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RECYCLING AGRICULTURAL PLASTICS PROGRAM

Developing infrastructure & markets for recycling waste film & rigid plastics from all sectors of agriculture

A Cornell University Collaboration

IDENTIFYING COMMON PLASTICS USED IN AGRICULTURE

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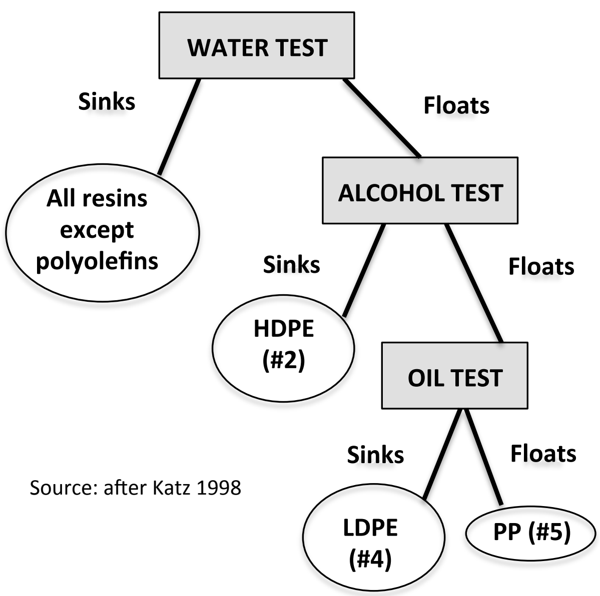
Plastics recyclers are usually quite particular about the kinds of plastic (*i.e.,* which plastic resins) they will accept for processing. Reasons include: which plastics are called for in "recipes" for the products they make, how the recycling plant is set-up to handle emissions, and capabilities of the equipment at hand, as well as cost factors. It's a plus for farmers and those involved with recycling programs to be able to differentiate among the common plastic resins used in agriculture so that sorting and separating can happen at the point of collection. The tests described here can be carried out—even in the field—with minimal supplies.

Sink/Float Flow Chart:



Source: after Katz 1998

Density of Common Plastic Resins:

Plastic Resin		Density g/cm^3 at 70ºF
POLYOLEFINS	PP (polypropylene, #5)	0.90
	LDPE (low density polyethylene, #4)	0.92
	LLDPE (linear low density polyethylene, #4)	0.92
	Mid-density polyethylene	0.94
	HDPE (high density polyethylene, #2)	0.94-0.97
Water		1.0
Nylons		1.02-1.14
ABS (acrylonitrile-butadiene-styrene)		1.05
PS (polystyrene, #6)		1.05
Polycarbonate		1.20
PVC (polyvinyl chloride, #3)		1.29-1.44
PET, polyester (polyethylene terephthlate, #1)		1.38-1.39

Sink/Float Test: This test involves dropping small flakes, pellets or chips of plastic (about ¼-1" sq.) into a jar of water, then shaking the jar. Wait a moment for the pieces to settle out or float.

Plastics that are less dense than water float in water. Most agricultural plastics—including greenhouse and tunnel covers, mulch films, bags from supplements, bale wrap and silage covers, pesticide containers, etc.—are primarily polyolefin[i] plastics (polypropylene and the polyethylenes) that float in water.

To differentiate *among* the polyolefins, fluids with a lower density than water—*e.g.,* alcohol and oil—can be used. Low-density polyethylene (LDPE #4) and polypropylene (PP #5) float in alcohol, while high-density polyethylene (HDPE #2) sinks. Polypropylene—the least dense of the polyolefins—floats even in oil. *Try it!*

Other plastics sink in water, so this test can identify plastics that cannot be recycled with polyolefins. *E.g.,*

- Adhesives used to bind smaller pieces of film into the large sheets needed to cover greenhouses may have an incompatible chemistry and need to be cut away in order to recycle the film.
- Most recyclers do not accept polyvinyl chloride (PVC), but old maple tubing, some brands of irrigation drip tape, and drainage pipes were (or still are) made with PVC resin and must be separated out.

- Collections of nursery pots and trays typically include a mix of products made from polystyrene, polyethylene and polypropylene. Only the polystyrene planters sink in water.
- Horticultural row covers are made from both spun polyester and polypropylene. The products can be difficult to differentiate just by looking at them, but those made from polyester will sink in water.

Burn Test: Resins can be differentiated by the color of their flame, the odor produced, whether they drip, and whether they continue to burn after the flame source is removed.

Polyethylenes and polypropylene (the polyolefins) continue to burn after the flame source is removed. They burn slowly, produce a blue flame tipped with yellow, and will drip. Polypropylene smells sweet while burning whereas the polyethylenes smell like paraffin wax. Polystyrene also continues to burn after the flame source is removed, but it burns rapidly with a yellow flame and leaves a dense black sooty smoke.

Nylons, polycarbonate and PVC also burn, but their flame extinguishes when the flame source is removed. Nylon burns with a blue flame tipped with yellow, will drip, and has the odor of burned wool. Polycarbonate burns with an orange flame, will drip, leaves a black sooty smoke, and has a faint sweetly aromatic odor. Most PVCs burn with a yellow flame, do not drip and smell acidic, acrid or (in the case of PVC/Acrylic) fruity.

Polyesters burn quickly with a yellow flame, shrinking away from the flame source and forming hard, dark, round beads. It may continue burning slowly after the flame sources is removed. While burning, polyester emits a slightly sweet chemical odor and black smoke, but does not drip.

Feel, Flexibility & Other Characteristics: With experience, resins can often be differentiated by feel and by observation (*e.g.,* polypropylene is harder to scratch than the polyethylenes, and polystyrene is hard and brittle). However, these cues can be tricky because many products are made with blends or multiple layers of different resins so as to optimize for desired characteristics such as flexibility, strength and puncture resistance.

Color & Translucence/Opacity: Without added colorants, low-density polyethylene (LDPE) and linear low-density (LLDPE, which is also classified as #4) are translucent, with a milky hue. Of the two, LDPE is the more transparent. And it has a glossy appearance. In contrast, high-density polyethylene (HDPE) is a semi-translucent milky white, and polypropylene (PP) is opaque. Polyester is clear. Polyvinyl chloride (PVC) is transparent to yellowish in color, as is ethylene vinyl alcohol (EVOH), which is used as a barrier film.

Flexibility & Strength: LDPE is slightly more flexible than LLDPE, but both will stretch rather than tear. Of the two, LLDPE has greater tensile strength and is more resistant to punctures and cracking. Thus LLDPE films alone or in blends with LDPE are typically thinner than a comparable LDPE-only product. But used alone, LLDPE film tends to be sticky and thus can be difficult to handle.

Of the polyethylenes, HDPE is the strongest, least flexible (more brittle and stiff), and most resistant to chemicals, cracks and UV. HDPE bags can hold 2000 times their weight, but eventually will tear rather than stretch. Since HDPE bags are stronger at a thinner gauge, HDPE film is typically thinner than (L)LDPE films.

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[i] *Olefins*, from a French word that means 'oil-forming', are also called *alkenes*. They are unsaturated hydrocarbons containing a double bond between carbon and hydrogen. The general formula for olefins is C_nH_{2n}. (source: *New Oxford American Dictionary)*

SOURCES: The *Sink-Float Flow Chart* is excerpted from David A. Katz, ***Identification of Polymers***, 1998, which he modified from *Plastics Analysis Lab*, **Hands On Plastics: A Scientific Investigation Kit**, American Plastics Council and National Middle Level Science Teachers Association (http://www.chymist.com/Polymer%20Identification.pdf). The *Density of Common Plastic Resins* table draws from data in Katz 1998 and Stelray Plastic Products, Inc. (http://www.stelray.com/reference-tables.html). Information about burning is primarily from Boedeker Plastics, Inc., 2007, ***How to Identify Plastic Materials Using The Burn Test,*** http://www.boedeker.com/burntest.htm, which Boedeker credits to Materials Engineering, Penton/IPC, Cleveland, OH, and from FabricMart (http://www.fabricmartfabrics.com/Burn-Test-Chart.html). Other information about properties of plastic resins is from personal experience and personal communications with Donald Reeners, Ultimate Recycled Plastics, Port Gibson, NY; Island Plastic Bags (http://www.islandplasticbags.com/products-pb.html), TBL Performance Plastics (http://www.tblplastics.com/difference-between-ldpe-lldpe-tubing/); Global Plastic Sheeting blog, Nov. 10, 2014, Nana Hinsley (http://www.globalplasticsheeting.com/our-blog-resource-library/bid/92164/HDPE-LDPE-LLDPE-What-s-the-difference-anyway); and The Ultimate Plastic Breakdown, Nov. 23, 2009, Amanda Wills, Earth911.com. Thanks to Nate Leonard and Donald Reeners for reviewing.