PET-Bottles - Designed to be recycled?

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The flood of packaging waste should be contained and our rivers and oceans should become cleaner. Everyone in the world is talking about recycling; politics is trying to solve the problem with bans. But te question of how to organize an effective circular economy begins with the production of the goods, products, the packaging and in our case with the production of the PET bottle.

From the perspective of the manufacturers of PET bottles, the process should be as cost-effective as possible, robust to handle and technically manageable. In addition to a perfect appearance, high transparency and good feel, the PET bottle should have a very low content of acetaldehyde of <3 ppm in the bottle wall, especially for the packaging of water. Not to mention the least possible use of material, i.e. low preform weight.

Ideal would be the use of a bottle-PET granulate of IV 0,78 – 0,82 dl/g, containing acetaldehyde <1 ppm, an average crystallinity at 40-50%, a pellet weight in the range of 15-17 mg / chip and a DSC melt temperature t_m in the range of 255 ° C.

With this material, an optimally adjusted preform extrusion line can produce preforms with a content of acetaldehyde <3 ppm. There are normally no acetaldehyde scavengers, dyes, stabilizers or lubricity additives required.

Optimal process control means that the granules are well pre-dried (<50 pm moisture) and preheated to about 150 ° C and fed directly to the extruder, and the temperature control of the extruder is adjusted to minimize heat by shear and as much as possible heat is supplied by heat conduction from the outside. An important further detail is the setting for the lowest possible back pressure on the screw tip and low shear within the injection mold.

With these process data, the author achieved by using a virgin standard bottle resin an average content of acetaldehyde of 1.8 ppm and a maximum content of acetaldehyde (critical preform position) of 2.9 ppm during internal industrial tests using a Husky 144 cavity preforming machine.

However, such attempts have little in common with the harsh reality of preform manufacturing in the industry. For convenient compliance with the acetaldehyde limits, the addition of the AA scavengers like for instance anthranilamide is widely applied. In addition, blue or green dyes come in different concentration and depths of color, stabilizers, fast heat-up additives and lubricants. In addition, for ease of handling, these additives are very often provided in liquid form, often by the additive manufacturer as a combo-batch in carrier oil. This means that the carrier oil counts as an additional impurity.

Analytical tests on different flake samples from the market confirmed that, in addition to the typical bottle impurities (glue, PP, PVC, environmental pollution) a substantial number of metabolites (degradation products) of the above mentioned added additives are frequently detected.

Everyone familiar with organic chemistry is familiar with the fact that organic compounds begin to degrade thermally above a substance-specific temperature. The extrusion of PET which is taking place at

temperatures of about 280°C is accompanied for a short time during melting process of much higher temperature peaks (up to 350°C) . This means the additives are also treated at those temperature peaks. Especially in the closed loop material flow (i.e. all bottles are produced, circulated, collected, processed into flakes, decontaminated and re-granulated and processed back into preforms/bottles) the originally used additives are repeatedly thermally treated. In addition, often new additives are added again to the still recycled PET pellets at each cycle to ensure compliance with quality standards like low AA content.

The question posed in the title "PET bottles - developed for recycling?" can be answered with "still insufficient" for current practice. Besides a number of beverage manufacturers, bottlers and branded products, such as Coca Cola™, Fanta™ or mineral waters from various manufacturers such as Gerolsteiner ™or Vösslauer™, who have meanwhile switched to colorless, transparent PET bottles, mineral waters or other soft drinks one can find even today many PET bottles in deep colors in various supermarkets (Fig. 1)

Figure: A glance at a supermarket shelf confirms colorless transparent and deep colored bottles.

Even deep dark blue or green bottles can still be found. Even the transparent and colorless bottle offers a number of attractive possibilities to make it easier for the customer to recognize the product by means of a well-designed eye-catching label or a specially colored cap.

At this point it should be pointed out that functional colors such as dark brown for the light protection of beer or white non-transparent for the light protection of milk are necessary and correct, where bottles with these colors in particular can be easily separated in automatic sorting systems and thus processed separately.

Compared to mineral water or soft drinks, the situation with PET bottles for soaps and household chemicals is much more precarious. Here, product designers very often and very deeply delve into the modular system of deep and bright colors and only a few products are offered in transparent and colorless bottles. This is all the more annoying as these bottles are detected as useful PET in the sorting systems and recycled.

At this point, it can be summarized that there is still a lot of room for maneuver when it comes to taking high-quality recycling into account when designing packaging materials.

The most important prerequisite for a small addition of auxiliary materials are high-quality re-granulate, from which a large part of the additives which are used during bottle production and the contaminations which are diffused into the bottle wall during use had been removed. Those decontaminations are removed during the recycling process by intensive washing, decontamination by vacuum extruder and decontamination during the solid phase condensation (SSP) required for IV build-up.

In addition, one should do without the elimination of dyes, stabilizers or lubricants and the use of the lowest possible concentration of acetaldehyde scavenger. In case additives are unavoidable, the choice of polymer additive masterbatch based on PET or PBT is preferable to the use of liquid additives.

Of course, such a restriction may require higher developed equipment and/or financial expenditure, which could slightly affect the price of the products. In particular, market players who organize the production of PET bottles, filling, distribution, collection and re-pelletizing covered by one roof are rewarded because the proportion of virgin PET resin required to meet quality standards can be significantly reduced.

In society as a whole, the benefits of PET bottles which are consciously and purposefully developed for recycling are obvious due to the higher recycling rate to be achieved.