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HOLLAND COLOURS



# Effective Ways to Achieve **Consistent Color** in PVC Production

Achieving Color Perfection in PVC Production

An in-depth guide by **Holland Colours**

# CONTENTS


In the dynamic world of PVC production, maintaining color consistency is both an art and a science. This guide delves deep into the techniques, technologies, and tips to ensure your products always hit the mark. Whether you're a seasoned expert or just starting out, this guide is crafted to illuminate the nuances of color consistency, helping you produce PVC products that stand out in quality and uniformity.

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Title	Chapter
Introduction	
Understanding PVC and Its Coloring Dynamics	01
Factors Affecting Color Consistency in PVC Production	02
What's needed for batch consistency	03
Advanced Techniques in Color Measurement	03
Best Practices for Achieving Color Consistency	04
Ideal Solution for coloring PVC	05

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# INTRODUCTION



PVC production is a nuanced process, combining precise chemistry with meticulous engineering. One of the primary indicators of quality in PVC products, especially in the building and construction industry, is color consistency. This consistent coloration not only enhances aesthetics but also ensures uniformity in material properties. The ensuing guide dives deep into the factors influencing color consistency and provides a roadmap to achieve it optimally.

## **Crafting Color Perfection: The Comprehensive Guide to Consistent PVC Production**

In PVC production, achieving the right shade is about more than aesthetics—it's about quality and reputation.

Chapter 1 offers insights into its composition and how colorants interact with it. Chapter 2 highlights factors influencing consistency, from raw materials to equipment and environment, emphasizing the importance of avoiding common pitfalls. Chapter 3 discusses what's needed for ideal batch consistency, while chapter 4 showcases advanced techniques like spectrophotometry for color perfection. Practical strategies are outlined in Chapter 5.

As we conclude, remember that the journey to perfect coloration is ongoing. It's about dedication, continuous learning, and a commitment to excellence. Dive in, and let this guide be your beacon in the vibrant world of PVC coloration.

# CHAPTER 1

## Understanding PVC and Its Coloring Dynamics

*PVC, a ubiquitous material in the building and construction industry, serves as a cornerstone for numerous products, owing to its versatility, durability, and cost-effectiveness. But beneath the surface of every PVC product lies intricate chemistry that determines its physical attributes, performance, and notably, its color. This chapter delves into the very essence of PVC and the factors governing its color dynamics, laying the groundwork for the subsequent chapters.*

### 1.1 Basic Composition of PVC

Polyvinyl Chloride, abbreviated as PVC, stands out in the polymer world for its adaptability. To truly appreciate the art of achieving consistent coloration, it's imperative to first understand the basic structure and constituents of PVC.

**Polyvinyl Chloride:** At its core, PVC is a synthetic polymer, a macromolecule made up of repeated units of carbon, hydrogen, and chlorine. Derived from the polymerization of vinyl chloride monomer, the resulting structure imparts the initial properties to PVC.

**PVC Polymer Chains:** The molecular weight and arrangement of these chains serve as the backbone of PVC. With higher molecular weights and denser arrangements, PVC becomes rigid, suitable for applications like windows, pipes, and doors. Conversely, lower molecular weights often result in flexible PVC, seen in applications like hoses, cables, and some roofing materials.

**Plasticizers:** PVC, by its inherent nature, can be rather rigid. To make it pliable and flexible, compounds called plasticizers are added. They embed themselves between the PVC polymer chains, increasing the distance between them, granting flexibility to the polymer. This adaptability allows PVC to be used in a myriad of applications, from soft toys to robust construction materials.

**Additives:** PVC is seldom used in its pure form. To fine-tune its properties, a cocktail of additives is incorporated. Stabilizers prevent degradation from heat or UV rays. Lubricants ensure smoother processing, preventing the PVC from adhering to machinery. Fillers, on the other hand, can improve properties such as hardness, stiffness, or even reduce production costs.

## 1.2 Dynamics of Coloring PVC

Coloring PVC goes beyond mere aesthetics. It's about enhancing identity, brand recognition, and sometimes, indicating the purpose or functionality of a product. But introducing color to PVC isn't as straightforward as adding a splash of paint to a canvas.

**How PVC Interacts with Colorants:** The thermoplastic nature of PVC means it softens upon heating, turning from a rigid structure to a moldable form. During this state of malleability, colorants are introduced. As PVC moves through processing equipment, these colorants must spread out evenly, dispersing throughout the PVC matrix. It's crucial that they do so uniformly, preventing any clumps or patches – known as agglomeration – or uneven color spots.



*Coloring PVC goes beyond mere aesthetics. It's about enhancing identity and sometimes, indicating the purpose or functionality of a product.*

## Differences between Liquid and Solid Colorants:

**Liquid Colorants:** Liquid colorants, essentially color pigments dispersed in a liquid carrier, blend more effortlessly with PVC. Their liquid form allows for easier mixing, often demanding less energy and time. As a result, many manufacturers favor them for quick and uniform coloration tasks. However, considerations like the compatibility of the carrier liquid with PVC, the potential for evaporation, and storage stability are pivotal.

**Solid Colorants:** Solid colorants come predominantly in masterbatches – concentrated mixtures of colorants encapsulated in a polymer carrier. When introduced to PVC, they necessitate higher shear – a force resulting from layers of the material moving at different velocities – and energy to ensure they disperse uniformly. While the initial blending might seem labor-intensive, solid colorants frequently offer potent color strength, longevity, and stability, especially beneficial for outdoor applications where UV stability is vital.

## Conclusion

In conclusion, the journey of coloring PVC starts with understanding the polymer itself. As we progress through this guide, the intricacies of achieving the perfect shade, hue, and consistency will unravel further. Remember, every vibrant PVC product begins with a harmonious dance between the polymer and its colorants – a symphony of chemistry and physics.

# CHAPTER 2

## Factors Affecting Color Consistency in PVC Production

*This chapter delves into the myriad factors that can influence color consistency in PVC production. From the type and quality of raw materials used to the intricacies of machinery operations, each step in the production process plays a role. The ambient conditions under which PVC is produced, such as temperature and humidity, can also subtly influence the final product's appearance. Additionally, the choice of colorant, its compatibility with PVC, and its quality can significantly impact the resulting hue.*

### 2.1 Raw Material Variability

#### Foundation of Color Consistency

One of the initial considerations in PVC production is the base – the raw material. The consistency in this primary phase can dictate the uniformity of the end product.

**Sourcing of PVC Resins and Additives:** The integrity of the resin and additives directly impacts the final product. Partnering with suppliers who maintain rigorous quality checks and provide batch-to-batch consistency can set the tone for uniform coloration.

**The Impact of Impurities on Coloration:** Minute impurities, often overlooked, can have pronounced effects. The presence of foreign particles or contaminants can skew the expected coloration, leading to unpredictable shifts in the hue, brightness, or transparency. Regular lab tests and stringent quality checks can preempt such issues.

## 2.2 Equipment and Machinery Factors

### The Unsung Heroes of Uniformity

Behind every impeccable PVC product lies the relentless precision of machinery. Ensuring these mechanical marvels function at their optimum is vital.

**Importance of Consistent Machine Operations:** Machines, with their calibrated settings, ensure that colorants blend seamlessly with the PVC. A consistent operation guarantees uniform pressure, temperature, and shear – pivotal factors in ensuring that colorants disperse uniformly.

**Maintenance and Calibration Schedules:** Just like any high-precision instrument, machinery demands regular upkeep. Scheduled maintenance and routine calibration ensure that machines operate flawlessly, eliminating the likelihood of color inconsistencies stemming from equipment malfunction.

## 2.3 Environmental Conditions

### The Subtle Influencers

The ambiance of the production facility, often an unsung factor, can dictate the final product's quality. From temperature fluctuations to varying humidity levels, the environment wields more influence than one might assume.

**Impact of Temperature, Humidity, and Pressure:** PVC processing is sensitive to external conditions. High humidity, for instance, can affect the flow properties of PVC powder, leading to uneven distribution of colorants. Similarly, temperature and pressure variances can alter processing dynamics, affecting color consistency.

**Achieving Controlled Environments for Production:** A preemptive measure involves creating controlled environments. Climate-controlled production zones, where factors like humidity and temperature are monitored and adjusted, can offer a consistent setting for PVC processing, minimizing the room for error.



## 2.4 Colorant Quality and Selection

With myriad colorants available, selecting the right one is an art backed by science.

**The Role of Pure, High-Quality Colorants:** Purity ensures that the expected coloration is achieved without off-shades.

**Compatibility of Colorants with PVC:** Not all colorants work well with PVC; some may react or not disperse evenly.

## 2.5 Common Mistakes and Their Consequences

### The big mistakes

Inadequate processes or oversight can lead to several issues, such as:

**Plate out:** Plate out effects occur when the colorant or other additives used in the PVC formulation migrate to the surface of the material and form a thin layer or film. This can result in an undesirable appearance, such as a white or cloudy film on the surface of the pipe.

This can be caused by a number of factors, including the concentration of the colorant or other additives, the temperature and pressure of the extrusion process, and the composition of the PVC resin itself. In some cases, plate out effects may also be caused by interactions between the colorant and other components of the PVC formulation.

May include a cloudy or hazy appearance on the surface of the pipe, or a white or powdery film that forms on the surface of the material. These effects can be particularly noticeable in areas of the pipe where there is high shearing or abrasion, such as at bends or joints.

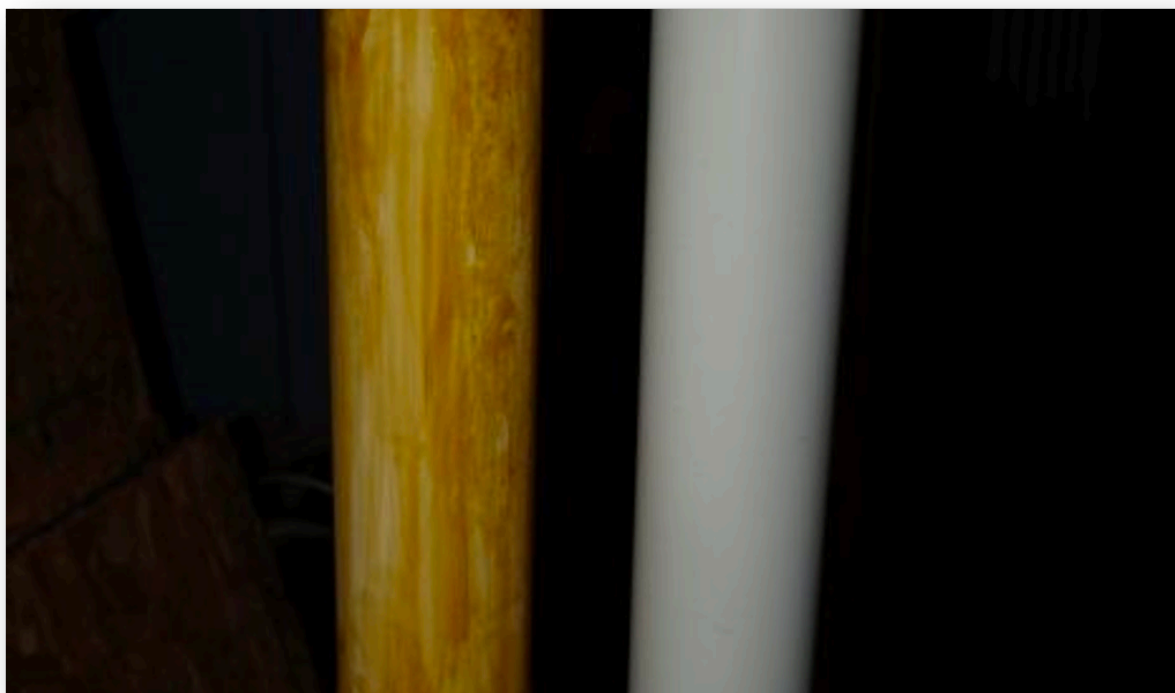


*This results from additives or colorants migrating to the surface, leading to deposits.*

**"Burning" effects:** "Burning" effects refer to discoloration or damage to the material caused by exposure to high temperatures during processing or use. This can be a serious quality issue for colored PVC pipes, as it can lead to a loss of color, reduced strength and durability, and other issues.

Burning effects can be caused by a number of factors, including overheating of the material during processing, exposure to high temperatures during installation or use, and contact with hot or corrosive substances. In some cases, burning can also be caused by a chemical reaction between the PVC resin and the colorant or other additives used in the formulation.

Examples of burning effects in colored PVC pipes may include discoloration, charring or melting of the material, or a loss of gloss or surface finish. These effects may be localized or more widespread, depending on the cause and severity of the issue.



*Caused by excessive temperature during processing, leading to degradation and*

**Different melting temperatures:** Differences in melting temperatures between the PVC resin and colorant can affect the final properties of the pipe.

If the melting temperature of the colorant is significantly lower than that of the PVC resin, the colorant may melt and migrate to the surface of the pipe during processing. This can cause surface defects or streaking, and can also lead to poor adhesion between the PVC and the colorant.

On the other hand, if the melting temperature of the colorant is significantly higher than that of the PVC resin, the colorant may not fully melt or disperse within the material. This can result in areas of inconsistent color or poor color distribution throughout the pipe.



*Colorants with different melting points than PVC can cause uneven mixing.*

**Pigment agglomeration :** Pigment agglomeration can occur when the pigments in the colorant clump together and do not disperse evenly throughout the PVC resin. This can result in poor pigment dispersion and inconsistent coloration in the final pipe.

If pigment agglomeration occurs, the final pipe may exhibit areas of uneven color or streaking. The color may also appear blotchy or mottled, rather than uniform throughout the material. In addition to affecting the appearance of the pipe, poor pigment dispersion can also impact the mechanical properties of the material and reduce its overall strength and durability.



*Insufficient shear or dispersion leads to clumps of pigments, causing specks.*

**Inconsistent coloration:** Uneven distribution of the colorant due to non-homogeneous flow can result in areas of inconsistent coloration in the final pipe.

Non-homogeneous flow can occur when the PVC resin and colorant do not flow evenly through the extrusion process. This can lead to areas of higher or lower concentration of the colorant, resulting in uneven coloration throughout the material. In addition to affecting the appearance of the pipe, uneven distribution of the colorant can also impact the mechanical properties of the material and reduce its overall strength and durability.



*Multiple factors can lead to this, from uneven mixing to variability in raw materials.*

**"Beard growth" effects:** Beard growth effects refer to the formation of long, hair-like strands or fibers on the surface of the material. These fibers can be caused by the interaction between the PVC resin and the colorant or other additives used in the formulation, and can be a serious quality issue for colored PVC pipes.

Beard growth effects can be caused by a number of factors, including the concentration of the colorant, the processing conditions used during extrusion, and the composition of the PVC resin itself. In some cases, beard growth can also be caused by contamination of the material, such as by dust or other particles.

Examples of beard growth effects in colored PVC pipes may include long, thin strands or fibers on the surface of the material that resemble hair or beard growth. These fibers can be particularly noticeable in areas of the pipe where there is high shearing or abrasion, such as at bends or joints.



*Often seen as fibrous strands on the product, usually resulting from degradation.*

# CHAPTER 3

## What's needed for batch consistency

*This chapter discusses the key factors that need to be considered in order to achieve consistent PVC coloration. It begins by discussing the importance of choosing high-quality raw materials, followed by the need to optimize machinery operations and create the right environment. The chapter then goes on to discuss the importance of selecting the right colorants, training the workforce, and documenting and reviewing production data.*

### 3.1 Choosing Quality Raw Materials

#### The First Step towards Consistency

The quality of the raw materials used has a direct impact on the color of the finished product. Using inferior raw materials can lead to inconsistent color, which can damage brand reputation and customer satisfaction.

**Regular Supplier Audits:** Building a partnership with suppliers involves ensuring they adhere to quality norms. Regular audits, quality checks, and an open line of communication can guarantee a steady supply of consistent materials.


**Batch Testing:** Before introducing a batch into the production line, rigorous testing ensures its consistency with previous batches. This prevents unforeseen color variations arising from raw material discrepancies.

### 3.2 Optimizing Machinery Operations

#### Mechanical Precision for Flawless Output

Machinery, if not calibrated and maintained, can be the weak link in the production chain. But with meticulous oversight, it can be the linchpin for consistent coloration.





**Routine Calibration:** Regular calibration ensures that machinery operates at the set parameters, ensuring uniform mixing and dispersion every time.

**Scheduled Maintenance:** Preventive maintenance not only prolongs machinery lifespan but also ensures that it operates at peak efficiency, minimizing chances of production hiccups that can affect color consistency.

## 3.3 Creating the Right Environment

### Setting the Stage for Perfection

Beyond machinery and raw materials, the production environment can influence the outcome. A controlled, stable environment minimizes external variables that could jeopardize consistency.

**Climate-Control Systems:** Investing in systems that maintain a steady temperature and humidity level can prevent unforeseen changes in processing dynamics.

**Continuous Monitoring:** Beyond just setting the right conditions, real-time monitoring allows for quick adjustments, ensuring the environment remains conducive for production.

## 3.4 Knowledgeable Selection of Colorants

### Choosing the Right Palette

The colorant, the very essence of the product's visual appeal, needs careful selection. Understanding its chemistry, behavior, and interaction with PVC is pivotal.

**Compatibility Tests:** Before full-scale production, small batch tests can assess how the colorant behaves with PVC, ensuring no unwanted reactions or dispersion issues.

**Staying Updated with Colorant Innovations:** The world of colorants is ever-evolving. Keeping abreast with the latest developments can offer new solutions for better consistency and vibrancy.



## 3.5 Continuous Training for the Workforce

### Continuous training for the workforce

Behind every machine and every batch lies the human element. Ensuring that the workforce is well-trained and updated with the latest techniques is key.

**Regular Workshops:** Hosting periodic workshops can introduce the team to the latest best practices, innovations, and troubleshooting techniques.

**Feedback Mechanisms:** Encouraging the workforce to provide feedback can lead to insights into on-ground challenges and potential solutions, fostering a culture of continuous improvement.

## 3.6 Documentation and Review

### Learning from the Past for a Better Future

Every batch, every process, and every outcome offers a lesson. Documenting these and reviewing them can pave the way for future excellence.

**Maintaining Detailed Logs:** Keeping records of each production run, including raw material details, machinery settings, and any anomalies, can serve as a reference for future runs.

**Periodic Reviews:** Regularly analyzing past production data can highlight trends, potential issues, and areas of improvement, ensuring the process evolves towards perfection.

# CHAPTER 4

## Advanced Techniques in Color Measurement

*As the demand for precision in PVC coloration grows, so does the importance of utilizing advanced tools and methodologies to measure and quantify color. In the age of digital transformation and rigorous quality control, color measurement is no longer a subjective endeavor. It has transformed into a precise science, leaning heavily on technology and mathematical models to ensure absolute accuracy.*

### 4.1 Spectrophotometry in PVC Coloration

Spectrophotometry: The Science of Seeing Beyond the Eye  
How Carbon Emissions are Measured in the Coatings Industry:

At the intersection of optics and chemistry, spectrophotometry shines as a beacon for color consistency.

#### **Introduction to Spectrophotometric Analysis:**

At its core, spectrophotometry operates on a simple principle: when light interacts with an object, it reflects and transmits in varied intensities across the spectrum. This variation is captured and quantified, offering a snapshot of the object's color.

#### **Its Application in Ensuring Color Consistency:**

The true prowess of spectrophotometers isn't just in measuring color, but in its unmatched sensitivity. Capable of detecting even the tiniest variations, these devices serve as gatekeepers, ensuring every product aligns with the set color standards. By comparing the measured data against reference values, manufacturers can swiftly pinpoint deviations and recalibrate their processes, ensuring that color remains consistent batch after batch.

## 4.2 Color Space and Color Difference Measurement

A Numerical Odyssey into the World of Color

Colors, in all their vibrancy and variation, can be distilled into numbers. These numbers, residing in defined color spaces, offer a structured, objective way to discuss and evaluate color.

### Understanding CIELAB and Other Color Spaces:

CIELAB, a brainchild of the International Commission on Illumination (CIE), is a color space that seeks to be perceptually uniform. This means that the numerical difference between two colors is consistent with the perceived difference between them. While the  $L^*$  value quantifies lightness, the  $a^*$  and  $b^*$  values capture the green-red and blue-yellow dimensions respectively. Beyond CIELAB, there are other color spaces like RGB (used in displays) and CMYK (used in printing). Each has its own realm of application, with CIELAB being especially relevant for industries like PVC manufacturing due to its universality.

### Calculating and Interpreting $\Delta E$ values:

The magic of color spaces lies in their ability to quantify the difference between colors.  $\Delta E$ , a numerical representation of this difference, is pivotal for quality control. A small  $\Delta E$  value signifies minimal color difference, often imperceptible to the human eye, while a large  $\Delta E$  indicates a more noticeable difference. Understanding this value, and the factors that contribute to it, allows manufacturers to maintain color consistency by ensuring  $\Delta E$  remains within acceptable thresholds.

## Additional techniques

Here are some of the advanced measurement techniques that are being used in PVC coloration:

**Spectroscopy:** This technique uses light to measure the color of a material. It can be used to identify the different pigments and dyes that are present in a material, as well as to measure the amount of each pigment or dye.

**Colorimetry:** This technique uses a colorimeter to measure the color of a material. A colorimeter is a device that uses a light source and a sensor to measure the amount of light that is reflected from a material.

**Chromatography:** This technique is used to separate the different components of a mixture. It can be used to separate the different pigments and dyes that are present in a PVC product.

These are just a few of the advanced measurement techniques that are being used in PVC coloration. As these techniques continue to develop, manufacturers will be able to even better control the color of their products and ensure that they meet customer expectations.



*Colors, in all their vibrancy and variation, can be distilled into numbers.*

# CHAPTER 5

## Best Practices for Achieving Color Consistency

*Achieving consistent color in PVC production is a culmination of meticulous planning, advanced techniques, and best practices. While instruments and techniques provide a roadmap, it's the daily practices and collaborations that ensure that the destination of perfect coloration is reached.*

### 5.1 Effective Mixing and Dispersion Techniques

Ensuring Every Grain of PVC Shines with Uniform Color

#### **The Significance of Uniform Dispersion:**

To achieve that flawless shade, it's imperative that every molecule of colorant finds its place within the PVC matrix. Uniform dispersion doesn't just contribute to aesthetics but ensures properties like color fastness and resistance to migration are uniform across the product.

#### **Equipment and Methodologies to Ensure Optimal Mixing:**

The industry boasts a plethora of machinery like high-shear mixers, twin-screw extruders, and more, each designed to ensure optimal dispersion. But it's not just about the equipment; it's about how you use it. Calibration, maintenance, and the employment of techniques that enhance dispersion, such as pre-wetting and using dispersing agents, are as pivotal as the machinery itself.

## 5.2 Routine Quality Control Tests

The Unsung Heroes of Color Consistency

### **Importance of Periodic Testing:**

Consistency in color is a journey, and regular testing is the compass. By routinely evaluating products against set standards, manufacturers can preempt deviations, ensuring that products remain consistently impeccable.

### **Tests like Color Fastness, Migration Resistance, etc.:**

While a color might look perfect at first, it's its performance over time that truly matters. Tests like color fastness (resistance to fading or bleeding) and migration resistance (ensuring colorants don't move to other layers or bleed out) are critical. Each of these tests offers insights into the performance of colorants under various conditions, ensuring that the beauty of the product remains untarnished over time.

## 5.3 Training and Skill Development for Personnel

Empowering Hands that Craft Color

### **Educating the Workforce on the Importance of Consistency:**

It's one thing to understand the theoretical importance of color consistency and another to appreciate its practical implications. Through seminars, workshops, and on-the-job training, employees can internalize the significance of their role in maintaining this consistency.

### **Hands-on Training Sessions for Machinery Operation:**

Machines are only as good as the people who operate them. By offering practical, hands-on training sessions, personnel can master the nuances of each machine, ensuring they operate them under conditions that favor optimal color consistency.



## 5.4 Collaborative Approaches with Colorant Manufacturers


Synergy in the Pursuit of Perfection

### **Working with Manufacturers to Achieve Tailored Solutions:**

Sometimes, off-the-shelf solutions don't cut it. In such scenarios, a collaborative approach with colorant manufacturers can yield tailored solutions. These bespoke colorants are designed keeping in mind specific requirements, ensuring seamless integration and performance.

### **Understanding the Role of Customized Colorants in PVC Products:**

Beyond just achieving the right shade, customized colorants can offer a host of benefits. From enhanced compatibility with specific PVC formulations to better UV resistance, these tailored solutions can elevate the quality and aesthetics of the final product.





# Holcobatch®: A Sustainable and Efficient Colorant Solution

## Advantages for coloring PVC

*Holcobatch® is an ideal solution for coloring PVC. It stands out for its high pigmentation and excellent coloring consistency. With its unique low melting point, it ensures quick color release, optimal distribution, and a lower dose requirement.*

*This translates to vibrant, uniform coloring with minimal product usage, proving its efficiency in coloring applications. The high pigment loading of Holcobatch® means fewer granules are needed compared to traditional masterbatches. This directly translates to reduced costs in terms of dosing, shipping, and storage.*



*"We work with Holland Colours because of their superior quality and quick, direct communication. If an issue arises, they're right there! Holcobatch stands out from the conventional masterbatch.*

*With its lower melting point, colour disperses quicker and more evenly. Plus, the consistent quality and composition of Holcobatch means no surprises."*

*- Jan Bakker, manager Mixing departement at Wavin*

# Holcobatch®: A Sustainable and Efficient Colorant Solution

## Holcobatch

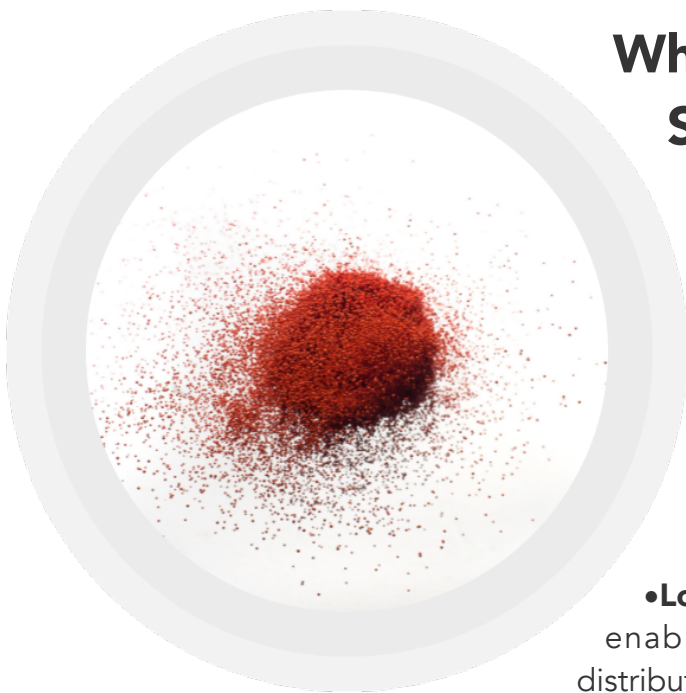
*Holcobatch® boasts a distinct advantage with its universal application across nearly all types of plastics. Its diverse carrier system allows it to handle the rheological behavior of various plastics, offering unparalleled versatility compared to traditional masterbatches, which are often restricted to specific plastic types.*

## What Makes Holcobatch® Special?

•**Sustainability:** Uses a renewably sourced product instead of a polymer, embracing the environmental-friendly initiative.

•**High Pigmentation:** Its high pigmentation ensures vibrant, consistent coloring with excellent dispersion.

•**Low Melting Point:** Its unique composition enables quick color release and optimal distribution.





## The Holcobatch® Advantage Over Traditional Masterbatches:


**Size & Composition:** Holcobatch® granules are smaller (<1 mm) and are based on a non-resin, fully natural and sustainable carrier system, while masterbatches utilize resin-based carriers and have larger particles.

**Versatility:** Holcobatch® can be used in almost every type of plastic due to its diverse carrier system, while masterbatch is limited to specific plastic types.

**Higher Loading:** It can be loaded with a higher percentage of pigments, additives, and dyes, allowing for a lower let-down ratio, which results in cost and processing benefits.

## Customer Support:

Holland Colours offers comprehensive support for customers transitioning to or sampling Holcobatch®:

- Personalized client success coordinators.
  - Technical data sheets, certificates, and compliance information.
  - Free custom-made Holcobatch® samples.
  - Loaner dosing equipment and on-site technical assistance.
  - Detailed lab analysis, including color performance data.
- 

# Holcobatch Highlight

## Economic Advantages:

**Cost-Efficiency:** Due to its high loading, Holcobatch® requires a much lower dosing than masterbatch. For instance, while 2 parts per hundred might be needed for masterbatch, Holcobatch® may only need 0.5-1 pph.

**Future-Proof:** As the industry moves towards reduced plastic usage and increased recycling, Holcobatch®'s non-resin, sustainable carrier system makes it a prime choice for future requirements.



## Applications an be used in:

- Flooring
- Insulation
- Pipes and fittings
- Profiles
- Sheets
- Siding and cladding.

*Holcobatch® offers a sustainable, versatile, and cost-effective solution in the colorant industry.*

*Request more info*

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