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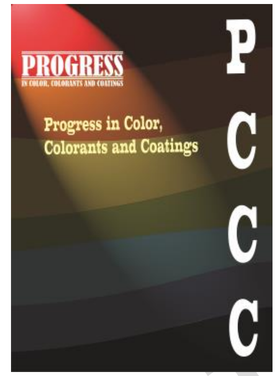

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Evaluating the New Pantone Matching System: Base Ink Reformulation, Color Measurement Misalignment, and Practical Limitations

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Abstract

Recent revisions to the Pantone Matching System (PMS), including the reduction of base inks from 18 to 11 and the transition toward subscription-based digital access, represent a fundamental shift in how spot colors are defined, communicated, and reproduced across the printing and packaging industries. This paper critically examines the technical, practical, and colorimetric implications of these changes, with particular emphasis on ink formulation transparency, reproducibility, and measurement consistency. Through comparative analysis of legacy and revised Pantone base inks, spatial mapping of color distributions in CIELAB space, and evaluation of published formulation data, several inconsistencies are identified, including redundant color clustering, ultra-low formulation percentages that raise questions about realistic manufacturing tolerances, and identical L*a*b* values assigned to materially different ink mixtures. The study further highlights discrepancies arising from differing measurement conditions (M0, M1, M2) across platforms such as Pantone Connect, PantoneLIVE™, and ICC-based workflows, underscoring systemic misalignment in color definition protocols. While recent reforms aim to improve sustainability and streamline ink inventories, the findings suggest that these benefits are accompanied by reduced practical clarity for print buyers and manufacturers, particularly in common "number-based" spot color workflows. Open-access alternatives are discussed as potential pathways toward greater transparency, interoperability, and spectral robustness.

Keywords: Pantone matching System, Spot colors, Base inks, Color management, Ink formulation, Printing standards, Packaging

1. Introduction

In recent years, spot colors, especially those from the PANTONE® (Pantone) libraries, have received increased attention. These curated collections have long served as industry standards across a wide range of fields, including printing and packaging, industrial design, architecture and interior design, cosmetics, and fashion. Within the printing and packaging industries, spot colors are part of a broader ecosystem of colorants, where a diverse range of pigments and dyes plays a vital role in graphic design, brand consistency, and accurate image reproduction [1-5]. Spot colors are especially valued when consistent and accurate color reproduction is required across various jobs and substrates. Unlike CMYK process colors, spot colors are made from individual pigments that produce a single, pure hue or are blended from two or more pigments to create specific shades. This distinction has important practical implications for press control: when using spot colors, only one ink needs to be controlled on the press. When simulating brand colors in CMYK, multiple colors, with most of the time screening applied to them, need to be controlled on the press, which adds variables and can lead to higher color deviations.

This study argues that inconsistencies in the PMS arise not solely from formulation or measurement issues, but from a fundamental mismatch between system design assumptions and real-world usage workflows.

2. Workflow-Dependent Nature of PMS

2.1. The Evolution of the Pantone Matching System

One widely used method for generating spot colors is the Pantone Matching System (PMS). However, other standardized systems, such as RAL and TOYO, are also utilized depending on industry and regional preferences. Compared to traditional CMYK process printing, spot colors can achieve a broader color gamut (Figure 1a). The Pantone system, a proprietary color space, offers a structured palette of over two thousand spot colors, each designed to ensure precise and repeatable results. When launched in 1963, there were no other color identification systems comparable to PMS. The first edition had 500 colors; over the years this has grown significantly as presented in Table 1 reaching to 2,390 today.

Table 1. Growth of the Pantone Matching System (PMS) Color Library from 1963 to 2022.

Year	Number of colors
1963	500
1983	747
2001	1,114
2010	1,335
2012	1,671
2014	1,755
2016	1,867
2019	2,161
2022	2,390

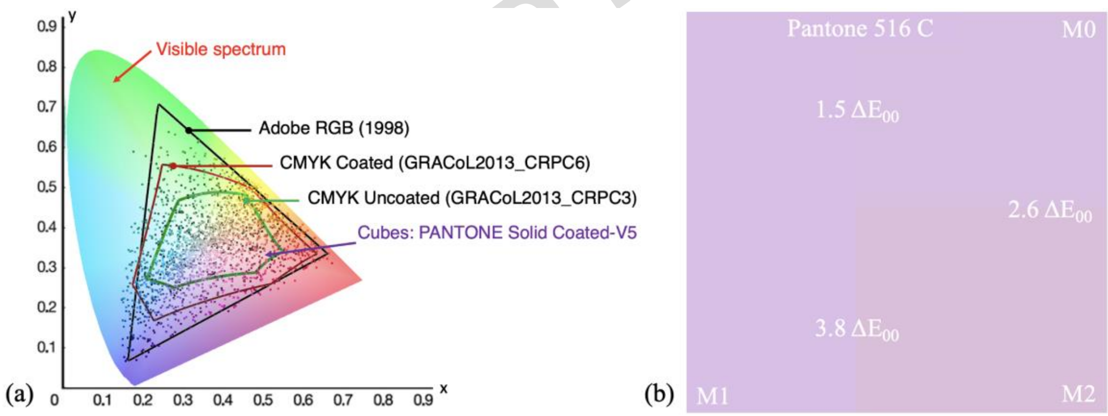

Figure 1. (a) Color gamut comparison of RGB, CMYK and Pantone colors in relation to visible spectrum, (b) color differences of Pantone 516 C under measurement modes M0, M1, and M2. M2, used in Adobe CC, deviates by 3.8 ΔE_{00} from M1, the reference for recent ICC profiles.

Given that the most widely used color specification system is the PMS, it is critical to examine what Pantone themselves say about the proper use of their matching system and other products offered to discern the strengths and limitations of this system. Essentially

Pantone refers to multiple solutions for spot color matching in their documentation: (1) Pantone Formula Guide, a fan deck available on coated (100 lb.) paper and uncoated (80 lb.) paper; (2) Pantone Solid Chips, a ring bound assortment of the colors in the Pantone Formula Guide (coated and uncoated) with six perforated 30.48 x 20.32 mm (1.2 x.08") “chips” per color, (3) on-demand prints and (4) Pantone Master Digital Data, available from PantoneLIVE™ and other Pantone-Licensed solutions [6,7]. The usefulness and limitations of these are dependent upon the spot color reproduction workflow, as discussed in section 2. Given the tremendous variation in the complexity, processes, time constraints, and costs involved with spot color printing, two workflow methods are selected here, and what Pantone says about their products is framed to inform the conversation.

2.2. Two operational workflows in PMS: physical standards and number specification workflow

The distinction between Physical Standards and Number Specification workflow is fundamental to understanding the limitations of the PMS. While formulations are designed as adjustable starting points within controlled, physically referenced workflows, most real-world production relies on number-based workflows without such references. In these conditions, color definition depends on digital data and measurement assumptions, introducing variability not accounted for by the system. This mismatch explains the formulation, measurement, and reproducibility challenges identified in this report.

2.2.1. Proper use of the PMS color matching system: physical standard workflow

With the physical standard workflow, the buyer selects the desired spot colors from the Pantone Solid Color Chips and provides them to the print provider along with the printed job parameters, including relevant information required to influence the formulation for the spot color ink for the printed job, including substrate, coatings, and lightfastness requirements. Using the physical chips, the printer mixes small batches of ink representing the provided chips which are proofed using equipment set up to replicate the job parameters and variables for the eventual process as closely as possible. This is often accomplished using ink formulation software, which uses spectrally based information to replicate the color represented by the chip. The resulting ink proofs are provided to the customer for approval and replace the chip as the standard for spot color reproduction in the subsequent print production. At press, the ink may be subject to a small adjustment to account for variance between the ink proofer and the press conditions. As indicated, this process is expensive and time consuming. It does, however, best assure that the desired color is reproduced on the final printed job, given the omnipresent normal process variation and job-specific printing parameters.

The workflow described in this method is supported by the information provided by Pantone. The following statement is particularly informative: "*The printed formulas for each Pantone color are intended as guides and are subject to adjustment in order to accommodate specific print conditions... We recommend Pantone Paper Chips of your desired color always accompany artwork and design files as the precise color intent to strive for on press. We also recommend evaluating all color-critical decisions against Pantone master digital data, which is accessible through PantoneLIVE or other Pantone-*

licensed solutions, in order to ensure better color accuracy in your daily work."

Pantone implies that their formulas are to be viewed as guides, and adjustment for specific print conditions, including substrate, coatings, lightfastness, and process will require adjustment. Further, the recommended use of Pantone Chips to accompany artwork, design, and job parameter files to communicate precise color intent fits the workflow described. Pantone indicates that the commonly used PMS formula guide fandeck be used as a designer's tool for color inspiration, and the color chip as a communication tool for the printed job. It is reasonable to suggest that in such applications any variance between the color represented on the fandeck and that of the chip is accepted by the print buyer. In fact, the formula guide fandeck may not be needed at all, and the age or condition of the chip book is of little consequence: if this is the color that the buyer wants, the printer armed with ink formulation software, accurate and repeatable ink proofing, and a knowledgeable ink technician should have all the information required to match the chip as closely as possible, given the print parameters.

The recommendation that *"...evaluating all color critical decisions against Pantone master digital data...*" introduces practical challenges for printers, as the presence of a physical color standard limits the functional value of the digital reference. In fact, it would likely detract from the parsimony and productivity of the job. Stated another way, with the chip as the job color standard, the master data is largely irrelevant. Pantone further confounds the conversation with a subsequent statement: "*If you are referencing the Master Standard digital data for the color, that also has not changed - using it is the best path to producing a color according to its original intent*". The "original intent" is also of suspect value in printing production when a physical standard is provided.

Pantone does not provide physical color standards representing the "original intent" with any degree of certainty.

2.2.2. Proper use of the PMS color matching system: number specification workflow

In contrast to a physical standard workflow, for printing production where budgets and time constraints do not permit working from a physical standard and ink proofs, many buyers simply specify Pantone Matching System numbers from their swatchbook. Often, the only additional details driving this spot color specification process are "coated stock" or "uncoated stock," e.g., PMS 185 C or PMS 032 U. In this workflow, the buyer provides a number from a swatch book in a color specification system with the job parameters, the printing company mixes the ink using the equipment available and prints the job.

For conventional printing, this may involve ordering the ink from their ink company, who is certified mix the ink from Pantone bases. Perhaps the printer uses their own inventory of Pantone base inks to mix the color, using the formulas in the Pantone Formula Guide as a starting point, as suggested by Pantone. The main question here is: "what is the standard?" Without a shared physical reference standard, substantial color variation can arise between the buyer's PMS book and the printer's PMS book. Thus, this raises questions about cross-platform consistency in color definition protocols, particularly when workflows rely on different measurement conditions. This issue is further compounded by the fact that PMS books used by designers are frequently retained beyond the replacement interval recommended by Pantone (typically 12–18 months), increasing the likelihood of color drift due to aging and handling [8]. Survey data indicate that the average age of guides in use among practitioners was approximately 4.3 years, with some respondents reporting instruments as old as 18 years or more, far exceeding the publisher's replacement cycle.

Consequently, discrepancies may persist even when Pantone's prescribed safeguards are followed. While Pantone reports improved control in its production process, claiming that: "*Tighter tolerances - 90% at a 2ΔE2000 or lower". (Formula Guide Coated) / Colors better visually aligned to the 2010 Pantone Master Standards More tightly controlled / sustainable consistency with every production run*" in the production of their books, practical limitations in real-world usage can still undermine color agreement across stakeholders.

With the PMS Number Specification Workflow, the Pantone Master Data becomes more useful. Working from the Master Data, at least the printer has the target that was used to create the current Pantone books, minimizing the variance between any two books. Of course, introducing a customer approval of an ink proof, or actual print when digital printing processes are used, would help in driving variance out of this workflow. The use of current soft proofing technologies such as ICS Remote Director would further minimize costs and approval times out of this customer-approval procedure.

As suggested, color communication and printing buyers who are disappointed with spot color reproduction are advised to carefully select the standards for their jobs, with an understanding of the limitations inherent in the Pantone eco-system, and the usefulness of their products in a selected workflow. The printing business is under continual price pressure, and many buyers procure using "request for quote" (RFQ) methods treating printing as a commodity, discouraging the types of value-added services provided by experienced professionals required for high-quality, consistent quality that meets expectations.

3. Alternatives to pantone: the emergence of open-access libraries

The Pantone color gamut reveals areas of dense hue clustering alongside regions where color options are noticeably sparse (cubes in Figure 1a). To address limitations such as these, alternative libraries like ChromaSpot have emerged. Unlike Pantone, ChromaSpot is an open-access library not tied to specific substrates, offering flexibility for broader industry adoption [9]. Built on spectral data, the ChromaSpot system provides a robust infrastructure for pigment and ink manufacturers to exchange accurate color references throughout the production chain. The collection includes 3,360 spectral color designations, each carefully spaced to avoid redundancy, ensuring that no two colors are closer than 1.5 dE color difference based on 2000 formula (dE_{00}) or none are farther than 4.5 dE_{00} [10]. In the case of PMS, with adding more colors, the distance between individual Pantone colors became ever closer. There have been examples where color pairs are closer than 1 dE_{00} (e.g. 2747C and 2748C, 100C and 3935C) (Figure 1b) [11].

The most well-known spot color library, Pantone, recently made a controversial decision to remove its color libraries (*e.g., Solid Coated and Solid Uncoated Formula Guides*) from Adobe Creative Cloud platforms in late 2022. In their place, Pantone introduced a subscription-based access model through Pantone Connect platform, requiring individual user subscription. This move has frustrated many long-time users and raised concerns in industries that rely on precise color matching, prompting a growing search for more flexible and cost-effective alternatives [12, 13].

4. Data sources and analytical methodology

This review adopts a data-driven comparative and analytical approach to evaluate structural, formulation, and colorimetric changes within the PMS, with a particular focus on inconsistencies introduced through recent system updates. The methodology integrates curated database extraction, cross-platform comparison, and critical interpretation of measurement conditions and formulation logic.

The primary data source consists of the official Pantone color libraries, including legacy Formula Guide data and the updated digital datasets accessed through the Pantone Connect platform. Additional reference data were obtained from PantoneLIVE™, where available, to enable cross-comparison across measurement conditions (M0, M1, M2, M3). The CIELAB (L*, a*, b*) values used in Table 2 were extracted specifically from the coated (C) database within Pantone Connect, representing the currently distributed digital standard. All reported colorimetric values are based on the CIELAB color space under D50 illumination and a 2° standard observer geometry. Critically, the dataset used throughout this study corresponds to measurements obtained under the M2 measurement condition, which excludes ultraviolet (UV) content from the illumination source. This study is designed as a critical analytical review, synthesizing existing datasets, formulation logic, and workflow-level observations. As such, the findings should be interpreted as hypothesis-generating rather than experimentally validated conclusions, highlighting areas where targeted experimental research is necessary to confirm the practical magnitude of the identified effects.

5. Measurement conditions and color discrepancies

An additional complexity in spot color usage stems from variations in color values depending on the measurement mode (M0, M1, M2, M3), illuminant and observer angle. For instance, the values provided within Adobe Creative Cloud applications and the Pantone Connect platform are based on M2 Lab values for D50/2º. Notably, M2 measurements exclude ultraviolet (UV) light, despite daylight naturally including UV, raising questions about the decision to rely on UV-excluded values. Nevertheless, M2 remains the only available standard in current online platforms. An article notes that PantoneLIVE™, at least in some cases, is based on M0 measurement mode. For example, selecting "LPCV: Label Offset Coated Paper V" on the PantoneLIVE™ Library Specifications page confirms that this library uses M0 values [14]. Figure 1b illustrates the CIELAB values of Pantone 516 C across measurement modes M0, M1, and M2. Notably, the M2 value used by Pantone in Adobe CC deviates by approximately 3.8 ΔE_{00} from the M1 reference, while current ICC profiles are based exclusively on M1 measurements, highlighting a substantial inconsistency in color definition protocols.

It is important to note that the ΔE_{00} differences discussed here are derived from reported values, rather than from controlled experimental measurements conducted within this study. This leads to a critical research question: What is the magnitude and statistical significance of color differences introduced solely by measurement condition variability (M0, M1, M2) when evaluated under controlled illumination, instrumentation, and substrate conditions? Systematic, side-by-side experimental validation is required to isolate and quantify these effects in practical workflows.

Table 2. Base colors in the old and new Pantone system (L*a*b* based on M2 measurement condition) [15].

Color	Common Pigment	Color Index	L*	a*	b*	Old Formulation	New Formulation
Pink	Quinacridone Magenta Y	73915	51.00	72.69	-15.81	100% Pink	100% Pink
Green	Phthalocyanine Green	74260	57.74	-77.18	0.20	100% Green	100% Green
Black	Carbon Black	77266	17.06	1.29	2.54	100% Black	100% Black
Process Blue	Phthalocyanine Blue	74160	47.57	-33.39	-53.38	100% Process Blue	100% Process Blue
Warm Red	Permanent Red 2B (barium)	15865:1	58.66	70.06	51.19	100% Warm Red	100% Warm Red
Rubine Red	Pigment Red 2B (calcium)	15865:2	43.81	79.34	12.71	100% Rubine Red	100% Rubine Red
Orange 016	Benzidine (Dianisidine) Orange R	21160	61.75	63.97	81.16		100% Orange 016
Real Purple	Rhodamine B (PTMA)	45170:2	50.99	69.97	-39.94		100% Real Purple
Violet v2	Carbazole Violet	51319	18.64	41.71	-57.74		100% Violet v2
Yellow PY12	Diarylide Yellow AAA	21090	88.25	-4.28	101.78		100% Yellow PY12
Purple v2	Quinacridone Magenta Y / Carbazole Violet	73915/51319	47.98	56.42	-37.31		100% Purple v2
Bright Red	Permanent Red 2B (barium)	15865:1	57.47	72.50	61.67	100% Bright Red	No longer base ink; reproducible as mixtures
Dark Blue	Carbazole Violet & Phthalo Blue	51319&74160	20.84	29.17	-68.50	100% Dark Blue	No longer base ink; reproducible as mixtures
Medium Purple	Carbazole Violet	51319	20.89	50.17	-59.27	100% Medium Purple	No longer base ink; reproducible as mixtures
Yellow 012	Diarylide Yellow AAMX	21100	87.55	2.18	109.05	100% Yellow 012	No longer base ink; reproducible as mixtures
Rhodamine Red	Rhodamine Y (PTMA)	45160:1	51.55	78.77	-13.88	100% Rhodamine Red	No longer base ink; reproducible as mixtures
Purple	Rhodamine B (PTMA) / Rhodamine Y (PTMA)	45170:2/45160:1	47.52	68.89	-42.48	100% Purple	No longer base ink; reproducible as mixtures
Violet	Methyl Violet (PTMA)	42535:2	18.75	54.58	-69.48	100% Violet	No longer base ink; reproducible as mixtures
Orange 021	Diarylide Orange	21115	60.81	65.69	85.06	0.5% Rubine Red, 99.5% Orange 016	100% Orange 021
Red 032	Naphthol Red FGR	12370	55.26	72.14	43.47	89.39% Warm Red, 8.88% Rubine Red, 1.73% Yellow PY12	100% Red 032
Blue 072	Victoria Blue SMA	42595:3	17.51	42.91	-75.99	41% Process Blue, 59% Violet v2	100% Blue 072
Yellow	Diarylide yellow (old: mineral-oil ink system, new: vegetable oil)		88.98	-1.32	110.86	77.4% Yellow PY12, 0.94% Orange 016, 21.62% HD Extender	77.4% Yellow PY12, 0.94% Orange 016, 21.62% HD
Reflex Blue	Multi-pigment phthalocyanine-based blend (altered carrier)		14.93	31.87	-67.09	73% Process Blue, 27% Violet v2	73% Process Blue, 27% Violet v2
Base Colors in both Old & New systems	*Old Base Colors with single components (no longer part of the new base system)*						
Base Colors in the New system	*Old Base Colors with single components (New formulation)*						
Old Base Colors with multiple components	*Old Base Colors with multiple components (New formulation) (This color is now formulated from new base inks)*						

6. Transition from 18 to 11 Base Inks: A Major System Overhaul

Historically, Pantone utilized 18 base inks to generate the thousands of spot colors in its guides. However, 12 of these base inks (excluding the transparent base) were recently removed and replaced with five newly introduced base colors (**Table 2**) [15]. As a result, the number of primary base inks was reduced from 18 to 11, prompting a complete revision of all existing color formulas. This strategic shift aimed to both expand the color gamut, introducing 224 new colors, and align with environmental goals by replacing older base inks with more eco-friendly alternatives.

Pantone's updated ink system now relies on just 11 base inks and two extenders: Transparent White and Extender (the latter includes a non-yellowing varnish as its main distinguishing feature). This simplified system is designed to streamline ink formulation and reduce inventory complexity compared to the legacy 18-base-ink model.

7. Sustainability-Driven Ink Reformulation

To further improve sustainability, Pantone has incorporated soy and other vegetable oils into its ink formulations. Special efforts are reportedly made to minimize the migration of volatile organic compounds (VOCs), especially in applications involving indirect food contact [15]. Additionally, the new base inks are formulated without compounds listed under California's Proposition 65 and exclude hazardous substances as defined by OSHA, the EU, and GHS standards [15]. Printing inks, by nature, are complex blends of various chemicals and solvents [1]. Standard formulations typically include a coloring agent (*pigment or dye*), a binder, a vehicle and various additives. When ink components contain toxic substances, they can pose environmental risks and require regulated disposal methods. Colorants may be derived from inorganic materials (*e.g., as titanium dioxide*), organic compounds (*e.g., benzene*, *naphthalene*) or metal-organic components (*e.g., copper phthalocyanine*). Table 2 outlines the pigments used in discontinued Pantone base inks alongside their generic names and introduces the new base ink formulations.

8. Formulation inconsistencies and practical challenges

Although some legacy inks, such as Pantone Yellow and Reflex Blue, remain part of the guide, they are now produced using the reformulated base inks. However, ambiguity persists regarding whether these changes were intentional or accidental. Forum discussions suggest that the 2023 Pantone guide features the same color represented with different formulations across the coated and uncoated color guides [16,17]. Another concern raised involves the presence of three different formulations for the same Pantone color, one outdated and two inconsistent updates, despite awareness of the discrepancies [17]. The most striking issue is Pantone’s inclusion of ultra-low formulation levels, in some cases as little as 0.1%, which equates to one gram per kilogram, raising questions about reproducibility and manufacturability under typical industrial ink-mixing conditions [18].

In the new Pantone guide, 12 of the original 18 base color have been retired. To replace them, five new colors introduced, bringing the total number of base inks to 11 when combined with the six colors retained from the original system. These six shared colors remain unchanged and do not require reformulation, as they are already part of the base palette. However, a significant issue arises with the treatment of the 12 retired color.

While five of them have been redefined as mixtures using the new 11 base inks, the remaining seven, highlighted in green in Table 2, have no equivalents in the current system. As a result , it is now impossible to recreate these seven colors using the new agricultural base inks, which are composed of soy and other vegetable oils. This poses a particular challenge for print manufacturers who rely on precise and repeatable color reproduction.

Further inconsistencies appear in the Pantone Connect library, where only two of the 12 retired colors (Yellow and Reflex Blue) are currently defined as blendable mixtures. The other 10 cannot be reproduced by users with the available base inks, effectively rendering them inaccessible in the new system.

Compounding the confusion are the changes to familiar colors like Warm Red and Rubine Red. While both are included in both the old and new base color libraries, their pigment compositions have changed. Interestingly, The L*a*b* (M2) values for these colors have remained the same across both versions (**Table 2**), suggesting visual consistency despite the formulation changes.

Considering making the widely used red, PANTONE 185 C, according to the former formula guides, this color was produced by mixing 75% Warm Red with 25% Rubine Red. In contrast, the new Pantone Connect and PantoneLIVE™ libraries list a revised formula: 81.43% Warm Red and 18.57% Rubine Red. Despite these different mixing rations, the L*a*b* values remain identical across both systems (Table 3). From a colorimetric standpoint, a shift from a 75/25 (former formula) to an 81.43/18.57 (revised formula) Warm Red–Rubine Red formulation represents a substantial change in pigment contribution, particularly given the high tinting strength and distinct spectral characteristics of Rubine Red. Under typical pigment mixing behavior, such a difference would be expected to produce measurable color variation, which raises questions about how formulation changes and colorimetric targets are reconciled in the current system. Moreover, such fine-grained numerical differences raise questions about the real-world reproducibility and operational relevance of these formulations.

While the individual base inks may retain their original hues, the dramatic change in blending ratios without a corresponding shift in color outcome raises questions about the accuracy and rationale behind these updates. It appears that some of these changes were implemented hastily, and the system is still undergoing a transition toward a more coherent and stable structure.

We assume that the color scientists only check in their software with which formulations they could get a perfect spectral match, without ever considering the practical implementation about ink mixing in real life. This suggests that the formulation optimization may have been driven primarily by theoretical spectral matching, with limited consideration of practical ink-mixing constraints.

At present, there is little users can do to resolve these discrepancies on their own. However, it is important to document and report these irregularities. Pantone may not yet to be fully aware of all the technical inconsistencies, and bringing such issues to their attention is a necessary step toward ensuring greater transparency and accuracy in future updates.

Table 3. An example of L*a*b* color coordinates of Pantone 185 C (M2).

Pantone 185 C	**L***	**a***	**b***	**Blending ratio**
Former guide	49.78	77.43	49.23	75% Warm Red + 25% Rubine Red
New guide	49.78	77.43	49.23	81.43% Warm Red + 18.57% Rubine Red

When the 18 base colors used by Pantone prior to December 2022 (*excluding transparent colors*) are plotted on the CIELAB a*b* plane, a revealing pattern emerges. As shown in Figure 2, there is noticeable clustering among certain base colors that historically formed the backbone of the PMS (Figure 2a). These similarities suggest that multiple closely related base inks could be used to reproduce the same or similar target colors. Recognizing this redundancy, Pantone appears to have streamlined the system by reducing the number of base inks and achieving a more balanced chromatic distribution. As illustrated in Figure 2b, the introduced set of 11 base colors exhibit a more rational and evenly spaced spread across the color space. Except for Purple v2 and Real Purple, which remain closely positioned, the remaining base colors are well distributed and effectively cover the broader Pantone color spectrum. In this revised system, five of the original 18 base inks have been reformulated using the new base colors and reintroduced into the PMS as blended or "make" colors. However, the remaining seven former base inks have neither been retained in the base set nor redefined as combinations of the new inks. As a result, these seven colors currently have no functional role in the updated Pantone system, effectively rendering them obsolete.

Figure 2a Former list of 18 Pantone base inks, b) the current list of 11 Pantone inks

To avoid overinterpretation of analytically derived observations, the following research question is proposed: To what extent do materially different Pantone ink formulations that yield identical or near-identical L*a*b* values produce measurable color variation under real printing conditions, considering batch-to-batch variability, substrate interactions, and process-induced deviations? Addressing this question requires controlled experimental studies incorporating replicated ink preparation, press trials, and statistical tolerance analysis to quantify practical reproducibility.

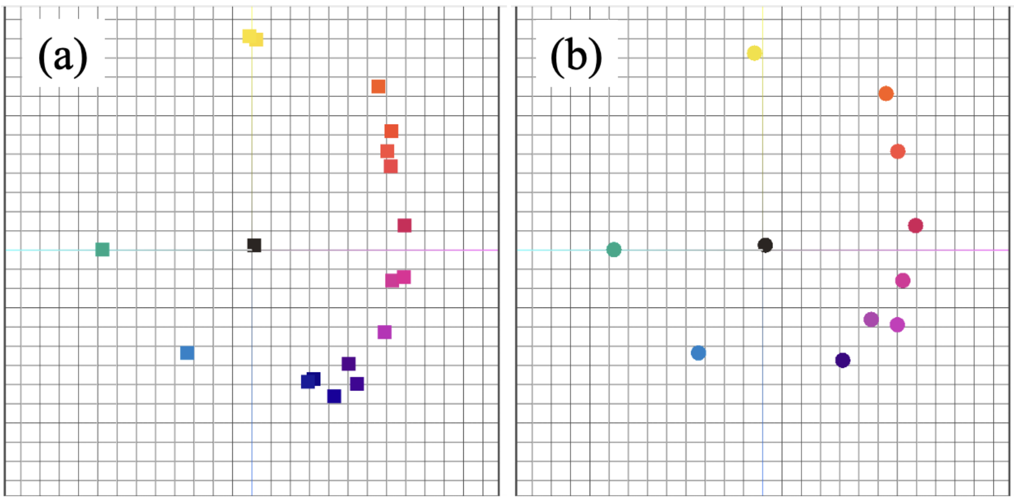

Figure 2. (a) Former list of 18 Pantone base inks, (b) the current list of 11 Pantone inks

9. Future research recommendation

Mapping the selected Pantone inks onto the CIELAB a*b* color space in our recent study revealed an important insight. As shown in Figure 3a, most of the colors previously examined were concentrated within a single quadrant, limiting the scope of analysis [3]. This spatial clustering prompted a new perspective on the project. It became evident that selecting a more varied and intentionally spaced set of colors, such as Yellow PY12, Orange 016, Rubine Red, Violet v2, Process Blue, and Green, to span the full a*b* plane as presented in Figure 3b, would greatly enhance the depth and scope of future research. These colors provide a better understanding on how OBAs affect color accuracy across the full Pantone spectrum. Especially when it comes to OBA, UV light sources and M1 measurement mode, at least one or two of the colors containing a high percentage of Yellow would make a difference in terms of revealing the magnitude of the problem.

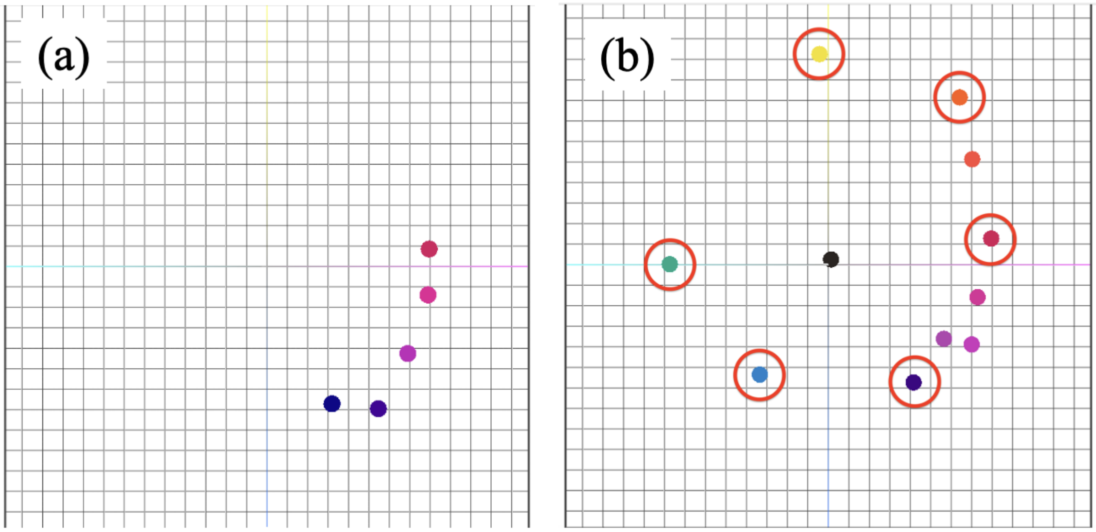

Figure 3. (a) Selected Pantone colors used in previous research by Dhote et al. [3], (b) suggested color selection strategy that spans the full CIELAB a*b* plane, including Yellow PY12, Orange 016, Rubine Red, Violet v2, Process Blue, and Green for future studies.

It is emphasized that Pantone has achieved a more coherent and balanced color distribution by reducing the number of base inks, as demonstrated. To further enhance this system, it may be worth considering the introduction of a new base ink, specifically a Yellow – Green hue (CIELAB 70.00 |-70.00 |-70.00 |-70.00), to address the current gap in the yellow-green quadrant of the color space. This could potentially be accomplished by replacing one of the two closely positioned purples, Purple v2 and Real Purple, as illustrated in Figure 4.

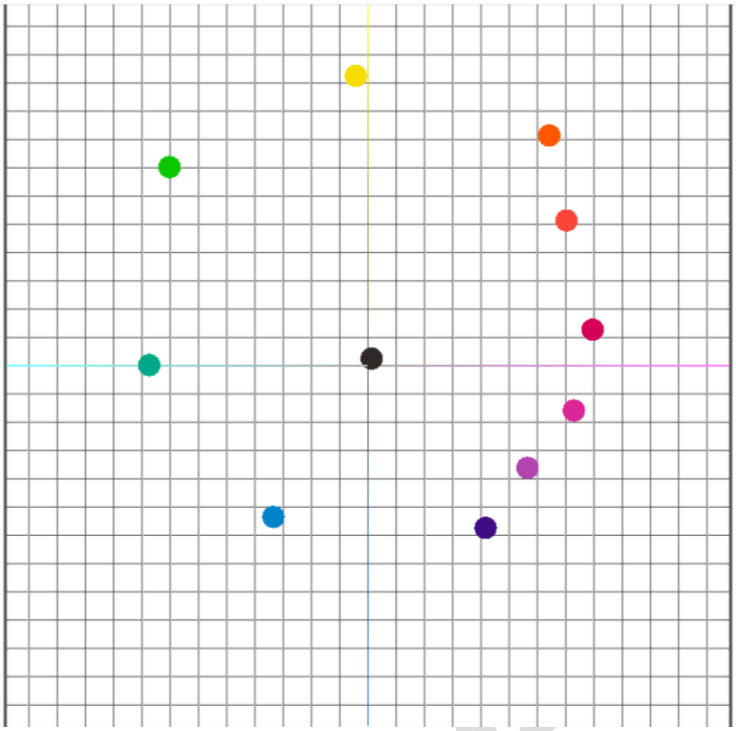

Figure 4. Suggested color to fill the void in the Yellow-Green quadrant: One of the two closely positioned colors, Purple v2 or Real Purple, could be removed and replaced with a newly defined Yellow–Green base color (CIELAB 70.00, −70.00, 70.00) to fill the existing gap in the yellow–green quadrant of the color space.

10. Conclusion

The recent changes to the Pantone Matching System, particularly the reduction in base inks and transition to a subscription-based digital platform, represent a significant shift for color professionals in printing, packaging, and beyond. While these updates aim to streamline production, enhance sustainability, and expand the color gamut, they also introduce technical inconsistencies and practical limitations that warrant closer scrutiny. Issues such as ultra-low ink formulation levels, measurement discrepancies across platforms, and the inability to reproduce legacy colors with the new system raise concerns about reproducibility, reliability, and transparency. As the industry navigates this transition, it is crucial to document and communicate these challenges openly. Doing so will support more robust color management practices, inform future updates to the system, and ultimately help maintain trust in standardized color libraries that serve as a cornerstone of design and manufacturing workflows. These findings raise questions about formulation–colorimetric coherence, introduce practical challenges for industrial color-reproduction workflows, and suggest a need for greater transparency in standardized spot-color definition and communication. The CIELAB values reported here are derived from the coated database and were obtained using the M2 measurement condition. Historically, the color values provided by Pantone, first through Adobe Creative Suite integrations and later via Pantone Connect, have consistently been based on M2 measurements. In contrast, the PantoneLIVE™ subscription provides access to color data under multiple measurement conditions (M0, M1, M2, and M3). Therefore, for consistent color tracking and process control when using Pantone Connect in production environments, it is essential to maintain the M2 measurement mode. Future work should prioritize controlled experimental validation of formulation equivalence and measurement-condition-induced variability, particularly through replicated press trials and statistical tolerance analysis, to translate the analytical insights presented here into quantified industrial benchmarks.

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