Less is more

Using less material in package design is a target, propelled by cost reduction and sustainability drivers. Reducing overall plastics consumption by making designs in mono-material, by using materials which are easy to recycle, and by reducing the weight of the packaging have favoured polyolefin solutions

Worldwide designers, converters, as well as brand owners of beverage closures have been looking into ways to improve the long-time reference bottle neck and closure design, known as PCO 1810.

This has led to the development of the PCO1881 global voluntary standard, which describes a shorter bottle neck finish and a light-weight closure. In 28-mm closures, the new standard has reduced the weight of the PET bottles by 1.3 g/piece, and the weight of the closures by minimum 0.5 g/piece. In water closures, the lightest closures these days weigh less than 1 g.

The demands of the HDPE material for such light-weight closures are increasing, both in terms of processing (even faster production, both in injection moulding and compression moulding), as well as in terms of mechanical properties, most importantly being creep and ESCR (environmental stress crack resistance) at high temperatures.

Here, traditional uni-modal HDPE grades are literally being stretched to the limit, and the new generation of multi-modal HDPE's are showing clear advantages.

Multimodal HDPE for beverage closures

In Table 1, the MFR and flow length of traditional uni-modal materials are compared to multi-modal HDPE. It clearly shows how the multi-modal grade flows better than an equivalent density uni-modal material, which is beneficial in multi-cavity closure moulding. Recent machinery and mould design developments have increased compression moulding cavitation from 64 up to 80, and injection moulding from 96 up to 144 cavities.

At the same time, the ESCR of the multi-modal material is far superior to that of a uni-modal one with the same density and an MFR of 1 g/10 min, as shown in Table 2.

This is of major importance in countries with higher temperatures, as HDPE's stress cracking typically creates more closure failures in hot environments. The move towards thinner closures has made this tendency even stronger, especially in carbonated drinks with significant inner bottle pressure.

More and more emphasis is also placed on preserving the original taste and odour of the beverages, especially in the case of bottled water applications. For this purpose, one of the critical elements on the plastics raw material side is the migration of low molecular weight fractions to the liquid. Also in this respect, multi-modal HDPE is showing some of the industry's best-in-class results. The organoleptic properties of the advanced materials are typically being checked by taste and odor testing of every batch produced.

For beverages with a high level of carbonation, or containing sugar, specific additive packages have been developed to control the opening and closing torque levels of the closures.

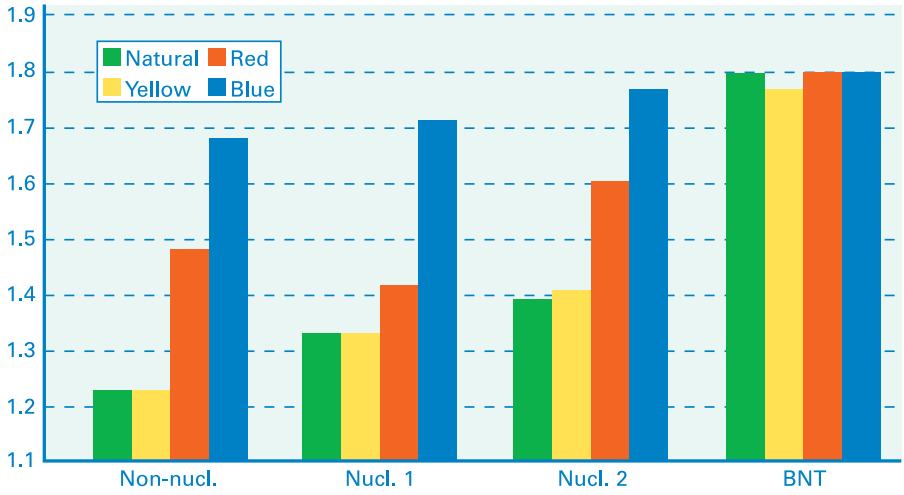
Property	Test condition	Multimodal HDPE	Uni-modal HDPE
Static flow rate	Melt flow rate (g/10 min 190° C at 2.16 kg)	1.5	4
Dynamic flow length at injection pressure	800 bar (40°C mould, 2 mm)	33 mm	28 mm
	1400 bar (40°C mould, 2 mm)	52 mm	42 mm
	2000 bar (40°C mould, 2 mm)	69 mm	50 mm

Table 1: Melt flow rate and flow length of uni-modal/multi-modal HDPE

Property	Test condition	Multi-modal HDPE	Unimodal HDPE MFR 1
Environmental stress crack resistance	Bell test - ASTM D1693	180 h	40 h
	Full notch creep test - ISO/DIS 16700/2000 (3.5MPa – 50 °C)	100 h	30 h

Table 2: ESCR of uni-modal/multi-modal HDPE

Table 3: Shrinkage ratio versus colour with different nucleated PP systems



Nucleated Polypropylene benefits for beverage closures

Traditionally, PP has been used for carbonated soft drinks 2-piece closures, in combination with an inner liner in EVA or LDPE. The inherent advantages of PP lie in the excellent stiffness at high temperature, providing low creep levels and resistance against the so-called "doming" effect. Furthermore, PP is the only polymer which appears to be totally immune to environmental stress cracking.

The above is important for carbonated soft drinks or other beverages which have an elevated inner pressure in the bottle, and this particularly in countries with very high summer temperatures. There, even today the 2-piece PP closure remains the best technical solution.

Nucleation of PP has helped to make the product more homogeneous, and as such create a better stiffness-impact balance. The most efficient nucleation system for polypropylene today is achieved through the Borealis Nucleation Technology (BNTTM), which does not use external nucleating agents, but creates super high crystallisation as a side-effect of the proprietary catalyst.

Borouge will produce BD950MO, a BNT PP block copolymer for standardized closures, in its Middle East production plant in the UAE.

The grade offers a stable shrinkage across all colors, as its nucleation effect is faster than any pigment's nucleating ability (see Table 3). This means that injection or compression molding cycle times can be reduced, and the processing conditions for any color closure can be kept unchanged, improving the production yield ratio.

About Borouge

Borouge's moulding business specialises in supplying advanced polyolefin plastics for injection and blow moulding processing technologies. Utilising leading technologies such as Borstar and BNT (Borealis Nucleation Technology) offers a product portfolio for a variety of high-performance packaging applications. With over 50 years of experience and pioneering solutions, Borouge together with Borealis have established a leading position on the film and moulding market across Europe, the Middle East and Asia.