Biodegradable Mulch Films: Their Constituents and Suitability for Organic Agriculture

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Abstract: In October 2014, the National Organic Program (NOP) of the US Department of Agriculture (USDA) added synthetic biodegradable biobased mulch film (BBMF) to the list of allowed substances for certified organic production (see NOP criteria below). The most common biobased feedstocks used to make BBMF are starch, polylactic acid (PLA) and polyhydroxyalkanoates (PHA). If sourced in the U.S., starch may be derived from genetically modified organisms (GMOs), specifically corn or sugar beet. PLA and PHA are produced by fermentation using GM yeast or bacteria. To date, none of the biodegradable plastic mulches on the market has been approved for use in certified organic production systems. This is because none of the mulches meet the certification requirement of using only biobased feedstocks; currently available BBMF contain a maximum of 20% biobased feedstocks. Additionally, GMOs are used to manufacture the biobased feedstocks. This poster presents BBMF products available on the market with information about their feedstocks, manufacturing processes, and biodegradability.

Figure 1. WeedGuardPlus (allowed for certified organic production) with pumpkin in biodegradable mulch experiment at WSU Mount Vernon Research Center in 2016.

USDA NOP Rule 7 CFR § 205

❖ **Biodegradable biobased mulch film (BBMF). A synthetic mulch film that meets the following criteria:**

1) Meets the compostability specifications of one of the following standards: ASTM D6400, ASTM D6868, EN 13432, EN 14995, or ISO 17088 (all incorporated by reference; see §205.3);
2) Demonstrates at least 90% biodegradation absolute or relative to microcrystalline cellulose in less than two years, in soil, according to one of the following test methods: ISO 17556 or ASTM D5988 (both incorporated by reference; see §205.3); and
3) Must be biobased with content determined using ASTM D6866 (incorporated by reference; see §205.3).
4) Must be produced without organisms or feedstocks derived from excluded methods (see §205.601)

❖ **USDA NOP Policy Memo 15-1**

- Biodegradable mulch film that contains non-biobased synthetic polymer feedstocks, such as petrochemical resins, does not comply with the USDA organic regulations.
- Pigments and processing aids are not considered feedstocks.
- However the memo does not provide clarity regarding additives: are they processing aids or feedstocks?

❖ **OMRI Report to USDA NOP (June 5, 2015)**

- Biobased content for currently available commercial BBMFs is ~10-20%, with the remaining portion being fossil fuel feedstocks, minerals and dyes.

Table 1. Product names, polymer ingredients, and manufacturers of currently available biodegradable mulches. Currently, no biodegradable mulch is approved for use in certified organic agriculture except paper (cellulose) mulches.

Product Name	Polymer Ingredient(s)[1]	Manufacturer	Location
Bio360	Mater-Bi (TPS + PCL); PBAT	Dubois Agrinovation	St. Remi, QC, Canada
BioAgri	Mater-Bi (TPS + PCL); PBAT	BioBag International	Askim, Norway
Biocycle	Sucrose/PHA blend	PHB Industrial	São Paulo, Brazil
Bio-Flex	PLA / co-polyester	FKuR Kunststoff	Willich, Germany
Biomax TPS	Starch + TPS	DuPont USA	Wilmington, DE, USA
Biomer L	PHA	Biomer	Krailling, Germany
Bionolle	TPS + PLA + (PBS or PBSA)	Showa Denko Europe	Münich, Germany
Biopar	TPS / co-polyester	BIOP Biopolymer Technologies	Dresden, Germany
Biosafe	PBAT / TPS blend; PBS; PBSA	Maxim Industries (HK) Limited	New Territories, HK
Eastar Bio	PBAT / TPS blend	Eastman Chemical	Kingsport, TN, USA
EcoCover	Recycled paper (cellulose)	EcoCover Holdings Limited	Auckland, New Zealand
EcoFilm	Unspecified plastic	Cortec Corporation	St. Paul, MN, USA
Eco-Flex	PBAT; TPS	BASF SE	Ludwigshafen, Germany
Ecovio	PLA; PBAT / TPS	BASF SE	Ludwigshafen, Germany
Eco-One	Unspecified plastic; oxo-degradable	EcoLogic LLC	Oshkosh, WI, USA
EcoWorks	PBAT + PLA	Cortec Corporation	St. Paul, MN, USA
Enviro	PBAT; PLA; TPS	Enviro Plastics SDN BHD	Port Klang, Malaysia
Garden Weed Barrier	Cellulose	DeWitt Company	Sikeston, MO, USA
GreenBio	PHA	Tianjin GreenBio Materials	Tianjin, China
Landmaster	Cellulose	Easy Gardener Products, Inc.	Waco, TX, USA
Naturecycle	Starch + polyester	Custom Bioplastics	Burlington, WA, USA
Paragon	Starch + TPS	Avebe	Veendam, Netherlands
Planters Paper	Cellulose	Ken-Bar Inc.	Reading, MA, USA
ReNew	PHAs	ENSO Plastics	Mesa, AZ, USA
Skygreen	Terephthalic acid co-polyester	SK Chemicals	Seongnam-si, Korea
Weed Block	Cellulose	Easy Gardener Products, Inc.	Waco, TX, USA
WeedGuardPlus	Cellulose	SunShine Paper Co	Aurora, CO, USA

[1] Abbreviations: PBAT: poly-(butylene adipate terephthalate); PBS: poly-(butylene succinate); PBSA: PBS-co-adipic acid; PCL: poly-(caprolactone); PHA: poly-(hydroxyalkanoates); PLA: poly-(lactic acid); TPS: thermoplastic starch

Adapted from: Hayes et al., 2012 and Miles & Ghimire, 2015

Figure 2. BioBag with tomatoes in biodegradable mulch experiment at WSU Mount Vernon Research Center in 2012.

Figure 3. Field study with five biodegradable mulches at WSU Mount Vernon Research Center in 2015.

Table 2. Common biodegradable polymers, their sources of origin, and their estimated rate of biodegradation in the soil.

Ingredient[1]	Feedstock[1]	Synthesis	ERBD in Soil[2]
Cellulose	**Biobased**	**Biological**	**High**
PBAT	**Hydrocarbon**	**Chemical**	**Low moderate**
PBS	**Hydrocarbon**	**Chemical**	**Low moderate**
PBSA	**Hydrocarbon**	**Chemical**	**Low Moderate**
PCL	**Hydrocarbon**	**Chemical**	**Moderate**
PHA	**Biobased (GM)**	**Biological**	**Moderate high**
PLA	**Biobased**	**Biological & Chemical**	**Low**
Sucrose	**Biobased**	**Biological**	**High**
TPS / Starch	**Biobased**	**Biological**	**High**

[1] Abbreviations: provided in Table 1. GM: genetically modified

[2] Estimated relative rate of biodegradation; Brodhagen et al. 2015.

Adapted from: Miles & Ghimire, 2015

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USDA SCRI Project No. 2014-51181-22382. This material is based on work supported by the National Institute of Food and Agriculture, under award number 2014-51181-22382. Any opinions, findings, conclusions or recommendations expressed in this presentation are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

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