N90-24351

INDUSTRIAL PLASTICS WASTE: IDENTIFICATION AND SEGREGATION

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ABSTRACT

Throwaway plastics products, mainly packaging, are inundating our landfills and incinerators. Most are "ethenic" thermoplastics, which can be recycled as new products or fossil-fuels. Lab experiments are described, involving destructive and non-destructive tests for identifying and using plastics. The burn-test, with simple apparatus and familiar samples, is recommended as quick, cheap and effective.

INTRODUCTION

Our throwaway society is generating a hundred-billion dollar waste-disposal industry as costs approach a hundred dollars per ton. Programs to segregate and salvage metal-paper-glass are commonplace, albeit under-utilized. Programs to recycle plastics are rare, although the bulky films-fibers-foams are littering landscapes and choking landfills. In the U.S.A., seventy-five percent of all trash tonnage and ninety-nine percent of all plastics waste now go to landfills. This includes five million tons (907 kg/T) of dirty diapers/year. By 1990, about one sixth of 1960 landfills will be open, yet trash volume will have doubled.Environmental activists have stymied most plans for new landfills and incinerators. Simultaneously protecting our ecology and preserving our economy is a challenge. Technology's task is to simplify the admittedly complex subject of polymer chemistry, to include plastics in the curriculum, to establish realistic priorities, to publicize an optimal solution to interactive problems, and to promote public consensus rather than conflict.

PROBLEMS

Plastics are polymers (giant molecules) from fossil-fuels (coal, oil, gas) or from bio-mass (animal, vegetable). It seems foolish to mix irreplaceable and priceless fuels with garbage, or to embalm degradable compost in sealed hi-tech landfills. Yet government regulations and class-action lawsuits await the unwary. At present, the salvaging of plastics mainly involves recycled scrap (in-house) and remolded products (low-quality). Waste-to-energy plants, that vast market for mixed-plastics trash, are publicly seen as "incinerators". Polluters of land (toxic ash),water (leachate), and atmosphere (acid-rain, ozone-depletion, smog) are banned. Yet, everyone pollutes the environment.

Inherently, plastics are glassy and amorphous, thus low-density (0.9-2.0 g/cc). Being non-conducting and non-magnetic, they hold static charges. Thermal expansion and moisture-absorption bring curling and clinging problems, which hinder compacting and handling. Although materials are generally formulated as w/o (percent by weight), the waste plastics are better described in v/o (percent by volume). Some 30-50v/o of municipal trash is plastics, mainly from consumer packaging.

Most polymers are carbon compounds (organic) or silicon compounds (inorganic) with only six other elements (chlorine, fluorine, hygrogen, nitrogen, oxygen, sulfur). Possible polymers are myriad, considering isomers-copolymers-terpolymers-alloys and elastomers; but the usual plastics waste-stream only consists of a few "vinyls" (ethenics) as solid-liquid-gas in many forms (block, sheet, fiber, cloth, felt, film, or foam). Natural colors are clear-cloudy-white, subsequently contaminated with dyes, or pigments, and readily degraded to yellow-orange-brown-black by radiations (ultra-violet, infra-red, gamma). Mechanical properties (strength, stiffness, hardness) can vary widely (with structure and additives). Melting point is a misnomer, when plastics are "super-cooled" liquids; better terms are "softening or molding" ranges, with upper and lower "glass-transition" temperatures. True crystallinity is best attained in "thermosets" (cross-linked networks) with strong co-valent bonding; but partial-crystallizing occurs in "thermoplastics" (drawn or molded linear-chains) with weak surface-bonding. Mers can make plain "aliphatic" chains or be linked as "aromatic" rings. The same name may apply to many polymers; several names may apply to the same polymer. Tests can help to dispel such confusion.

EXPERIMENTS

Several simple methods for identifying plastics types are recommended:

1. <u>Plastikit I</u> (25-thermoplastics) and <u>Plastikit II</u> (25-thermosets) are boxed sheets (10cm x 10cm, 5 commercial thicknesses) and were designed to SPE specifications for non-destructive tests (stiffness, clarity, moldability, flatness, expansion, density, moisture pickup, color). Also, spot checks of solvents, adhesives, stains and heat are feasible. Optimal stiffener-fins (1-1/2 t high, 2/3 t wide, 4cm long)are molded on the end of each thickness (t). Shrinkage marks (1-inch flow-direction, 2-inch cross-direction) are included for thin grades (30,50,70 and 90-mils; 1,000 mils/inch, 2.54 cm/inch).

2. <u>Resinkit</u> (43-thermoplastics) in notebook format was designed to SPE specifications for destructive tests (brittleness, toughness, burning). Samples look like combs (10cm long) with 14-teeth (each 2mm x 2mm x 2cm) formed at each end (28 possible burn-tests). A descriptive card for each plastic also describes its properties and processibility. These are used as "control" samples for comparison with unknown plastics specimens. Most unknowns will be glassy thermoplastic ethenics.

3. Unknown plastics waste may then be subjected to destructive and non-destructive tests. Common sources are

   <u>Polystyrene</u>-Trays, bowls, dishes, cups, covers, spoons (from restaurants and grocery stores); insulation (building panels).

Polyethylene-Milk or cider jugs, pipe caps, pop-bottle bases, 6-pack yokes, spun-bonded fabrics and envelopes.

Polyester-Pop bottles (thermoplastic PET); corrugated siding or roofing (thermoset FRP panels).

Polyvinyl Chloride-Synthetic leather (gloves, bags, shoes, chairs); hard pipes or fittings (white, grey, green).

Polyurethane-Yellow foam (packaging, insulation, rubber toys).

Polymethyl Methacrylate-Clothing (fibers) and lenses (auto).

Phenol Formaldehyde-Electric plugs, distributor caps, hot pan handles.

Melamine Formaldehyde-Plastic dishes (T/S, thick walls).

Elastomers-Tires, tubes, belts, rubber bands, balloons, and balls.

Silicones-Caulking strips and tubes.

Fluoro-carbons-Pipe thread tapes, pan coatings, anti-friction parts (white, grey).

Typical mechanical tests for stiffness, clarity, color, flatness, hardness, toughness and fold-endurance are first. Follow these with softening tests (with solvents, boiling water, soldering iron, hot-plate, or oven). Finally, conduct a "burn-test", observing flame, stickiness, smoke, smell and residue.

4. Burn Testing

Because plastics are essentially "low-temperature" materials, exposure to flame is probably the quickest and cheapest way to identify common samples of waste. Such tests are usually destructive, hazardous, and dramatic. Get small samples (say 1cm x 3cm x 2mm); fire-proof surface (ash-tray, pie-tin); controlled flame (match, candle, lighter, burner); sample holder (paper clip, spring clamp, tweezers, tongs); fire extinguisher (water bucket); and ample ventilation (hood).

Hold each sample at a 45-degree angle (film or foam may need compacting) and light the bottom edge. Remove flame and judge the combustibility (increased, stable, decreased, self-extinguished). Touch sample to pan and observe stickiness, bubbling, dripping, or charring. Watch the flame-base to see colors (tip usually yellow; base may be blue, purple, green, orange). Gently blow out flame (no splatter) and observe smoke (much or little; grey-black-white; soot). Gingerly waft the fumes toward your nose (do not inhale noxious fumes, smoke or flame) and describe the odor. Taste and smell are tricky; use imagination; breathe fresh air and drink water, between samples; emotional and physical states may influence perceptions. Do not touch hot samples. Repeat tests if needed (no large samples).

Finally, refer to a published "burn-chart" (see Dietrich Braun, "Identification of Plastics", ref. 10; contact technical-service representatives at Dow, DuPont, Hercules, or Shell Corporations).

Typical results are

1. Organic plastics support combustion. Thermosets are safer than thermoplastics. Sheets burn slower than films, which are slower than foams.
2. Styrene burns fiercely, has orange flame and sooty smoke, smells like marigolds, softens-drips-spurts.
3. Urethane burns like styrene, but has light yellow flame, less smoke, apple smell.
4. Ethylene feels waxy, burns blue like methane gas, smells and drips like a candle. Propylene is similar, but stiffer; better fatigue-life; whiter smoke.
5. Vinyl chloride is shiny, hard to light, green flame and white smoke, chlorine smell.
6. Fluorocarbon is hard to light, green flame, little odor or smoke.
7. Nylon is medium-burning, blue flame, smells like singed hair or burned wool.

ABBREVIATIONS (<u>Tradename</u> typical)

1. CPVC - Chlorinated PVC, like PVDC
2. CR - Poly Chloroprene Rubber (<u>Neoprene</u>)
3. FRP - Fiberglas Reinforced Polyester (T/S)
4. IIR - Poly Isoprene - Isobutylene Rubber (Butyl)
5. IR - Poly Isoprene Rubber (<u>Latex</u>)
6. MF - Melamine Formaldehyde (<u>Mel-mac</u>)
7. NBR - Poly Butadiene - Acrylonitrile Rubber (Buna N)
8. PA - Polyamide (<u>Nylon</u>); Aramid (<u>Kevlar</u>, <u>Nomex</u>)
9. PAI - Polyamide/imide (<u>Torlon</u>)
10. PC - Polycarbonate (<u>Lexan</u>)
11. PE - Poly Ethylene (Ethene, Olefin, <u>Tyvek</u>)
12. PET - Poly Ethylene Terephthalate (T/P Polyester, <u>Dacron</u>, <u>Mylar</u>)
13 PF - Phenol Formaldehyde (<u>Bakelite</u>)
14 PI - Polyimide (<u>Kapton</u>)
15 PMMa - Poly Methyl Methacrylate (<u>Lucite, Plexiglas, Orlon</u>)
16 PP - Poly Propylene (Propene)
17 PS - Poly Styrene
18 PTFE - Poly Tetra Fluoro Ethylene (<u>Teflon</u>)
19 PUR - Poly Urethane Rubber
20 PVC - Poly Vinyl Chloride
21 PVDC - Poly Vinylidene Chloride (<u>Saran</u>)
22 SBR - Styrene Butadiene Rubber (<u>Buna S</u>)
23 SI - Silicone (silane, siloxane, <u>RTV</u>)
24 SPE - Society of Plastics Engineers
25 SPI - Society of Plastics Industries
26 T/P - Thermoplastics
27 T/S - Thermosets
28 UF - Urea Formaldehyde

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BIOGRAPHY

E.L. Widener teaches mechanical engineering technology at Purdue University, concentrating on statics, fluid mechanics, materials labs, and technical writing...Member of ASME, ASEE, ASM, ISA, TAPPI. Registered P.E. in New York and Indiana...ABET visitor in 1983-1988...B.S.M.E. from Purdue University, M.S.E.M. from University of Kansas...Mechanical Development Engineer for "Coria" collagen casing with Teepak Co., Continental Group (1976-78). Process Group Leader for mechanical contractor, Baker-McHenry-Welch, Indianapolis (1974-76). Project Leader for creped-wadding and secondary-fibers with Kimberly Clark Co., Memphis, TN (1968-74). Process engineer for "Nomex" nylon with E.I. Dupont Co., Richmond, VA (1963-68). Associate Engineer for electro-furnace alloys with Union Carbide Co., Niagara Falls, NY (1952-60). Fuel Engineer with U.S. Steel Co., Gary, IN (1951-52).