Differences in Recyclability and Recycling of Common Consumer Plastic Resins

"Recyclabilty" of any materials, including plastics, rests on a number of key factors. First, the material must be separable or able to be sorted from other wastes or recyclables. Separation can take place in simple ways through establishment of material-specific collection containers or in more complex ways using back-end technologies such as infrared or float-sink sorting. Second, accumulation of efficiently collectible and transportable volumes is also a key to "recyclability." And then third, materials must have a feasible end-use in another product or application. In general, the best use applications are those where a material is turned back into the same product – i.e., bottle plastic returns to bottles. Alternatively, materials can be turned into a completely different use. Many plastics take this route, with single-use plastics recycled into durable products, such as plastic bottles into carpet or plastic bags into plastic lumber.

In comparison to other materials like glass and metal, plastic polymers require greater processing to be recycled. Each type melts at different temperatures and has different properties, so careful separation can be crucial. Most plastics are not highly compatible with one another, and while some commingled applications have been demonstrated they typically capture much lower values than virgin plastic.

Methods and technologies exist to sort and separate many kinds of plastic, and there are also numerous uses for many types of plastics. Some challenges still remain, especially in finding ways to not "down-cycle" plastics from the best use. However, the second leg of recyclability noted above – the creation of an efficient collection and transportation infrastructure – is probably the most difficult factor in determining which plastic gets recycled. Volume is critical and accumulating adequate amounts of some kinds of plastics can be very problematic. For example, polystyrene foam cups and dinnerware are prevalent types of plastics but very difficult to collect and transport efficiently due to their widely dispersed generation and low weight-to-volume ratio.

Polyethlene terephthalate - PET (#1) and high density polyethylene - HDPE (#2) bottles have proven to have high recyclabilty and are taken by most, if not all, curbside and drop-off recycling programs. The growth of bottle recycling has been facilitated by the development of processing technologies that increase product purities and reduce operational costs. Recycled PET and HDPE have many uses and well-established markets. Also, the accumulation of large quantities through mass collection programs has helped the infrastructure develop to move the materials efficiently to markets.

By contrast, recycling for polyvinyl chloride - PVC (#3) bottles and other materials is limited. A major problem in the recycling of PVC is the high chlorine content of raw PVC (56 percent of the polymer's weight) and the high levels of hazardous additives added to the polymer to achieve the desired material quality. Additives may comprise up to 60 percent of a PVC product's weight. Of all plastics, PVC uses the highest proportion of additives. As a result, PVC requires separation from other plastics before mechanical recycling. PVC bottles are hard to tell apart from PET bottles, but one stray PVC bottle in a melt of 10,000 PET bottles can ruin the entire batch. For this reason, PET bottle recyclers make sure that PVC bottles do not contaminate their mix. PVC recycling is particularly problematic because of high separation and collection costs, loss of material quality after recycling, the low market price of PVC recyclate compared to virgin PVC and, therefore, the limited potential of recyclate in the existing PVC market. There has been some success in the recycling of vinyl siding, where separability and higher weight-to-volume helps in collection and transport efficiency.

Low density polyethylene - LDPE and LLDPE (#4) are resins used rarely in bottles but prominently in plastic bags. LDPE and LLDPE products are recyclable at recycling centers, but no publicly-operated curbside or drop-off program in North Carolina accepts plastic bags. The economics of recycling plastic bags is not appealing to many plastic processors. According to the San Francisco Department of the Environment, it costs $4,000 to process and recycle one ton of plastic bags, which can then be sold on the commodities market for $32. From the process of sorting, to the contamination of inks and the overall low quality of the plastic used in plastics bags, recyclers would much rather focus on recycling the vast quantities of more viable materials such as soda and milk bottles that can be recycled far more efficiently.

Recycling polypropylene - PP (#5), the material used in many food containers, is technically possible. The challenge is in separating it from other plastics, including its own many variations, once it arrives at recycling centers and beyond. Because of the difficulty and expense of sorting, transporting, cleaning and reprocessing plastics of all kinds, in many places it is only economically viable to recycle a few select types (usually PET and HDPE). Many recycling facilities today operate manually and are not equipped to sort PP products.

Polystyrene - PS (#6), as discussed above, is found in a wide array of consumer products other than bottles. In its expanded form (EPS), it is widely recognized in products such as disposable coffee cups and food clamshells. PS is recyclable in some curbside programs nationwide, although none of North Carolina's programs collect it. In addition, most industry-sponsored polystyrene recycling facilities no longer exist. Current estimates by the California Department of Conservation peg the cost of recycling PS at more than $3,000 a ton, meaning that PS has a very high negative scrap value.[i] As noted above, hurdles to polystyrene recycling include its light weight, which makes it expensive and difficult to transport and the demand that the polystyrene be uncontaminated by food, dirt or other grime. Recycling of other common forms of PS, such as CD casings, is made difficult by challenges in accumulating quantities that are efficient to ship.

All "other plastics" (# 7) is a wide-ranging, highly-confusing category. It includes polycarbonate, which contains BPA (bisphenol A), but also the burgeoning crop of bioplastics. These include polyactide - PLA, made from plants, especially corn. At the moment, PLA is not easily recyclable, and can be confused with PET. Estimates of the amount needed to contaminate a PET load are as low as one bottle in 1,000.[ii] In general, the recyclability of PLA has not been proven, especially the efficient accumulation and transportability of the material.

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i. California Department of Conservation. "2009 Processing Payments." December 15, 2008. http://www.consrv.ca.gov/DOR/Notices/ProcessingPayments.pdf

ii. Cornell, David D. "Biopolymers in the Existing Postconsumer Plastics Recycling Stream." Journal of Polymers and the Environment, (2007) 15:295–299.