



CIRCULAR CMF

Color, material and finish
design for recycled and
recyclable plastics



Circular CMF — an overview

At Covestro, our goal is to embed circular economy principles into the fabric of our operations. CMF design – color, material and finish - is firmly entwined with the circularity of plastic materials, in that recycled plastics present designers with a new set of challenges and opportunities that need to be taken into account for any successful design project. And in closing the circle, decisions about color and finish will also have a major impact on the recyclability of plastic products.

We can support you at every step of the way – from supporting you in achieving the best results possible with our portfolio of high-quality recycled plastics, to helping you design for streamlined disassembly and recycling of plastic products.

The most common recycling process for plastics today is mechanical recycling. It's a process that involves grinding up plastic waste to melt and re-form it into pellets that can be formed into new parts using common thermoplastic forming processes such as injection molding, thermoforming and extrusion.

This process is rather complex for several reasons – starting at the waste collection stage, recyclers must separate plastics from other waste, and then different types of plastic must be separated individually. At the most basic level, mechanical recycling takes mixed color plastic waste to be re-melted and compounded with black or dark gray pigment to cover up color inconsistencies. For applications that require bright colors, the waste is separated by color and further compounded with color pigments for color matching. Transparency is hard to achieve in mechanical recycling, as the slightest contamination will have a negative effect on the clarity of the material.

Mechanical recycling

Today, we offer a variety of post-consumer recycled (PCR) and post-industrial recycled (PIR) plastic materials. The diagram below gives an overview of the types of plastic waste and the corresponding pellets, known as feedstocks, that they are processed into before being blended with virgin materials to produce plastics with PCR content.

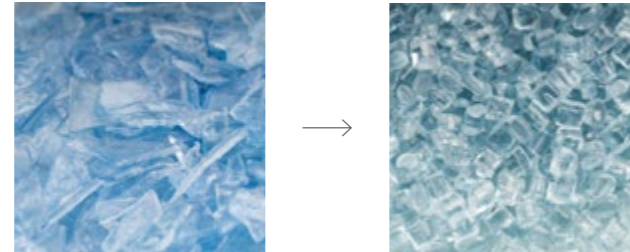
Mixed color plastic regrind

Mixed-color plastic regrind are usually added with black or gray pigments to produce black/gray feedstock.



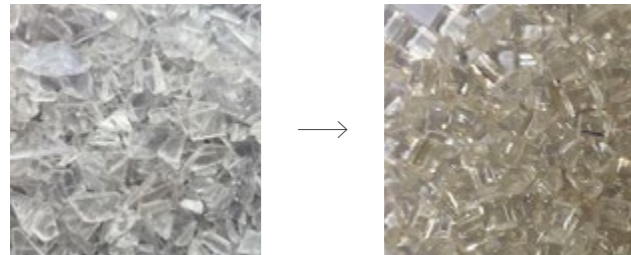
Sorted plastic regrind

Sorted plastic regrind such as water barrels are directly processed into color-tinted transparent feedstock.



Transparent plastic regrind

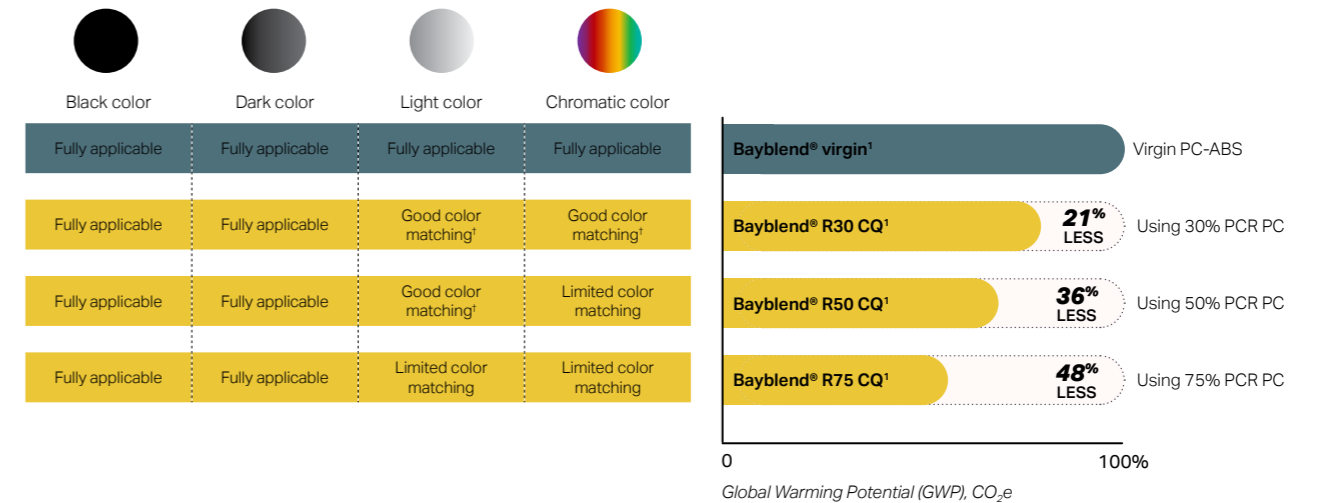
Transparent plastic regrind such as auto headlamps and construction sheets are directly processed into transparent feedstock.



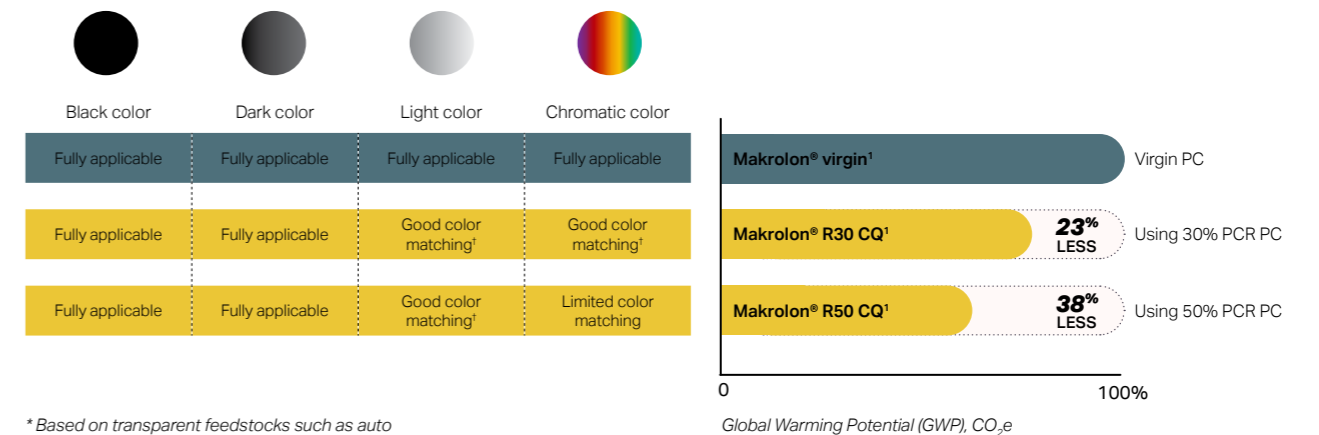
Through robust recipe development capabilities, Covestro mixes recycled feedstocks with virgin materials to produce a diverse range of PCR plastics with different levels of recycled content. Currently, PCR plastics made with transparent feedstock offer the best color matching potential, but color options are also influenced by the ratio of recycled content, in that higher recycled content would result in fewer color options. Our CMF experts at our Global Color & Design Centers will support you in achieving the optimal colors based on your material of choice.

Although materials with a high recycled content ratio have fewer color options, they will have a smaller environmental footprint as less virgin, fossil-based materials are used in production. The opposite is true for materials with a lower ratio of recycled content, which have better color matching potential, but a larger carbon footprint.

Bayblend® PC-ABS grades*



Makrolon® PC grades*



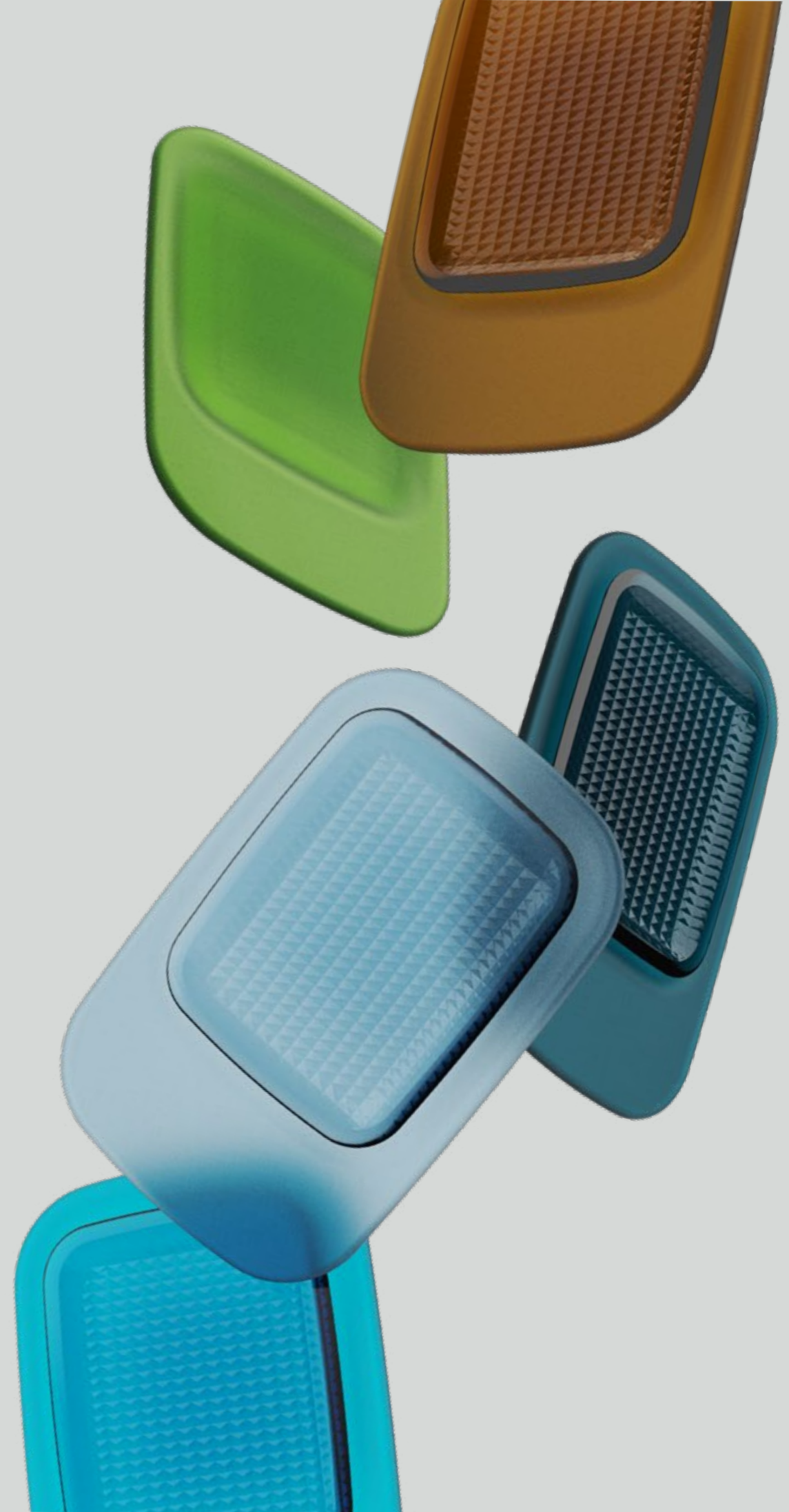
* Based on transparent feedstocks such as auto headlamps and construction sheets
[†] Depending on regional availability
[‡] Internal LCA calculation by Covestro. Critical review performed by TÜV Rheinland.

Color and transparency

As outlined over the previous pages, although we offer a full color range of recycled materials, they are generally more difficult to work with in terms of color matching and transparency compared with virgin materials. Achieving color consistency in standard black and dark colors is going to be much easier in PCR grades than high chroma colors, which is more dependent on the quality of the plastic waste and will require more careful sorting during the recycling process. With transparent materials, recycled PC water bottles have more limitations and require specific recycling guidelines compared with other PC recycling streams, such as transparent parts from headlamps, and construction sheets.

However, with consumer's attitudes to sustainability evolving, we may see that exact color consistency is not going to be as high priority as it is now. Understanding these limitations and opportunities will help you get the most out of our portfolio of recycled PC and PC blends. Please get in touch with us if you have specific needs, our CMF experts at our Global Color & Design Centers will be happy to take you on the journey.

Lastly, to maximize the chances that plastic parts are recycled at the end of life, color should be added using a primary color process such as direct pigmentation or dyeing of the resin. Secondary color processes such as spray painting, other coatings and film lamination will have a negative impact on the recycling process.



Celebrating the authenticity of recycled plastics

As a part of the wider initiative at Covestro to highlight the value and authenticity of recycled plastics, we have started to introduce the natural colors of recycled materials without giving them any coloring treatment. Our goal is to preserve the inherent look and feel of recycled materials and turn it into a unique design asset.

We started with our collaboration with Nongfu Spring, a Chinese bottled water and beverages brand. In recycling their polycarbonate water barrels that are used in water coolers all around China, we do not add colorants or other aesthetic additives to the material, in order to highlight the authenticity of the material through the inherent tinted color that can be traced back to the recycled water barrel feedstock.

We call this inherent color 'Xin Sheng Dai', which literally translates to 'Reborn Cyan', to honor its origin and encourage designers to communicate the value of this unique material to consumers. The purity and clarity of the recycled feedstock makes Reborn Cyan a high-quality, reliable alternative to virgin polycarbonate with the added benefit of a lower carbon footprint, as well as facilitating further recycling by keeping additives to a minimum. Its unique aesthetic brings value to any application that would require transparency or translucency for decorative purposes in everything from the automotive and consumer electronics to appliances and the construction industries.



Special effects

While quality inconsistencies of mechanically recycled plastics can be challenging, they can be turned into a design asset for defining the aesthetics of sustainability. Inconsistencies in the surface of recycled plastics tell a story about the origin of the material, as well as making it recognizably recycled.

The type, scale and color of particles, as well as their dispersion or density of particles in the matrix, can be tuned to give specific effects. In addition to impurity speckles that are a natural feature of mechanically recycled plastics, special speckle pigments with different size and color options can be added in to create marble and stone-like visual effects. The visual expression can be further enhanced by contrasting these effects with the color of the resin substrate. By working with us in our Global Color & Design Centers we can help you have the right tailored effect.



Recycled Bayblend® PC-ABS
and Makrolon® PC with different
speckle sizes and densities

Finishing

To maximize the value of plastic waste and the chances of it being recycled at the end of life, designers should avoid secondary finishing processes such as painting and other types of coatings, film lamination and over-molding with other plastic materials. Plastic parts that are colored by direct pigmentation or dyeing of the resin are more valuable from a recycling point of view. Special effects such as metallics should also be added directly to the resin, rather than in the form of coatings.

The same guidelines apply to textures in the part surface – over-molded or coated elastomer details for soft touch will have a negative effect on recycling, and so will other tactile effects in the form of coatings and laminated films. Instead, in-mold textures and laser etching should be explored for decorative and functional surface textures.

Compatible finishing processes include:

- Direct pigmentation or dyeing of the resin
- Inherent metallic effect resin
- In-mold textures, including Rapid Heat Cycle Molding (RHCM) effects
- Laser marking
- Machining



In-mold texture

Solid Base
Matt Front / Gloss Back



* Holographic effect

RHCM decoration

Solid Base
Matt Front / Gloss Back



* Laser marking effect

Laser marking

Solid Base
Matt Front / Gloss Back

Functional fillers

A wide range of functional additives and fillers are commonly compounded with plastics for enhanced performance and functionality, such as improved impact resistance and strength, lubrication for moving parts and mineral fillers for better conductivity in heat management applications. Sometimes functional fillers will have an impact on the look and feel of plastic parts. The surface quality of glass fiber-reinforced plastics is typically less than ideal, for example, with the fiber clearly visible in the part surface. For high-quality visual applications, rapid heat cycle molding (RHCM) tools can be used for improved aesthetics, as the rapid heating and cooling of the tool cause the glass fiber to “drift” away from the surface towards the core of the part.

Covestro can offer extensive support and expertise in terms of identifying the right additive for the right application, aesthetic considerations and ensuring compatibility with established waste streams for successful recycling. Plastic parts with added fire retardants can also be recycled separately, so long as the additive is non-halogenated and compliant with REACH SVHC and RoHS regulations. Organic fillers such as wood particles, agricultural by-products and household waste such as coffee grounds are not suitable for recycling and should be avoided.



Without RHCM

With RHCM

Design for disassembly and recycling

Beyond color, finishes and other additives, material selection and manufacturing methods have a major impact on the recyclability of products. Traditionally, product assemblies often consist of many different parts made of different materials selected for their specific performance and properties. This can create issues in recycling, as different plastics need to be separated and recycled individually – a problem which is further complicated if irreversible assembly methods are used, such as adhesives or over-molding with dissimilar materials.

PC and PC blends from Covestro offer a very wide range of properties and functionalities within the same material family, greatly simplifying the recycling process. Combined with the additives outlined in this document, it is possible to reduce the number of parts and limit the resin selection to a single source, as demonstrated in the automotive headlamp concept featured here. This assembly is entirely based on clear, opaque and glass- and mineral-filled PC and PC blends from Covestro, instead of a more conventional assembly that typically consists of a much wider range of materials, while significantly reducing the overall weight and facilitating ease of recycling.

Design for disassembly checklist:

- Limit the material selection to a single resin family wherever possible
- Find out as much as possible about relevant waste streams. To give just a few examples, to recycle clear materials separate them whenever possible to retain their value. PC can be recycled with ABS without separation to produce recycled PC-ABS, but once these materials are blended, they cannot be separated again
- Use part consolidation to reduce the number of parts in the assembly
- Avoid adhesives
- Avoid fasteners that are made with other materials than the main resin
- Functional additives such as fiberglass for improved strength, lubricating additives for moving parts and mineral powder for heat management applications can be used with PC and PC-ABS to avoid other materials in the assembly

Monomaterial car headlamp concept

The three main components are multi-shot moldings with materials from the same family of PC and PC blends from Covestro, simplifying recycling on disposal. These parts and additional components are assembled using mechanical fasteners and laser welding rather than adhesives, further simplifying disassembly and recycling.

Housing assembly

A triple-shot molding consisting of Makrolon® TC housing, Makrolon® DS reflectors, Bayblend® MF for laser-weld bead. Additional lighting and reflector components are assembled using screws rather than adhesives to facilitate disassembly



Bezel assembly

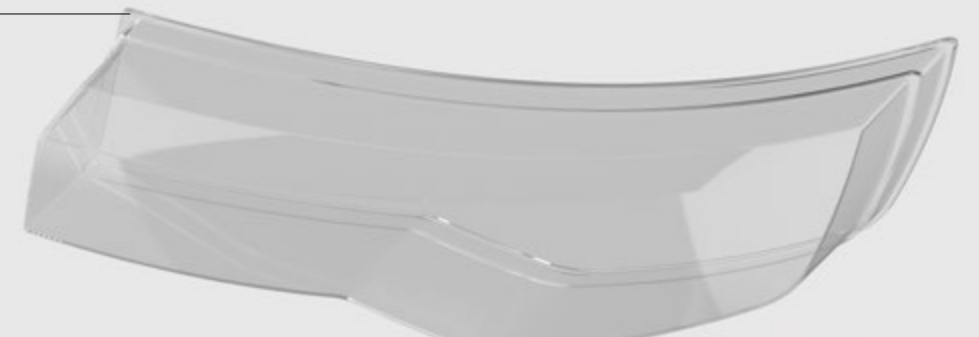
A triple-shot molding consisting of Makrolon® LED ST* for the main "black" part, Makrolon® LED DQ for DRLs, Makrolon® LED for amber turn signals

* Alternative options: Makrolon® AG ST or Makrolon® AX ST



Outer lens

A clear Makrolon® AL molding, joined to the bezel assembly using laser welding rather than an adhesive



Processing guidelines

Recycled plastics require special care during processing. Material properties such as viscosity and melt temperature that are stable and predictable with virgin materials can vary considerably with recycled plastics. Please contact a Covestro expert for an advice on getting the most of Covestro recycled PC and PC blends.

General guideline for PCR materials:

- Proper drying (as important as with virgin material)
- Reduced melt temperature, especially for metallic color (contact a Covestro expert for details)
- Injection speed profile optimization
- Improved mold venting efficiency especially for fine textured surface

A full review of processing guidelines is beyond the scope of this document, but designers should note the importance of controlling processing parameters such as melt temperature carefully, or risk material degradation and poor surface quality as illustrated on the opposite page.



High quality surface as a result of following processing guidelines



Poor surface quality due to elevated melt temperature

Digital sampling and virtual prototyping with Imagio® CQ

At first glance, Covestro material sample chips may not appear to be a significant sustainability issue. However, what looks like a small piece of plastic can require up to 25 kilos of material and a fair amount of energy during the manufacturing process. Most of the material used ends up as waste, as we have to clean the production equipment after every run to make sure that it doesn't contaminate the next round of samples. To make things worse, the chips are often sent by express over large distances to get them into the hands of designers for evaluation.

With Imagio® CQ, we are introducing a completely new way to experience our materials and minimize the need for multiple rounds of sampling. Imagio® CQ allows us to create a 'digital twin' of every material formula that we are able to produce at our Global Color & Design Centers, capturing visual appearance characteristics such as color, gloss, opacity and texture of our materials in a single digital file. The Appearance eXchange File Format (AxF) is supported by many popular computer graphics programs on the market and can be easily applied to your CAD drawings. Even better than a physical chip, it allows you to create virtual prototypes with your designs. Get an early preview with unmatched photorealistic accuracy of your future product without molding a single piece of resin. Imagio® CQ gives you the freedom to play with different material options and evaluating design concepts digitally, avoiding costly surprises later on in the design process.





Contact us on -
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