



recycling

By Mark Stephen, editor

For years, the recycling industry has scrapped residual materials left after sorting and processing because they don't blend well. But it doesn't have to be this way. Functional additives can improve compatibility and offer upcycling opportunities for both recyclers and brand owners.

MIXING IT UP

with Compatibilizers

Garbage in, garbage out. If the famous adage applies anywhere, it applies to the recycling of post-consumer plastics. Because if recyclers don't get a good yield from the mixed-material bales coming in, the quality of the product going out will be underwhelming, suitable only for lower value goods due to poor material performance.

And it doesn't help that most plastics recyclers are currently seeing sharp decreases in bale quality and yields. "The residual materials that are left over after a bale has been processed are often sold for a few pennies per lb (if they can be sold at all), which is far less than what the recyclers actually paid for the bale," said Kim Holmes, the director of recycling and diversion at the Society of the Plastics Industry. "Recent findings suggest HDPE recyclers are experiencing a 20 per cent yield loss; in PET recycling, the yield loss is 40 per cent. And in bales of material where the resin types are inherently highly mixed, such as bales of plastics from electronics, the most desirable resin types like ABS and HIPS might make up only about 60 per cent of the bale."

So what do recyclers do with that 40 per cent of material that can't be further segregated by resin type, either due to technical challenges related to collecting, cleaning, and sorting or to economic infeasibility? For years, the recycling industry has scrapped incompatible residual materials that

are left after sorting and processing, which is an excellent way to lose money. Interested in staying in the black instead? Consider using compatibilizers.

TALK, TALK

Compatibilizers aren't exactly new to the plastics world, but they have long been confined to prime material applications, allowing resins that would not normally blend together to bond in a way that creates enhanced performance when compared with either polymer alone.

More and more recyclers, however, are now finding using compatibilizers as the keys to recycling multi-resin products, chief among them flexible packaging. Take barrier packaging, in which more than one type of resin is present. "Barrier films often contain EVOH and/or nylon layers, which are incompatible with many polyolefins," Holmes said. "But by using compatibilizers, these layers of otherwise incompatible resins can 'talk to each other' and be blended and then used in varying levels to make parts for durable goods." In short, the use of compatibilizers permits multi-resin, residual recycle materials that would otherwise not be compatible to be blended and used in more valuable applications, creating true upcycling opportunities.

A new compatibilizer from Stow, Ohio-based additive

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supplier Struktol is a case in point. Called TR 052, the compatibilizer and blending aid is designed for incorporation of regrind/recycled product in a wide range of polymers. “Processors can realize improved physical properties and overall improved processability of compounds requiring some level of recycled content,” the company said. “TR 052 has been shown to significantly improve the processability and performance of mixed recycled streams used when separation of the resins is not done prior. The additive compatibilizes dissimilar polymer systems, allowing for expanded use of these mixed recycled streams.”

POLAR OPPOSITES

But even though the case for using compatibilizers is solid, recyclers still have to do their homework. As noted by Holmes, there are several categories of compatibilizers available as material additives in the marketplace today, beginning with bipolar copolymer compatibilizers, which allow polymers with different polarities — in short, whether or not they have positive or negative charges — to be made compatible. (Some examples of polar plastics are PA, PC, PMMA, and ABS. The most common non-polar plastics are PP, PE, SEBS, PS, and PTFE.) “A number of commercial TPEs are based on block copolymers of polar aromatic styrene monomer and non-polar aliphatic butadiene monomer; when the butadiene styrene block copolymer is added to a resin blend, its built-in bipolarity acts to attract the dissimilar polar polymers, creating a compatibility effect,” she said. “This approach works well with known segregated streams, such as a non-polar polyolefin with a polar polymer such as nylon, but is of limited value in post-consumer recycle

MIX MASTERS

The lowdown on some of today's top compatibilizers

MATERIAL SUPPLIER	BRAND NAME	TARGET RESINS FOR BLENDING
Arkema	Lotader AX8840, Lotader AX8900	PET, PBT, PPS
Arkema	Lotader 3210, Lotader 3410	Polyamide/polyolefin
BASF	Baxxodur EC 301	Cross-linking agent for epoxy resin systems
Dow	Retain	PE/EVOH or PA/EVOH/PE
Dow	Intune	PE/PP
DuPont	Fusabond M603	PE/ PA, PE/ EVOH, PA, EVOH/ PE
DuPont	Fusabond E226	PE/PA, Surlyn EVOH or PA
DuPont	Bynel 41E710	PE/EVOH or PA/EVOH/PE
DuPont	Surlyn 1650	Surlyn EVOH or PA
DuPont	Fusabond P353	PP/PA or PP/EVOH/PP
DuPont	Elvaloy PTW, Elvaloy 3427AC	Polysters/ PE
Struktol	TR 219	Polyamide, PET
Struktol	TR 229	Polyamides, PC, PC/ABS

streams containing a multiplicity of polymers that vary from batch to batch of recycled material.”

The second category is maleated copolymer compatibilizers. “Maleated polymers can be prepared directly by polymerization or by modification during compounding via the reactive extrusion process,” Holmes said. “Their anhydride groups can react with amine, epoxy, and alcohol groups. For example, DuPont’s Fusabond M603 is a random ethylene copolymer, incorporating a monomer that is classified as a maleic anhydride equivalent for application uses.”

According to Holmes, styrene maleic anhydride copolymer is another suitable agent for compatibilizing normally incompatible polymers such as nylon/ABS blends. “The limitation of this class of additives is their specificity, requiring known chemistry of the polymers to be compatibilized,” she said. “In addition, maleic anhydride depolymerizes condensation polymers such as PET and PC, thus




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obviating its use in mixed streams such as PCR containing olefins, PET, and other assorted polymers.”

The final category is in-situ macromolecular catalysts. “Since monomers become polymers in the presence of catalysts, copolymerization of two or more dissimilar polymers in the melt via in-situ catalysis using thermally stable organometallics holds the possibility of allowing the use of high levels of PCR in consumer goods,” Holmes said. “Ester forms of organometallics such as titanates, zirconates, aluminates, and zirco-aluminates provide possible chemistries for R&D in using high levels of PCR in consumer goods, since they are already used as esterification catalysts for PET and as single-site metallocene catalysts for polyolefins. In addition, it’s possible that this class of catalysts is synergistic with maleated copolymers.”

APTITUDE TESTS

A disadvantage of this last class of additives is their newness to the recycling industry. “Recyclers generally are not R&D chemists, and often require simple additive systems and processes that can be replicated easily in a practical manner and at a reasonable cost,” Holmes said. “For example, recyclers will have to become more familiar with reactive compound-

ing techniques to optimize the catalysis effects, and will need the capability to monitor and adjust melt-process conditions.”

And an aptitude for chemistry isn’t the only stumbling block to maximizing compatibilizer use. A second hurdle is the generally inconsistent nature of the resin mix. “It’s often very hard to predict the exact mix of resins in any feed stream, let alone the residual content of that stream after sorting out the desired materials,” Holmes said. “This means some further processing and separation might be necessary.”

Third, compatibilizers also target specific resin types, meaning recyclers can’t use just one compatibilizer for all the post-consumer materials in their recycle stream. “For compatibilizers to work consistently, the recycle feed stream itself has to be fairly consistent in resin composition,” Holmes said. “On the other hand, where there are varied recycle streams, the use of organometallic esters should be investigated more thoroughly and their efficacy established. Also, as with any new chemistry, food-contact approval for the compatibilizer use has to be obtained.”

These challenges notwithstanding, compatibilizers will no doubt continue to open up new economic opportunities for both recyclers and brand owners. The rebooted motto? Garbage in, quality recycled resins out.

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