased in origin. Reduced consumption, more efficient product design and applications, and shifts from disposables to reusables will be critical to achieving sustainability.

Continuous improvement: The contributors to these Guidelines believe that the sustainability challenges for bioplastics can be overcome. We seek in this document to identify key issues at each step of the life cycle that would make the biolastic more sustainable. This guidance document is not a rating system. It emphasizes goals rather than hard criteria.

We acknowledge that not all of the goals outlined in the Guidelines are immediately achievable. Developing the technology and markets for sustainable bioplastics will require time. For example, bioplastics have not yet been developed with the performance characteristics required for some applications. While the long term goal is to use products that are purely biobased, these Guidelines recognize the significant role that blends of biobased and fossil-fuel-based materials may play to meet performance criteria in certain applications in the short term.

For some goals, therefore, we have defined a progression of intermediate steps towards the ultimate goals (*"Steps to best practice"*). We anticipate developing more such progressions for other goals in the future. We also anticipate developing more measurable criteria by which to judge attainment of these steps and goals.

We encourage companies to evaluate their current practices and make public commitments to changes in practice toward these goals with milestones and timelines to demonstrate their commitment to continuous improvement.

Scope: These guidelines were initially developed specifically to address plastics produced from agricultural products. However, we anticipate that these guidelines will be applicable to a wider range of emerging plastics and chemicals derived from a diverse set of biobased materials including forestry products and other cellulosic feedstocks. While establishing a goal of 100% biobased material content, the guidelines acknowledge the role of blends with fossil-fuel-based materials in the transition and address increasing sustainability of these blends.

The product applications considered explicitly in the development of this document are disposable food service products (such as cups, utensils, and take-out containers), packaging (such as bottles and produce trays), bags, consumer fabric items (such as towels and clothing), and interior finish building materials (such as carpet and wall guards), but this document is intended to have broader applicability. An ongoing revision process is expected as technologies and understanding of their impacts improve in this rapidly evolving field.

Audience: These guidelines have been designed to provide guidance to all of the players involved in the emerging international bioplastic industry: *farmers* growing the feedstock, *manufacturers* creating the polymers from the feedstock and related *converters* turning the bioplastics into products, *wholesalers* and *retailers* selling the products, *buyers* of the final products, *recyclers or composters* of the discarded products, and *policy makers* setting the framework for support of this work. Creative economic structures may include organizations that combine roles such as farmer cooperatives that both grow feedstock and manufacture plastics.

Buyer engagement is critical. While all players are assumed to have some level of interest in improving the sustainability of the bioplastic industry, success in reaching these goals will depend upon buyers setting high standards and clearly communicating to the industry their commitment to purchasing products only from manufacturers and converters who demonstrate continuous progress toward supporting and attaining these goals.

Bioplastic buyers should visit www.sustainablebiomaterials.org for more information on purchasing critera.

Sustainability Goals for Bioplastics by Life Cycle Stage

The sustainability goals for bioplastics are defined below for the following major life cycle stages of the material:

1) Feedstock Production and Transportation
Farmers grow the crop and farmers or intermediaries transport the crop to a processing or manufacturing facility.

2) Processing and Manufacturing
Manufacturer converts the crop into a chemical form; it is polymerized and pelletized, then converted (often by another manufacturer – a fabricator or converter) into a final product.

3) Product Distribution and Use
Wholesalers and retailers market the product. End users purchase, use and maintain the product.

4) End of Product Life
End users discard the product, which is then reused, recycled, composted, incinerated or landfilled.

******Steps to best practice*** indicate a recommended progression of steps from the easiest to the ultimate best practices. These are intended to represent steps toward ideals. It is recognized that some of these ideals may not be attainable in the near term. The ***Steps*** outline a pathway to the ideal over time.

1) Biological Feedstock Production

The overall goal for feedstock production is agricultural systems that are sustainable for farmers, the environment, farm workers, and communities. This section defines the goals for the *farmers* that grow the crops. Attainment of these goals, however, will generally require the support of the *manufacturers* who buy the farmers' crops. *Buyers* can engage by encouraging manufacturers to preferentially purchase feedstock that addresses these goals. Buyers may also encourage the spread of these practices through participation in credible offset and certificate programs where the sustainably grown feedstock is not already readily available for the actual product.

a) Eliminate hazardous chemicals of concern

i) ****Steps to best practice are:*

(1) Use integrated pest and weed management to lower use of synthetic chemicals.
(2) Avoid use of bio-solids on cropland from sewage sludge due to toxic chemical content.
(3) Eliminate use of key hazardous chemicals of concern (see Appendix):
  (a) Persistent, bioaccumulative and toxic (PBT) chemicals
  (b) Very persistent and very bioaccumulative chemicals (vPvB)
  (c) Carcinogens, mutagens, reproductive toxicants and endocrine disruptors.
(4) Eliminate use of all hazardous chemicals.

b) Avoid usage of genetically modified seeds: Protect biological diversity, health and safety and access to seeds and non-transgenic varieties for farmers. See guidance for GMOs in production under Section 2 - Processing and Manufacturing.

c) Conserve, protect and build soil

i) ****Steps to best practice are:*

(1) Use no-till or conservation tillage, cover crops, mulch and crop rotations to optimize water retention, increase carbon sequestration, build soil health, and sustain and enhance soil fertility.

(2) Use other soil retention and conservation practices, such as terraces; contour farming; strip cropping; undersowing/interplanting; permanent waterways; wind or fire breaks.

(3) Use perennial deep-rooted crops and grasses to protect soil.

d) Conserve nutrient cycles

i) Utilize on-farm nutrients, such as well composted animal and green manures that do not contain toxic or hazardous contaminants.

ii) Use cover crops and mulches to supply nutrients and minimize losses.

iii) Grow well-adapted crops that integrate into the farm's nutrient cycling.

iv) Minimize the amount of nutrients that are imported onto the farm such as feeds.

v) Minimize use and eliminate the runoff of synthetic fertilizer.

e) Protect air and water access and quality

i) Utilize well-adapted crops in systems that do not require irrigation.

ii) Eliminate pollution from erosion, pesticides and nutrients or other waste products.

iii) Minimize water use by maximizing efficiency of irrigation and other water utilization systems.

iv) Do not use water beyond replacement levels.

v) Return surplus water to original ground and surface water sources. The returned water must be clean and able to support drinking water needs and healthy aquatic ecosystems.

vi) Eliminate wind erosion, odor, chemical and biological drift and other air quality impacts.

vii) Create on-site biological water treatment systems.

f) Promote biological diversity

i) Avoid monoculture planting. Develop feedstocks raised in polyculture and perennial-based agricultural systems serving multiple purposes; plan crop rotations so some fields always provide food (intentionally planted wildlife food crops or crop leftovers), water, and cover for priority and other wildlife.

ii) Use selection of plant species and varieties adapted to site-specific conditions and/or non-chemical weed control methods to reduce or eliminate herbicides, herbicide tolerant crops, and other technologies that threaten plant diversity.

iii) Use selection of plant species and varieties adapted to site-specific conditions and/or biological pest control methods, including development of habitat for natural enemies; companion planting; release of predators/parasites of pest species; provide habitat for insect predators, birds and bats; or other biologica controls.

iv) Restore and/or protect wildlife habitat, corridors, migratory pathways, waterways and wetlands; restore and/or maintain natural buffers, such as wildlife corridors and riparian zones; when appropriate, flood fallow fields to provide habitat for waterfowl and shore birds; create means for safe passage of wildlife through parts of the farm, by adapting or reducing fencing; avoid conversion of sensitive habitats to farm production. Base wildlife restoration on native species and pre-agricultural ecosystems.

v) Develop conservation plans that include protection of endangered species, species of special concern, keystone species, and genetic resources, and prevention of the introduction and spread of invasive species; provide habitat for pollinators.

vi) Do not convert existing forest, wildlife refuge or parkland or other important habitat to plantations or crop land. Conservation Reserve Program (CRP) lands can be used only with crops and farm plans compatible with the CRP purpose.

g) Reduce impacts of energy use

i) Minimize total energy use.

ii) Use renewable energy sources, preferably produced on-farm or within the region of the farm.

iii) Use only renewable energy sources – ideally from on-farm generation and local cooperative supplies.

h) Reduce transportation impacts

i) Establish local processing facilities to reduce transportation distances.
ii) Assure that vehicles transporting crops are loaded efficiently and are in good operating condition to optimize fuel economy and minimize environmental effects.
iii) Use renewable energy for transportation.
iv) Reduce or eliminate packaging.
v) Use packaging for farm crops that is biobased and compostable or is 100% recycled content and is recyclable.

i) Develop and certify a comprehensive sustainable agriculture plan

i) Use a program developed with farm stakeholder engagement that encourages farm planning and practices and that promotes the goals listed above. Certify implementation. (Examples include the IATP Third Crop Working Landscapes Certificate program,[2] USDA organic[3] or state certified organic[4] and IFOAM organic member organizations.[5] Programs from organizations that meet the criteria of ISEAL Alliance[6] full membership (such as Working Landscapes and IFOAM programs) will tend to encompass a more comprehensive scope of environmentally sustainable agriculture harvest methods than other organic programs.
ii) Observe similar sustainability guidelines for production of timber for wood cellulose based polymers. Use only certification by Forest Stewardship Council accredited programs.

j) Protect workers. See Appendix

2) Processing and Manufacturing

The overall goal in the processing and manufacturing phase is to establish processes that support sustainable feedstock production and minimize the direct environmental impacts of the production process – ultimately moving toward regenerative processes. Goals in this section outline steps for *manufacturers* and *converters* to take toward these production goals. Manufacturers are also responsible to create products that are healthy and safe for the environment during use and that will work well in end-of-life reclamation processes.

a) Support sustainable feedstock production

i) Support growers who do not use genetically modified seed stocks. *(Note: The avoidance of genetically modified organisms (GMOs) applies only to application of genetically modified seeds in the field. See below and further discussion in Appendix)*

****Steps to best practice are:**

(1) Provide an option for customers to buy GMO-free source offsets equivalent to the feedstock needed for the purchase size.
(2) Purchase GMO-free source offsets equivalent to all manufacturing operation feedstock purchases.
(3) Use 100% identity preserved GMO-free feedstock.

ii) Preferentially purchase feedstocks that address the full range of feedstock production goals defined in section 1 above. Utilize programs such as those described in 1i) above to certify sustainability.

****Steps to best practice are:**

(1) Provide an option for customers to buy sustainably harvested offsets equivalent to the feedstock needed for the purchase size.
(2) The company purchases sustainable harvest offsets equivalent to all manufacturing operation feedstock purchases.
(3) Use 100% identity preserved certified sustainably harvested feedstock.

iii) Improve economic and social conditions of family farmers by preferentially purchasing crops from family farms, especially small to mid sized family owned and operated farms and from distribution systems that help ensure the long-term protection of farm land free of development threats.
iv) Develop products that utilize feedstocks that do not compete with food stocks.
v) Support state and federal farm policies that provide incentives to farmers to produce crops in a more sustainable manner.
vi) International sourcing raises particular challenges for following the above guidelines for sustainable feedstocks. Seek to source feedstock that is certified for sustainability and fair trade by international organizations.

b) Reduce impacts of energy use

i) Use local biobased feedstock supplies and use decentralized manufacturing to reduce transportation energy usage

ii) Maximize energy efficiency of process.

iii) Maximize on-site or local renewable energy.

****Steps to best practice are:*

(1) Renewable energy credits. These can be useful to bring the entire process to carbon neutrality, particularly for energy use in parts of the process out of the manufacturers' control, such as the feedstock crop harvesting, but every effort should be made to maximize energy production from the next two sources first.

(2) Renewable energy from local sources with priority to sources owned by area farmers or cooperatives and local governments.

(3) Energy derived from agricultural wastes and renewable energy harvested onsite at the facility (for example, rooftop solar, on-property wind energy).

iv) Seek to be a net energy provider to community solely with on-site renewable or process sources.

v) Avoid use of all non renewable energy resources, on-site or from utilities, including fossil and nuclear fuels. Add no new coal fired capacity on-site or in the utility grid to fuel operations. Avoid energy from incineration of municipal waste or other recyclable or compostable waste streams or "energy conversion" technologies utilizing mixed municipal waste.

c) Avoid problematic blends and additives and encourage recycling

i) Avoid blends with fossil-fuel-derived plastics. It is recognized that the development of durable goods that are entirely compostable and made without blends is a challenge that may require blends at first and will improve over time. It is also recognized that some durable applications may be better suited to recycling than composting. Particularly avoid blending with virgin or recycled non-preferred fossil-fuel-based plastic (including PVC, PS, ABS, PC, and PU). Blends should be labeled clearly, identifying the blended materials and the percent biobased.

****Steps to best practice are:*

(1) Blend with virgin preferred fossil-fuel-based plastic (PE, PP, PET)[7]

(2) Blend with recycled preferred fossil-fuel-based plastic (PE, PP, PET) or all bioplastic blend. The product should be recyclable, even if it doesn't meet composting standards for speed or toxicity.

(3) Blend with fossil-fuel-based polymer that is fully recyclable or compostable to standards as listed in End-of-Life section 4 of these guidelines

(4) Blend only bioplastics, no fossil-fuel plastic, all recyclable and/or compostable

(5) Use only a pure single bioplastic, all recyclable and/or compostable

Note: Disposable foodware should start at step 3. No biobased foodware should be made that is not fully compostable. Steps 1 and 2 are only acceptable as interim development steps for durable goods.

ii) Maximize recycled content – particularly post consumer

iii) Eliminate hazardous additives. This includes both additives mixed into the polymer and surface treatments, such as labels, adhesives, stain resist and printing inks and dyes.

****Steps to best practice are:*

(1) Provide information on the toxicity of all additives, including their rating on a chemical hazard assessment protocol.

(2) Eliminate highest priority persistent or bioaccumulative toxic chemicals (PBTs) and priority carcinogens and reproductive toxicants on California's Prop 65 list. See Chemicals of Concern in Appendices.

(3) Eliminate all known hazardous chemical additives.

(4) Use biobased additives and surface treatments, including vegetable-based inks and dyes.

(5) Design polymer or application to avoid need for additives.

iv) Exercise caution with nanomaterials. Use only nanomaterials that have been subjected to thorough testing and environmental health and safety impact assessment across their life cycle. Follow the Precautionary Principle, substituting safer alternatives in preference to nanomaterials that may have serious adverse effects. Utilize nanomaterials only in a manner that protects against human exposures or environmental releases. Label all uses of nanomaterials and include toxicity information on nanomaterials for worker protection on material safety data sheets.[8]

d) Maximize process safety and minimize hazardous emissions

i) Use safe catalysts. Develop screening methods for safe catalysts with guidelines for genetically modified enzyme development, especially, but not solely for transgenic varieties. See Appendix for further discussion

ii) Redesign processes to eliminate hazardous emissions and criteria air and water pollutants.

iii) Develop closed loop process systems with no waste.

iv) Protect worker health and safety ****Steps to best practice* for managing safety hazards are:

(1) Personal protective equipment
(2) Administrative support for safe practice
(3) Engineering controls to manage
(4) Isolation to reduce potential interactions
(5) Substitution to eliminate hazard

e) Continuous improvement - Establish ISO 14001 type goals to identify current practice and desired endpoints and proposed timelines to demonstrate commitment to continuous improvement and clarity of goals.

f) Protect workers. See Appendix.

3) Product Distribution and Use

The overall goal for use is that products be safe and not harmful for humans and the environment during use and not overburdening the world's farmland and other resources. *Manufacturers* are responsible for designing products that meet healthy exposure goals. Many of the goals of responsible manufacture listed in the previous section also contribute to safety during the use phase. *Manufacturers*, *wholesalers* and *retailers* are responsible to fully disclose contents of products to users and educate them. *Users* are responsible to move to reusables, reduce their usage of disposables and be efficient in use.

a) Reduce quantity used

i) Be efficient in use of all products. Evaluate needs and change use patterns to reduce product demand.

ii) Use reusables, where possible, instead of single-use products. For example, efforts to reduce the impacts of retail bags should focus on providing incentives for the use of cloth reusable bags, rather than single-use bags, biodegradable or not. (See Appendix on biodegradable bag applications.) Likewise, food services should evaluate the feasibility of moving to reusable food service ware instead of single use products - bioplastic or otherwise - especially when composting or recycling are not possible.

b) Avoid unhealthy exposures

i) Limit VOC emissions from products to meet the strictest applicable standards:

- Paint, coatings, sealants, adhesives and lubricants must meet California South Coast Air Quality Management District (SCAQMD) VOC regulatory limits.[9]
- Furniture and interior finish materials must pass CA 01350[10] and/or GreenGuard Children and Schools VOC test.

ii) Use no materials that leach synthetic compounds into aqueous or lipid-containing solutions or into the environment.

c) Create opportunities for sustainability education

i) Use branding and marketing opportunities to support education on sustainability.

ii) Use school/community/business partnerships to develop increased awareness and education of potential benefits of sustainable bioplastics.

d) Label material content – Disclose all materials utilized in the product, including percentage of biobased content.

e) Prefer local - Decentralize distribution and buy local to reduce the environmental footprint of production, transportation, and consumption.

4) End of Product Life

The overall goal for bioplastic products at the end of their intended use is to ensure that the loop is closed, cycling the product back at the end of its life to be reutilized. The general preferred hierarchy of disposition at the end of product life is: reduce, reuse, recycle, compost.

Disposal, whether in landfills or incinerators (including for energy generation), is to be avoided. Bioplastics are just another burden on the landfill unless they are closed-loop recycled or composted into a safe soil amendment product at the end of product life. Without the technology and infrastructure in place to handle these materials – and consumer awareness to use it – bioplastics are likely to end up being thrown away rather than recycled or composted.

Buyers should explore all options for reducing waste by using energy and resource efficient reusables before procuring bioplastic single-use products and by seeking post-consumer recycled content in all products. Recycling bioplastics in a closed loop primary recycling system may frequently represent a higher value end use than composting, reclaiming more of the energy and resources embodied in the product. No bioplastic products, however, are currently being recycled at the end of their intended use. *Buyers* can help speed the development of recycled biobased products by signaling manufacturers through establishing preferences for post-consumer recycled content in purchasing specifications.

Alternatively, many bioplastic products available today are certified as compostable in commercial facilities and can help the functioning of food discard composting operations. One benefit of compost operations is that they tend to be locally based, accepting organics and selling product within local economies. Buyers can help develop the needed infrastructure to reclaim bioplastics through composting until the critical mass exists to support a recycling infrastructure.

Manufacturers are responsible for designing products that will work well in end-of-life reclamation processes. *Manufacturers, retailers, users and public* and *private waste management entities* must all work together to create and use the highest possible end-of-life management systems for products.

In the case of beverage containers, biobased bottles pose both a technical and economic threat to PET and HDPE recycling operations and are not currently economically compostable (see Appendix). Likewise in the case of plastic bag or other film products, biobased products may become contaminates in conventional film plastic recycling. Compostable bioplastic film or bags, especially for retail applications, should only be considered where there is an adequate local food scrap organics collection and composting infrastructure. Before introduction of these potentially destabilizing products, *manufacturers, converters and retailers* should work first with the recycling community to develop economically viable systems for recovering bioplastics. For compostable biobased bags, food scrap collectors and processors should also be involved to make sure that the bags will work in local systems. Transition to biobased plastics will likely entail some disruption of current systems, but the key is to explore options that minimize that disruption and result in a net environmental benefit (for example, reduction in energy and product waste).

a) Ensure safe and rapid biodegradation

i) Ensure that products are certified compostable in a timescale that works with municipal and other commercial composting systems and that they leave no toxic residue of heavy metals or organic chemicals when they degrade. Give preference to third-party lab certification.

****Steps to best practice are:*

(1) Certification to “ASTM D6400-04 Standard Specification for Compostable Plastics” and ASTM D6868-03 “Standard Specification for Biodegradable Plastics Used as Coatings on Paper and Other Compostable Substrates” and D6094-97 “Standard Guide to Assess the Compostability of Environmentally Degradable Nonwoven Fabrics” by the Biodegradable Products Institute.[11]

(2) Certification to a standard with more stringent heavy metal restrictions. Labels include: Belgium’s AIB Vincotte Inter (AVI)[12], Australia’s Good Environmental Choice[13], Japan’s GreenPla[14] or Germany’s IBAW Kompstierbar.[15]

ii) Design for biodegradability in marine environment. Meet ASTM D7081-05 Standard Specification for Non-Floating Biodegradable Plastics in the Marine Environment and be safe for marine life if ingested (mouth, gills, etc) before and during biodegradation. *(Note that the ASTM standard only addresses "non-floating" plastics. Floating plastics are a major problem in the ocean. There is no known standard for floating plastics at this time.)*

b) Design product for recycling or composting

i) Design for minimum number of different material types. For multi-component products, design for quick disassembly and positive identification of component materials for recycling or composting. Avoid barrier materials that interfere with composting or recycling.

ii) Design for handling by small scale, locally managed composting and recycling systems. Design product and labeling that facilitates easy identification and sorting by the consumer. Bottle applications should be designed and labeled to facilitate easy sorting at materials recovery facilities.

iii) Certain products designed for long-term durability may not be able to be made compatible with composting programs. Landfilling and incineration are the least desirable end-of-life options as both will result in loss of the feedstock resources. Incineration (and landfilling in case of fire) will result in generation of particulate and — depending upon additives and conditions of burn — other harmful emissions.

****Steps to best practice* are:

(1) Design to downcycle to a lower quality use.

(2) Design for closed loop recycling to same or higher use or to be fully compostable.

(3) Design for closed loop recycling to same or higher use and full compostability.

c) Producer and converter industry participate in planning for complete life cycle (extended producer responsibility). Polymer manufacturer and converters should:

i) Maximize use of post consumer content.

ii) Set restrictions to eliminate use of hazardous additives by converters.

iii) Work with recycling community to find solutions for challenges of mixed waste streams containing similar products made of fossil fuel plastic and of bioplastic.

iv) Participate with recycling industry in developing and enforcing agreements on clear and consistent labeling/coding for easy separation and education for composting or recycling.

v) Work with retailers to take responsibility to assist development of end of life infrastructure for products, including development of automated sort technology. Manufacturer take back will be necessary for products as long as hazardous ingredients necessitating special handling remain in the product formulation.

vi) Not introduce products that are particularly disruptive of existing recycling systems, such as bottle applications, without first establishing economically viable commodity recycling systems. Direct manufacturer or retailer take back should only be as a bridge to development of economically viable independent systems. (Note that composting bottles is not currently economically viable due to sorting costs and fees charged by compost operations.)

d) Protect workers. See Appendix.

Appendices

Appendix: Chemicals of concern

Chemicals of Concern include

- Persistent organic pollutants (POPs) and other persistent bioaccumulative toxic chemicals (PBTs)
- Carcinogens
- Neurotoxins
- Reproductive toxicants
- Developmental toxicants
- Endocrine disruptors
- Mutagens
- All halogenated chemicals, including brominated or other halogenated flame retardants
- Other acute or chronic toxicants

The end goal of eliminating chemicals of concern is to affirmatively test chemicals for safety. The Green Screen for Safer Chemicals, developed by Clean Production Action (www.cleanproduction.org) is a protocol for rating chemicals based upon a series of characteristics of persistence, bioaccumulation potential and toxicity and the level of testing available to confirm safety. Ideal chemicals for use in bioplastics will all meet the Green Screen Benchmark 4 with low inherent toxicity to humans and wildlife, no bioaccumulation and rapid and complete degradation to benign degradation products or metabolites. These are chemicals that would meet the Principles of Green Chemistry. Further information on the Green Screen is available at http://www.cleanproduction.org/Green.Greenscreen.php

More information on lists of chemicals of concern is available from the Healthy Building Network's Pharos Project (http://www.pharosproject.net/wiki/index.php?title=Chemicals_of_concern)

Further discussion on these and other issues with high hazard additives to avoid can be found in Rossi and Lent, "Creating Safe and Healthy Spaces: Selecting Materials that Support Healing" in Designing the 21st Century Hospital Environmental Leadership for Healthier Patients and Facilities (http://www.healthybuilding.net/healthcare/HCWH-CHD-Designing_the_21st_Century_Hospital.pdf 135 pages PDF)

Appendix: Genetically modified organisms

While these Guidelines recommend against usage of genetically modified seed stock in the field, genetically engineered organisms, enzymes and other entities used in processing of feedstocks are conditionally supported. This is under the presumption that they are contained within the processing system and not viable outside of the system. It is important to evaluate viability outside of the process and potential for harm. The UN Cartagena Protocol on Biosafety (http://www.biodiv.org/biosafety/default.asp) provides useful guidance to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology, specifically focusing on trans-boundary movement of any living modified organism resulting from modern biotechnology that may harm the conservation and sustainable use of biological diversity.

The Protocol makes specific reference to the precautionary principle as stated in Principle 15 of the Rio Declaration of 1992. See Annex III for general principles, methodological steps, and points to consider in the conduct of risk assessment. The general principles include, among others, the following concepts: Risk assessment should be carried out in a scientifically sound and transparent manner; Lack of scientific knowledge or scientific consensus should not necessarily be interpreted as indicating a particular level of risk, an absence of risk, or an acceptable risk; Risks should be considered in the context of risks posed by the non-modified recipients or parental organisms; and that Risks should be assessed on a case-by-case basis.

Appendix: Recycling Challenges for Bottles and Bags

Bottles: When recycling systems exist and are successful, composting the product or package will lose the front end inputs that were used in its extraction, refining and production although this must be weighed against the costs of transportation and recycling. In addition, in the case of the bottles, polyethylene terephthalate (PET) bottles that are likely to be displaced by PLA bottles are extremely valuable for current recycling programs, generally selling for more than 20 cents per pound. That high value will be completely lost inasmuch as the economics of composting would not assign any value to PLA bottles. Moreover, beyond the lost revenues, in the near term during a transition to PLA bottles before investments in expensive auto sort equipment could be justified, bioplastics would contaminate and reduce the value in the PET bottles that are being recycled.

In the longer term, after auto-sort systems can be justified and become widespread, recyclers would still incur additional sortation costs to remove the PLA contaminant, which can range from around 1 - 2 cents per pound to separate the PLA from other plastic bottles. However, because bioplastics otherwise hold so much promise, research should be encouraged to develop and commercialize means to recycle rather than compost PLA to approximate the net value of PET. If that can be done and is corroborated by major recycling programs, pilot programs may be appropriate to validate such systems in a test. Based upon what is presently commercialized in the market, however, there is much controversy currently about the introduction of bioplastic predicated upon composting at the end of the life for bottles where there is an existing and successful recycling system. Potential PLA bottle manufacturers are urged to develop systems to successfully and economically recycle bioplastic bottles to overcome the challenges posed to the current recycling program before there is widespread production.This is in contrast to other applications such as cutlery, cups and utensils for which there is presently no flourishing recycling infrastructure.

Bags: Currently, all biodegradable/compostable bags available on the market contain a large percentage of fossil-fuel-based plastics. They also present similar challenges to existing plastic recycling systems as do bottles. Unless a composting collection infrastructure is in place for these, biodegradable bags for retail applications should be avoided (as should other single-use fossil-fuel based bags). One excellent application for biodegradable bags is to collect food waste for composting. Indeed, food scrap composting programs and use of compostable bags are expanding, most notably in the San Francisco Bay Area and some other key cities. While a lot of traditional plastic film is technically recyclable and demand for this material is high, only a tiny portion is actually being recycled (less than 1% nationally). One reason is traditional plastic film is not economically recyclable or compostable in household curbside collection programs. When this material is mixed with recyclables or organics at curbside, it becomes a major contaminant in recycling and composting programs. As curbside organics collection programs expand to include many types of compostable materials, compostable bags and film products have the potential to reach higher recovery levels than their petroleum-based counterparts.

Appendix: Protection of Workers

Farms, manufacturers, recyclers and others in the life cycle of biobased materials should all have policies that reflect international guidelines for the protection of worker health and provision of fair compensation. Issues addressed should at least be:

- **Protect worker health and safety.** Ensure that workplaces meet the highest levels of safety practice.
    - Provide health care benefits and ensure access to adequate medical care of employees' choice.
    - Minimize employee exposure to hazardous or toxic materials in the workplace by eliminating their use or choose least toxic alternatives. Display warnings about any hazards that cannot be avoided prominently. Provide adequate safety gear at company expense.

- **Pay Fair compensation.** Pay workers a living wage.
    - Provide social security, disability, maternity/family leave, sick leave, vacation, unemployment and retirement benefits.
    - Ensure farm workers have access to safe and adequate housing and to child care while parents are working.

Useful resources include:

- Global Reporting Initiative G3 Guidelines - Social Responsibility section (www.globalreporting.org)
- Social Accountability International – Social Accountability Standard (SA 8000) http://www.sa-intl.org
- Occupational Health and Safety Assessment Series (OHSAS) 18001 Health and Safety management specification (http://www.ohsas-18001-occupational-health-and-safety.com)

Definitions[16]

Biobased content is the amount of biobased carbon in the material or product as fraction weight (mass) or percent weight (mass) of the total organic carbon in the material or product.[17] ASTM Method D6866-05 is the US government approved method for determining the renewable/biobased content of biobased products.

Biobased material(s) are organic material(s) in which the carbon comes from contemporary (non-fossil) biological sources.[18]

Biodegradable plastics are plastics that can decompose into carbon dioxide, methane, water, inorganic compounds, or biomass via microbial assimilation (the enzymatic action of microorganisms). To be considered biodegradable, this decomposition has to be measured by standardized tests, and take place within a specified period time, which vary according to the "disposal" method chosen. The American Society of Testing and Materials (ASTM) has created definitions on what constitutes biodegradability in various disposal environments. Plastics that meet ASTM D6400, for instance, can be certified as biodegradable and compostable in commercial composting facilities. In Europe the equivalent standardized test criteria is EN 13432. In the US, there is a biodegradability standard for soil (ASTM D5988), a biodegradability test standard for marine and fresh water (ASTM D6692 and D6691), one for wastewater treatment facilities (ASTM D5271), and one for anaerobic digestion (ASTM D 5511). Other countries have similar standards and certifications. Belgium is unique in offering "The OK Compost" mark, which guarantees that the product can be composted in home composting systems. While many bioplastics are indeed certifiable as compostable in commercial compost facilities, not all can be home composted and not all are biodegradable in the marine environment. Furthermore, a number of fossil fuel-based polymers are certified biodegradable and compostable. Biodegradability is directly linked to the chemical structure, not to the origin of the raw materials.

Bioplastics are plastics in which 100% of the carbon is derived from renewable agricultural and forestry resources such as corn starch, soybean protein, and cellulose. Bioplastics are not a single class of polymers but rather a family of products which can vary significantly from one another. They differ from traditional plastics, which are derived from fossil fuels or non-renewable carbon. Not all bioplastics are biodegradable and not all biodegradable plastics are bioplastics.

Organic material(s) are material(s) containing carbon based compound(s) in which the carbon is attached to other carbon atom(s), hydrogen, oxygen, or other elements in a chain, ring, or three dimensional structure.[19]

References

Refer to www.sustainablebiomaterials.org for the most up-to-date version of this document and for other reference material.

[1] Anastas, P. T., and J.C. Warner. 1998. Green Chemistry Theory and Practice New York: Oxford University Press. Also see Green Chemistry Institute Web site at www.greenchemistryinstitute.org.

[2] More information about the Working Landscapes certificates program is available at www.workinglandscapes.org/

[3] United States Department of Agriculture (USDA www.ams.usda.gov/nop)

[4] State organic programs include California Certified Organic Farmers (CCOF www.ccof.org), Oregon Tilth Certified Organic (OTCO www.tilth.org) and Pennsylvania Certified Organic (PCO www.paorganic.org)

[5] The International Federation of Organic Agriculture Movements (IFOAM www.ifoam.org)

[6] International Social and Environmental Accreditation and Labeling Alliance (ISEAL Alliance www.isealalliance.org)

[7] For description of relative preference rating of fossil-fuel-based plastics, see Rossi and Lent "Creating Safe and Healthy Spaces: Selecting Materials that Support Healing" in Designing the 21st Century Hospital Environmental Leadership for Healthier Patients and Facilities (http://www.healthybuilding.net/healthcare/HCWH-CHD-Designing_the_21st_Century_Hospital.pdf 135 pages PDF)

[8] For more information and recommendations for the nanotechnology industry to protect public health., see the NRDC's web site at www.nrdc.org/health/science/nano.asp

[9] South Coast Air Quality Management District (SCAQMD) Rule #1168, (Adhesive and Sealant Applications), www.aqmd.gov/rules/reg/reg11/r1168.pdf. and SCAQMD Rule 1113, (Architectural Coatings) www.aqmd.gov/rules/reg/reg11/r1113.pdf. Rule 1107. Coating Of Metal Parts And Products and other rules address lubricants www.aqmd.gov/rules/reg/reg11/r1107.pdf

[10] For more information on certification programs that utilize the CA 01350 standard, see "Improving Indoor Air Quality with the California 01350 Specification" www.healthybuilding.net/healthcare/CHPS_1350_summary.pdf

[11] The Biodegradable Products Institute is at http://bpiworld.org/

[12] The standard is EN 13432 certified by AIB Vincotte Inter www.aib-vincotte.com/

[13] The standard is AELA 12-2004 - Compostable Biopolymer Products by the by the Australian Environmental Labeling Association www.aela.org.au/gec/biodegradable_plastic.html

[14] The standard is Biodegradable Plastics Society's Rules for Positive List www.bpsweb.net/02_english/

[15] The standard is DIN V 54900 certified by DIN CERTCO www.dincertco.de/en/

[16] Unless otherwise indicated, definitions were developed by Brenda Platt, Institute for Local Self-Reliance.

[17] Ramani Narayan, Michigan State University, www.msu.edu/~narayan/

[18] Ibid.

[19] Ibid