



Cycloolefin Copolymer (COC)

The opportunities for cycloolefins in packaging are many and varied

New Material with Potential. After several years of intense market development outside their primary market of Japan, cycloolefins have gained a firm market foothold in Europe and North America. Because of its unique properties, the relatively new material has found numerous applications in the medical, optical and packaging market segments. New products, higher quality and more attractive prices continue to fuel growth.

In the field between polyolefins and engineering resins, the polyolefins with a cycloolefinic structure (COC, COP) represent a class by themselves. Although chemically related to polyethylene and polypropylene, their property profiles sets them apart. When employed as a comonomer along with ethylene, norbornene, a cyclic olefin, makes COC very rigid and hard in contrast to polyolefin. Together with its high transparency, these properties impart an appearance that resembles glass. With the aid of the latest metallocene catalyst technology, an almost unlimited variety of glass transition temperatures and microstructures

can be achieved. The Ticona process for producing COC occurs in two essential steps. First, norbornene is synthesised from the C5 fraction dicyclopentadiene and ethylene. In the second step, the cycloolefin is polymerised in solution through the use of metallocene catalysts. Optimised process control and an extensive filter system yield a high-purity polymer. Japanese suppliers employ a different, more involved process that uses so-

called metathesis catalysts. With the commissioning of the first industrial-scale plant for COC with a capacity of 30 000 t/a at the end of 2000, Ticona opened up a new chapter in the history of cycloolefins (Table 1). Compared to older, existing plants in Asia, the size, state-of-the-art processing techniques and manufacturing technology employed in this plant provide considerable cost benefits that translate into more favourable market prices.

Applications and Markets

Cycloolefin copolymers and polymers (COC/COP) are found today in a great variety of applications (Fig. 1, Table 2). Transparency, barrier action with respect to water vapour, purity, biocompatibility, stiffness and ease of processing via common methods often make COC the material of choice. In the medical field, primary packaging – such as syringes, vials containers – and various medical and diagnostic devices are manufactured from COC/COP. Compared to glass, the plastic containers offer greater design freedom, a more efficient production process, good compatibility as well as better shatter resistance. These benefits

Polymer	Manufacturer	Capacity [in t/a]	Location	Trade name
COC	Ticona	30 000	Germany	Topas
COP	Nippon Zeon	10 000	Japan	Zeonex/Zeonor
COC	MCI	3000	Japan	Apel
COC	JSR	1000	Japan	Arton

Table 1. Overview of suppliers of cycloolefin copolymers (COC) and cycloolefin polymers (COP) (as of 2004)

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contributed to the decision of the glass specialist Schott to introduce a new series of pre-fillable syringes manufactured from Topas COC at the beginning of 2004. There is also great potential for diagnostic applications. These range from microtiter plates, lab CDs, biochips, cuvettes, and graduated vessels to tubes, pipettes and much more. The combination of transparency, purity, replicability and dimensional stability presents designers with interesting opportunities for miniaturisation.

At present, the greatest demand results from optical applications. The rapid expansion of production capacity for flat screen displays offers very good growth potential for COC. In addition to light guide plates (LGP) and light diffusion plates (LDP) for dis-

play illumination in cell phones, PDAs, notebooks and LCD televisions, COC/COP are being used increasingly as material for retardation film and polarisation film. Cycloolefins are clearly superior to other transparent plastics for large screen sizes in particular because of their low birefringence, low moisture uptake, and stable optical properties. Considering that large computer displays and large-screen televisions are only at the beginning of their development, it can be expected that the future holds a great deal of potential. In addition to the so-called light guide plates and optical films, lenses, LED's and other optical components for digital cameras, cell phones, scanners and printers are being produced in ever-greater quantities and contribute to steady growth.

There are also very many opportunities to use cycloolefins for packaging (title photo). Blister pack films of various types that are employed for pharmaceuticals, cosmetics and other consumer products represent a classical field of application. Here, COC are ideal because of their outstanding barrier properties with respect to water vapour and the very good deep-draw thermoforming characteristics. Traditional, halogen-containing materials such as PVC, PVDC and PCTFE are losing ground to COC in part because of the growing environmental awareness among consumers. The spectrum of film structures available today extends from multi-layer films with top layers of PP, PETG, PE-HD to laminates with PVC, PVDC, PCTFE and PAN. A

steam-sterilisable film produced from a COC-PE blend presents completely new opportunities. What is special about this innovative solution is the possibility to sterilise the prefilled packaging at a temperature of 121 °C and a steam pressure of 2 bars without affecting the dimensional stability or triggering shrinkage.

Another growing market is provided by sleeves, labels and shrink film for bottles, containers and other types of overwraps. In combination with other polyolefins, films are conceivable that exhibit low shrink activation temperatures and high shrink rates at low shrink-induced forces. Furthermore, for so-called shrink sleeves for PET bottles, the density difference can be adjusted such that via flotation in a water bath the polyester and polyolefin fractions can be separated from one another completely – an inestimable benefit for a functioning recycling system.

In addition to the above examples, which describe coextruded film with a discrete COC layer, many developers employ polyolefin blends with cycloolefins. The reasons for this are quite varied. For instance, by adding 15 % COC, the stiffness of PE-LLD can be increased by about 300 %. Since this combination also yields higher seal joint strengths, the processing characteristics can also be improved. This approach is being actively pursued for sealing films, for instance. If, in addition, a high-Tg COC is employed, the temperature resistance – and thus the physical integrity of the pouch – can be increased to such an extent that hot filling of products becomes possible in a reliable manner. An additional aspect with regard to self-supporting pouches, but also other such packaging, is controlled opening of a package via specific tearing characteristics, which can be addressed with COC. With proper mate-

Market	Applications	Property benefits
Medical/Diagnostic	Syringes, reagent vessels, flasks, cuvettes, microtiter plates, biochips, lab CDs, specimen carriers	Transparency, purity, moisture barrier, sterilisability, good transmission in near-UV range, low self-fluorescence, biocompatibility, chemical resistance to aqueous and polar organic solvents, halogen-free, wide spectrum of medical approvals
Optics	Lenses, prisms, light guides, flat screen displays, optical films, LEDs, sensors, reflectors, mirrors	Transparency, flowability, low water uptake, replicability, dimensional stability, low birefringence, high Abbé number, low density
Packaging	Blister pack film, all-around labels (shrink sleeves), shrink wrap film, cover film, sealing film, twist film, barrier cartons, zipper closure	Moisture barrier, transparency, stiffness, heat deflection temperature, thermoformability, low shrinkage forces, controlled seal/peel behaviour, dead fold, aroma barrier, halogen-free, wide spectrum of medical/food processing, regulatory approvals
Electrical/Electronics	HF antennas, high-frequency connectors, capacitor film	Low dielectric loss factor, low dielectric constant, good plateability
Office machines	Carrier material for black/white and colour film	Transparency, low water uptake, stable electrostatic behaviour
New markets	Foams	Heat deflection temperature, low density, polyolefin solution
	Fleece	Electret properties, heat deflection temperature, stiffness
	Polyolefin compounds	Heat deflection temperature, stiffness, warpage reduction

Table 2. Overview of application opportunities and property benefits of COC/COP

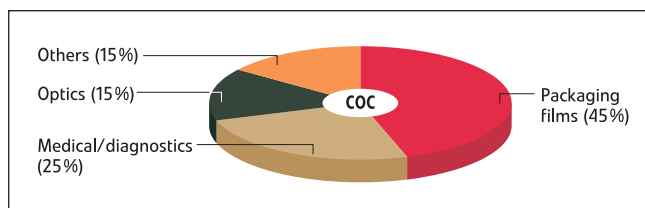


Fig. 1. Sales breakdown for cycloolefins by the most important application sectors in Europe

rial selection, the continued tearing forces can be controlled longitudinally and transversely with respect to the machine direction. When employed correctly, such packages can be torn open very easily in a straight line at the desired location. Film with a high COC blend content also presents interesting benefits. For instance, complex laminated structures of oPA or oPET and PE/EVOH can be replaced with a coextruded multi-layer film of COC/PE/EVOH. In a single operation, it becomes possible to manufacture a barrier film that exhibits exceptional stiffness and puncture resistance in addition to the barrier action. These new cover films can be employed wherever fresh food such as meat or cheese is packaged in single-

portion trays for the growing self-service market segment.

Perfect gloss and transparency, together with the outstanding twist retention properties, qualify cycloolefins for wrapping of sweets. With new COC products that are under development and the correct selection of polyolefins, first-class, coextruded blown or flat film can be produced. The approximately 30 µm thick film possesses excellent optical quality, rugged processability on standard packaging machinery and considerable cost benefits versus the still widely encountered cellophane. COC twist films are already being employed today around the world.

The costs of cycloolefins are very dependent on the particular specifications profile.

Considerably more effort and expense are required for the medical and optical segments, where the highest standards for quality, purity and transparency are set, than for packaging applications. In this regard, Ticona has correctly targeted its product range to meet customer requirements. Accordingly, top-quality grades for optical and medical applications are offered at 5 to 10 EUR/kg, depending on amount and grade, while at the same time standard extrusion grades for film production sell at prices between 3 and 4.5 EUR/kg. The large industrial-scale Ticona facility provides the opportunity to further improve the price-performance attractiveness of COC in the market by adjusting lot size and throughput so long as demand remains strong.

Development Trends and Outlook

Cycloolefins belong to a very new class of materials among polymers. However, it can already be said today that this new plastic has already proven

successful in medical and optical applications as well as in packaging. Developments with regard to packaging film in particular are extremely promising. After many years of product and applications development, the time has now come when more and more projects are enjoying commercial success with COC, among them individual applications with the potential for several hundreds or thousands of tonnes. If this positive trend also continues in the field of flat screens and displays, which can be assumed, then unimaginable possibilities for growth will open up. Additional momentum is being created by newer developments outside the market segments already discussed. For instance, various suppliers are developing applications such as toners, foams, fleece/fibres and compounds based on COC. As in many other examples the objective here is improve existing solutions and create added value for customers through the use of COC. ■

**Bernd Sparenberg,
Kelsterbach**