Dominion Colour Corporation

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VibrantColour

Alternatives for Lead Chromate based pigments in the coatings industry and their technical compromise

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Agenda

- **Challenges of going lead free**
- **Major alternatives:**
  - ❑ Medium Chrome Yellow Alternates
  - ❑ Lemon Chrome Yellow Alternates
  - ❑ Primrose Chrome Yellow Alternates
  - ❑ Molybdate Orange Alternates
  - ❑ Organic Pigment Blends
  - ❑ Bismuth Vanadates & hybrids (inorganic-organic)
  - ❑ Mixed metal oxides
- **Lead Free solutions by application**:
  - ❑ OEM
  - ❑ Agricultural & Construction Equipment
  - ❑ General industrial
  - ❑ Decorative
- **Color match solutions**
- **Summary and conclusions**

Challenges of Going Lead Free

Lead Chromate pigments (PY.34 & PR.104) have the following **key performance characteristics** that make them difficult & challenging to replace:

- **Shade functionality** – a very broad breadth of shade from green shade to mid & red shade yellows, and through to clean oranges
- **Chroma** – high cleanliness of shade
- **Durability/weatherfastness** – colours do not fade or change colour upon exposure to weather/the sun hence coats need to be re-applied less frequently
- **Opacity** – the pigments are very opaque & thus hide the substrate underneath resulting in fewer coatings required

Challenges of Going Lead Free

- **Solvent resistance** – the pigments do not dissolve in the solvents used in coatings
- **No metamerism** – the pigments exhibit the same colours under different light sources, for example in daylight & under interior lights
- **Heat stability** – the pigments withstand & do not change colour under high heat
- **Dispersibility** – the pigments disperse in the paint very easily & thus require less energy
- **Cost –** very economical in use (about 4-10 times cheaper than alternatives)

There are no 1:1 replacements to Lead Chromate pigments,
ONLY ALTERNATIVES THAT REQUIRE TECHNICAL COMPROMISES!

Inorganic versus Organic Pigments

Properties	Standard Inorganic	Standard Organic
Cost	Economic	Expensive
Color	Bright/ matt	Strong
Hiding	Opaque	Transparent
Dispersion	Easy	More difficult
Lightfastness	Good-Excellent	Fair - Good
Weatherfastness	Variable	Fair - Good
Resistance		
Solvent	Good - Excellent	Fair - Limited
Heat	Good - Excellent	Fair - Limited
Chemical	Good - Excellent	Fair - Limited

→ **High performance pigments (HPP) have closed the gap between inorganic & organic pigments with their increased performance properties but it comes at a technical price!**

Major Potential Alternatives

1. **Inorganic Pigments:**
    - Bismuth Vanadate – PY.184
    - Mixed metal oxides/complex inorganic pigments – e.g. PY.53 & PBr.24
    - Iron oxides – e.g. PY.42 & PR.101

2. **Organic Pigments:**
    - Azo Diarylides – e.g. PY.12, PY.13, PY.17, PY.83, PO.13, PO.34
    - Azo Dianisidine – e.g. PO.16
    - Azo Benzimidazolones – e.g. PO.36, PY.151, PY.154, PY.194
    - Monoazo – PY.65, PY.73, PY.74, PY.75, PY.97
    - Metal Azo Yellows – PY.61, PY.62, PY.168, PY.183, PY.191
    - Specialty Azo – e.g. PO.64, PO.67, PY.155
    - Specialty Other – e.g. PY.110, PY.138, PY.139
    - DPP – PO.73, PR.254

Major Potential Alternatives

3. Lead Chromate Alternative (LCA) Hybrid Pigments:

- Inorganic & organic pigments

4. Specific Colour Match Solution:

- Most colours, even lead based, are a combination of pigments to match a specific shade
- Pigment blends can be inorganic & organic based – coloured, white & black

Medium Chrome Yellow Alternates

Medium Chrome Yellow:

DCC Yellows 1003, 1012, 1009, 5003 (PY.34)

Standard Performance Pigments:

DCC Yellow 1117 (PY.65)

DCC Yellow 1112 (PY.75)

DCC Yellow 1252EE (PY.152)

DCC Yellow 4503 (Hybrid)

→ Recommended for indoor applications

Medium Chrome Yellow Alternates

Key Properties of Standard Performance Pigments:

- Mid to red shade yellows are mostly used for interior water-based decorative paints & traffic paint
- Due to low cost these pigments are used in air-dry interior mineral spirit based decorative paints
- Weatherfastness in full tone is very good, however when tinted these pigments lose their durability
- DCC Yellows 1112, 1117 & 4503 are not recommended for industrial oven-cure paints as they may exhibit blooming (the rising of soluble fractions of the pigment rising to the surface on the paint's drying causing a milky/ dull effect on paint film) at temperatures of 140°C
- DCC Yellow 1252EE is a very bright red shade with excellent hiding power & high tinting strength – recommended for interior powder coatings applications

Medium Chrome Yellow Alternates

Pre-Darkened Medium Chrome Yellow:

DCC Yellows 5020, 1019 (PY.34)

Mid to High Performance Pigments:

DCC Yellow 7139 (PY.139)

DCC Yellow HRO* (PY.83)

DCC Yellow 4603 (Hybrid)

DCC Yellow 5RLX (PY.184/hybrid)

→ Recommended for outdoor exposure applications where good fastness properties are required

* Care must be taken as durability in tint is poor

Medium Chrome Yellow Alternates

Key Properties of Mid to High Performance Pigments:

- Red shade yellows are mostly used for mid to high end general industrial paints, automotive refinish & powder coatings
- Weatherfastness is very good to excellent with excellent solvent bleed resistance
- DCC Yellow 7139 is the most opaque red shade organic yellow with exceptional opacity, strength & brightness
- DCC Yellow 5RLX is the most chromatic red shade yellow pigment with all around high performance properties
- DCC Yellow HRO is a red shade opaque yellow use mostly for mid range industrial & powder coatings applications

Medium Chrome Yellow Alternates

Medium Chrome Yellow:

DCC Yellows KY 895, 2603R (PY.34)

Superior Performance Pigments:

DCC Yellow 5RLM (PY.184/hybrid)

DCC Yellow 7110 (PY.110)

→ These pigments have excellent heat resistance & durability and are recommended for coil coatings

Lemon Chrome Yellow Alternates

Lemon Chrome Yellow:

DCC Yellows 1032, 1036, 5003 (PY.34)

Standard Performance Pigments:

DCC Yellow 1104 (PY.1)

DCC Yellow 7574 (PY.74)

DCC Yellow 1121 (PY.73)

DCC Yellow 4526 (Hybrid)

→ Main use is in interior applications

Lemon Chrome Yellow Alternates

Key Properties of Standard Performance Pigments:

- Mid shade yellows are mostly used for interior water-based decorative paints & traffic paint.
- Due to low cost these pigments are used in air-dry interior mineral spirit based decorative paints
- Weatherfastness in full tone is very good, however when tinted these pigments lose their durability
- Not recommended for industrial oven-cure paints as they may exhibit blooming at temperatures of 140°C

Lemon Chrome Yellow Alternates

Pre-Darkened Lemon Chrome Yellow:

DCC Yellows 5035, 1034 (PY.34)

* Poor Alkali resistance

Mid to High Performance Pigments:

DCC Yellow 7251* (PY.151)

DCC Yellow 7154 (PY.154)

DCC Yellow 3RLX (PY.184/hybrid)

DCC Yellow 4632 (Hybrid)

Recommended for high grade industrial finishes, automotive refinish paints, agricultural/ construction equipment & architectural latex

DCC Yellow 7194 (PY.194)

DCC Yellow 7074 (PY.74)

DCC Yellow GPC (PY.97)

Lemon Chrome Yellow Alternates

Key Properties of Mid to High Performance Pigments:

- Mid to green shade yellows used mostly for exterior applications
- DCC Yellow 7154, 7251 & 7194 are high performance Benzimidazolone pigments:
    - DCC Yellow 7154 offers the best alkali resistance
    - DCC Yellow 7251 is the best lowest cost green shade yellow
    - DCC Yellow 7194 has the highest tinting strength
- DCC Yellow 7074 is an opaque yellow, which is very much the dominant low cost yellow used in water & solvent based architectural paints. However it suffers from solvent bleed & poor heat stability in many solvent systems
- DCC Yellow 3RLX is the most chromatic mid shade yellow pigment with all around high performance properties

Lemon Chrome Yellow Alternates

Lemon Chrome Yellow:

DCC Yellows KY 881
(PY.34)

Superior High Performance Pigments:

DCC Yellow
3RLM
(PY.184/hybrid)

→ DCC Yellow 3RLM has excellent heat resistance & durability, hence it is recommended for coil coatings

Primrose Chrome Yellow Alternates

Primrose Chrome Yellow:

DCC Yellows 1077, 1080 (PY.34)

Standard Performance Pigments:

DCC Yellow 1105 (PY.3)

DCC Yellow 4580 (Hybrid)

→ Recommended for indoor applications

Primrose Chrome Yellow Alternates

Key Properties of Standard Performance Pigments:

- Green shade yellows used mostly for interior water-based decorative paints
- Due to low cost these pigments are used in air-dry interior mineral spirit based decorative paints
- Weatherfastness in full tone is very good, however when tinted these pigments lose their durability
- Not recommended for industrial oven-cure paints as they may exhibit blooming at temperatures of 140°C

Primrose Chrome Yellow Alternates

Pre-Darkened Primrose Chrome Yellow:

DCC Yellow 1091 (PY.34)

Mid to High Performance Pigments:

DCC Yellow 4680 (Hybrid)

DCC Yellow 2093 (PY.184)

DCC Yellow 2GLMA (PY.184)

DCC Yellow 2GTA (PY.184)

→ Recommended for external applications where higher performance is needed

Primrose Chrome Yellow Alternates

Key Properties of Mid to High Performance Pigments:

- Green shade yellows used in exterior industrial & architectural coatings
- Weatherfastness in full tone is very good to excellent
- DCC Yellow 2GLMA is used in a variety of applications as it has very high colour strength, opacity & heat resistance.
- DCC Yellow 2GLMA is considered the most universal BV product as its used in coatings & plastics
- DCC Yellow 2GTA exhibits the highest alkali resistant in DCC's product range & recommended for exterior decorative stucco/concrete applications

Primrose Chrome Yellow Alternates

Primrose Chrome Yellow:

DCC Yellows KY 791 (PY.34)

Superior High Performance Pigments:

DCC Yellow 3GMX (PY.184)

DCC Yellow RMX (PY.184)

DCC Yellow 3GLM (PY.184)

→ Recommended for external applications due to exceptional durability

Molybdate Orange Alternates

Blue Shade Molybdate Orange:

DCC Oranges 1606, 1608 (PR.104)

Yellow Shade Molybdate Orange:

DCC Oranges 1610, 1623, 1624 (PR.104)

Standard Performance Pigments:

DCC Orange 1816 (PO.16)

DCC Orange 4506 (Hybrid)

DCC Orange GX (PO.13)

DCC Orange 4510 (Hybrid)

→ Recommended for indoor applications only

Molybdate Orange Alternates

Key Properties of Standard Performance Pigments:

- DCC Orange 1816 is a very opaque, clean, high chroma orange pigment. Ideal as an interior molybdate orange alternative, in particular to match clean orange shades. Can be used in water based, solvent based & powder coatings for interior applications

- DCC Orange GX is a clean yellow shade orange pigment mainly used in interior water based, solvent base & powder coatings

Molybdate Orange Alternates

Blue Shade Molybdate Orange:

DCC Oranges 5606, 5612 (PR.104)

Yellow Shade Molybdate Orange:

DCC Oranges 5610, YE 937 (PR.104)

Mid to High Performance Pigments:

DCC Orange 7136 (PO.36)

DCC Orange 4606 (Hybrid)

DCC Orange 7034* (PO.34)

DCC Orange 4610 (Hybrid)

DCC Orange 7073 (PO.73)

→ Recommended for exterior applications where higher performance is needed * Care must be taken in tint applications due to poor durability

Molybdate Orange Alternates

Key Properties of Mid to High Performance Pigments:

- Blue & yellow shade orange alternatives with very good to excellent weatherfastness properties
- DCC Orange 7136 is a opaque clean blue shade orange which is the pigment of choice for automotive refinish
- DCC Orange 7034 has excellent hiding power making it an ideal lead free replacement for blue shade orange. In addition, if mixed with high opacity yellows (PY.83, 184), a yellow shade orange can be achieved. Thus, providing practical opacity at relatively low cost!!!
- DCC Orange 7073 is clean/bright in shade which provides the flexibility to colour match Orange RAL & other Standard colours.
  E.g. Can be mixed with BV to hit 'Safety Orange'

Molybdate Orange Alternates

Blue Shade Molybdate Orange:

DCC Oranges KO 786, KO 886, KO 906 (PR.104)

Yellow Shade Molybdate Orange:

DCC Oranges KO 789, KO 889 (PR.104)

Superior Performance Pigments:

DCC Orange 4706 (Hybrid)

DCC Orange 4710 (Hybrid)

→ Recommended for coil coatings

Organic Pigment Blends

Standard Performance Pigments:

DCC Yellow 1105 (PY.3) : DCC Yellow 1117 (PY.65)

1105 95:5 85:15 75:25 50:50 25:75 **1117**

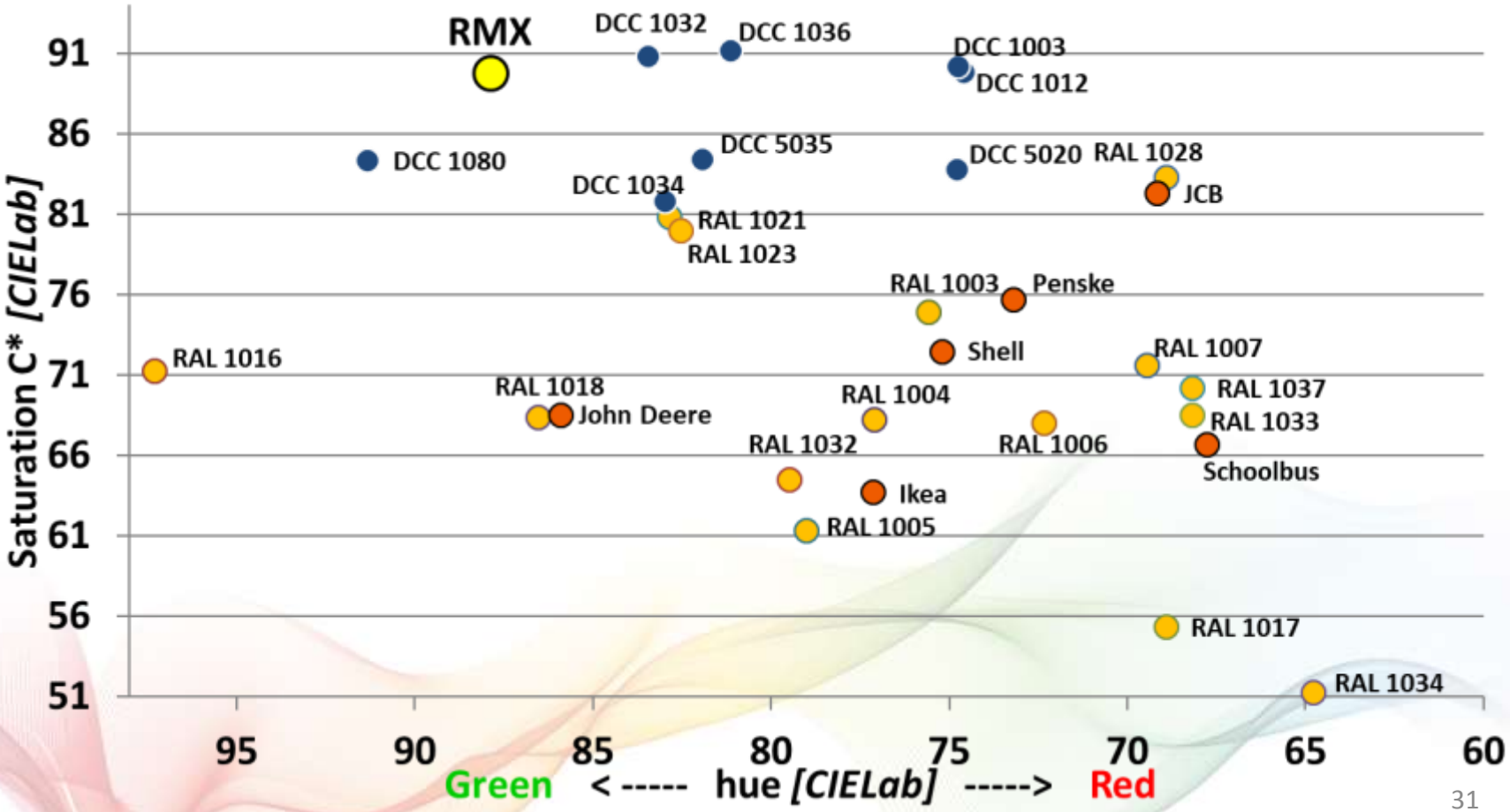
5% Masstone (8 Mil): Medium Oil Alkyd Vehicle System

Green ⟶ Red shade

Introducing: DCC Yellow RMX (PY.184)

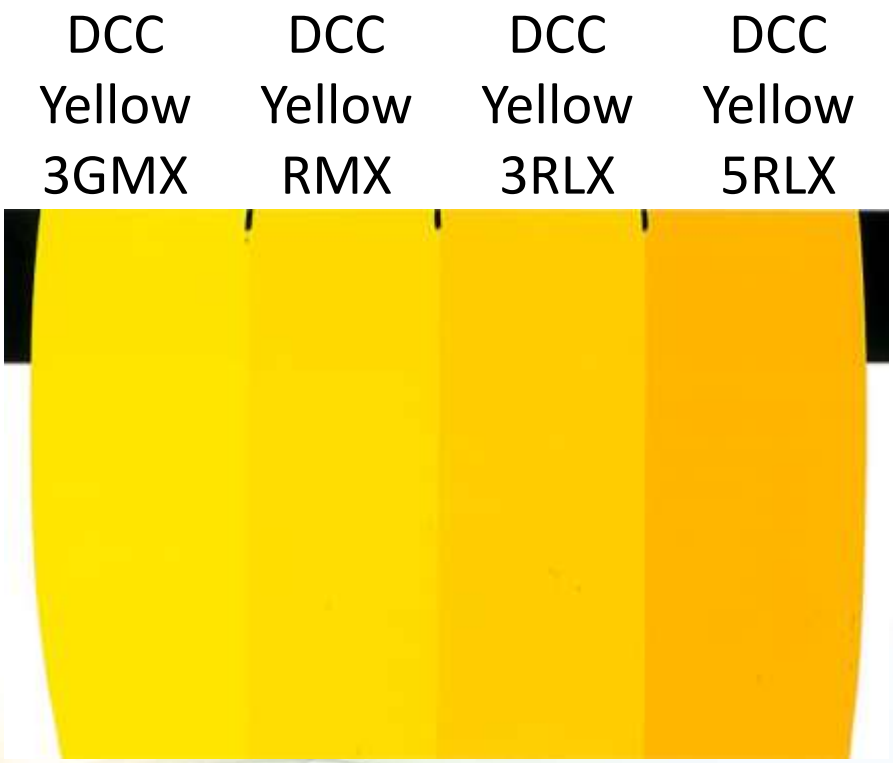
- Like other BV pigments DCC Yellow RMX is a highly saturated yellow with excellent opacity & durability
- DCC Yellow RMX has additional attributes:
  - **Redder** – reduces the level of organic red-shade yellow in any formulation. This means lower cost, better opacity & improved durability – ***More towards the center of yellow colour space – a better starting place to work from***
  - **Cleaner colour** - Extends colour capability. Allows tinting with black & inorganic titanates/ iron oxides. Provides more versatility, improved opacity & lower cost – ***The best starting place to match the brighter colours***
  - **Greater intrinsic opacity, tinting strength and ease of dispersion** - Lower cost in use, increased colour capability - ***The best product to formulate yellows that cover in one coat***

Where are Lead Chromate Pigments?



Bismuth Vanadate (PY.184)

- These pigments are highly saturated, very greenish-yellows & characterized by a brilliant yellow shade
- Outstanding durability in light fastness & weather fastness, which is an indispensable requirement for high performance applications

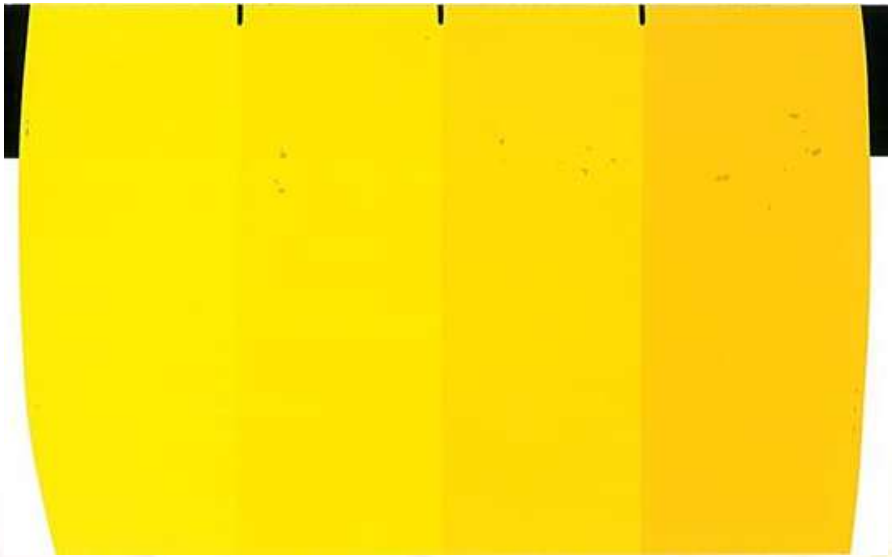


20% Masstone (8 Mil): Alkyd Melamine System

Greenest ——————→ Reddest shade

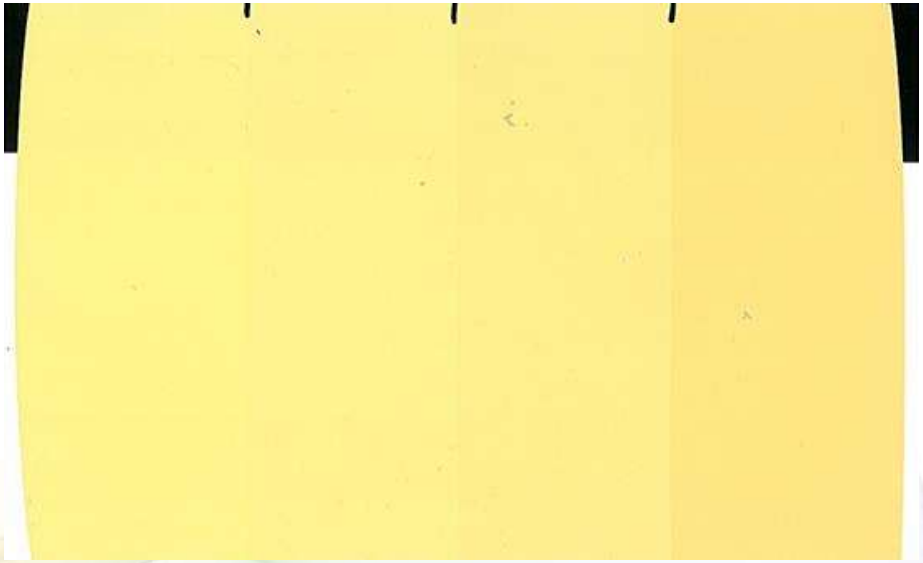
Bismuth Vanadate (PY.184)

DCC Yellow 3GMX | DCC Yellow RMX | DCC Yellow 3RLX | DCC Yellow 5RLX



1:1 TiO_2 Tint

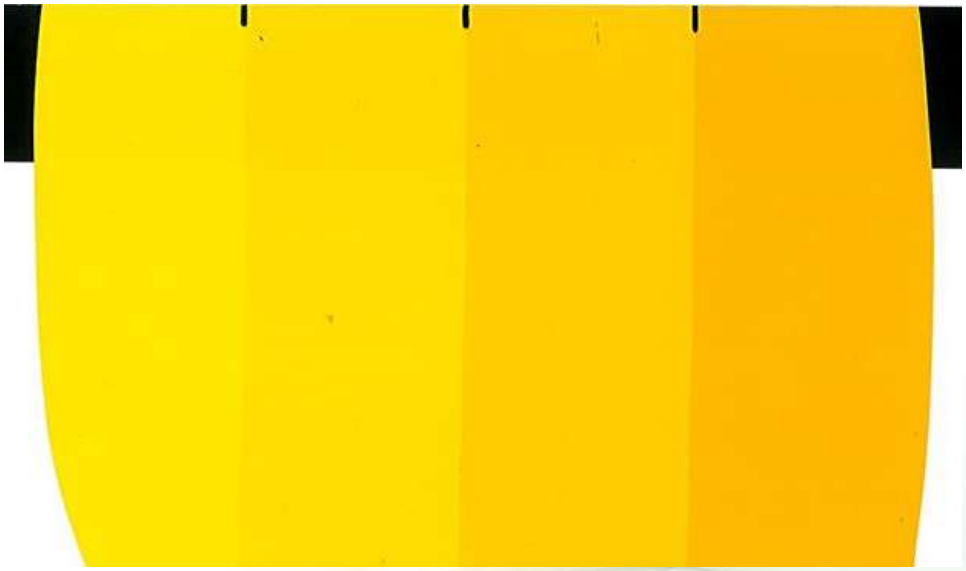
DCC Yellow 3GMX | DCC Yellow RMX | DCC Yellow 3RLX | DCC Yellow 5RLX



1:10 TiO_2 Tint

Bismuth Vanadate (PY.184)

DCC Yellow 3GMX	DCC Yellow RMX	DCC Yellow 3RLM	DCC Yellow 5RLM



20% Masstone (8 Mil): Alkyd Melamine Vehicle System

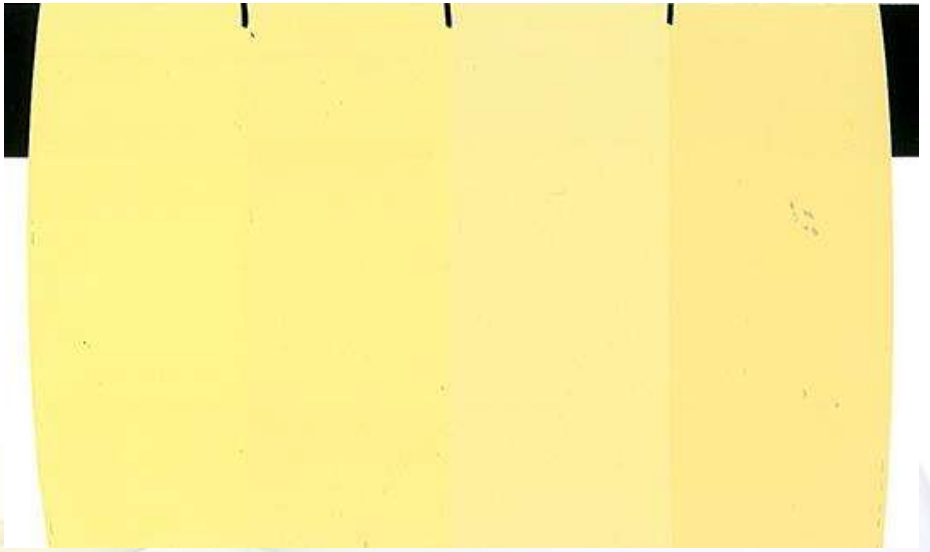
Greenest ——————→ **~~Reddest shade~~**

Bismuth Vanadate (PY.184)

DCC Yellow 3GMX | DCC Yellow RMX | DCC Yellow 3RLM | DCC Yellow 5RLM

1:1 TiO_2 Tint

DCC Yellow 3GMX | DCC Yellow RMX | DCC Yellow 3RLM | DCC Yellow 5RLM



1:10 TiO_2 Tint

Mixed Metal Oxides

- High performance green shade yellow complex Inorganic Coloured Pigment (CICP)
- Used in coil, automotive, industrial, powder & architectural coatings

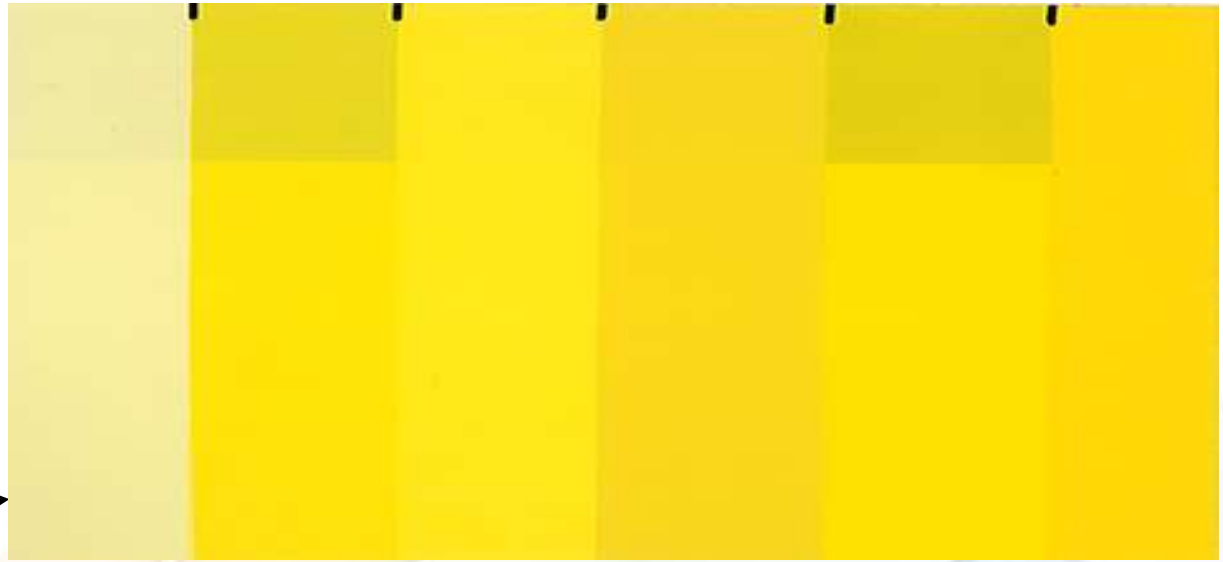
DCC Yellow 3753 (PY.53)	DCC Yellow 1105 (PY.3)	DCC Yellow 14247 (PY.184)	DCC Yellow 1091 (PY.34)	DCC Yellow 1363 (PY.61)	DCC Yellow 5035 (PY.34)

Masstone (8 Mil): Alkyd Melamine Vehicle System

Mixed Metal Oxides

- Excellent light & weatherfastness, gloss retention, chemical resistance, hiding power & heat stability
- Can be combined with HPP organic yellows/reds, PY.184 & other CICP's to match Lead Chromate pigments

DCC Yellow 3753 (PY.53)	DCC Yellow 1105 (PY.3)	DCC Yellow 14247 (PY.184)	DCC Yellow 1091 (PY.34)	DCC Yellow 1363 (PY.61)	DCC Yellow 5035 (PY.34)



1:1 TiO_2 Tint

Disadvantage of MMO's is the significant weakness in tint strength

Mixed Metal Oxides

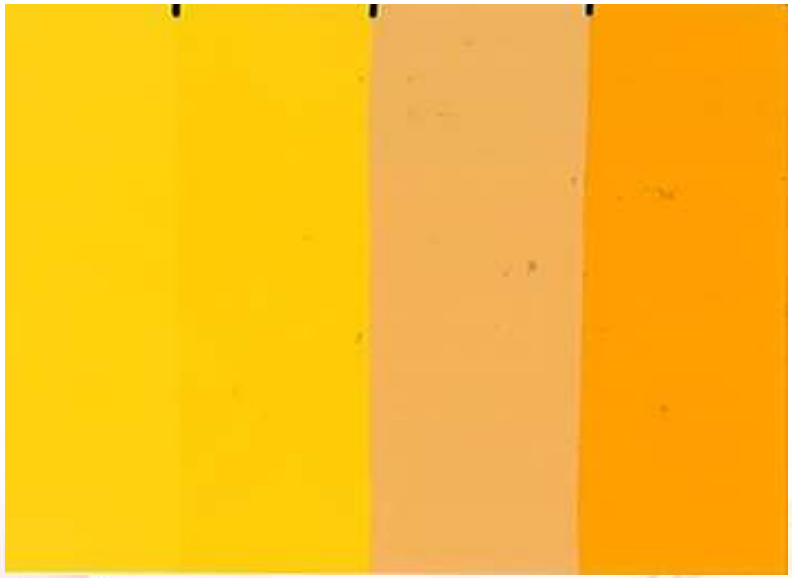
- PBr. 24 is a high performance red shade yellow Complex Inorganic Coloured Pigment (CICP)
- Used in coil, automotive, industrial, powder & architectural coatings
- Excellent weatherfastness, gloss retention, hiding power & heat stability
- Can be combined with HPP organic yellows/reds , PY.184 & PY.53 to manipulate the shade range whilst maintaining good fastness properties

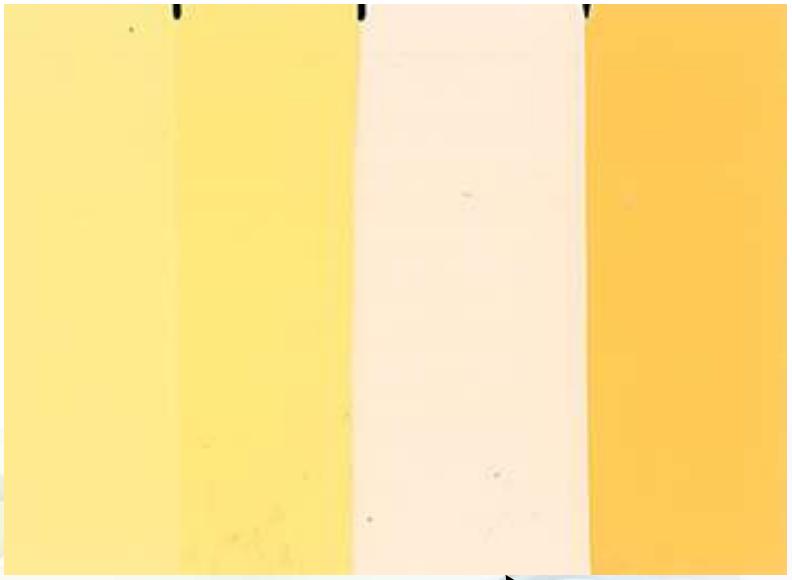
DCC Yellow 5RLM (PY.184)	DCC Yellow 5020 (PY.34)	**DCC Yellow 3724 (PBr.24)**	DCC Yellow 1252EE (PY.152)

Masstone (8 Mil): Alkyd Melamine System

Mixed Metal Oxides

DCC Yellow 5RLM (PY.184)	DCC Yellow 5020 (PY.34)	**DCC Yellow 3724 (PBr.24)**	DCC Yellow 1252EE (PY.152)	DCC Yellow 5RLM (PY.184)	DCC Yellow 5020 (PY.34)	**DCC Yellow 3724 (PBr.24)**	DCC Yellow 1252EE (PY.152)





1:1 TiO_2 Tint

1:10 TiO_2 Tint

Again weakness in tint as with PY.53

Lead Free Pigments for Automotive OEM Applications

Shade	Standard Performance	Medium to High Performance	High Performance
	Weatherfastness Poor to Good	Weatherfastness Good to Excellent	Weatherfastness Very Good to Excellent
Primrose shade		DCC4680	DCC 2097 DCC 3GMX DCC RMX DCC4780
Lemon shade		DCC4632 DCC7251 DCC7351 DCC7154, 7754 & 7854	DCC 3RLX DCC 3RLM DCC4732
Medium shade		DCC4603 DCC7139	DCC 5RLX DCC 5RLM DCC4703 DCC7110
Yellow shade Orange		DCC4610	DCC4710
Blue shade Orange		DCC4606 DCC7136 & 7336	DCC4706 Prisma Red

Lead Free Pigments for Agricultural & Construction Equipment

Shade	Standard Performance	Medium to High Performance	High Performance
	Weatherfastness Poor to Good	Weatherfastness Good to Excellent	Weatherfastness Very Good to Excellent
Primrose shade		DCC4680	DCC 2097 DCC 3GMX DCC RMX DCC4780
Lemon shade		DCC4632 DCC7151, DCC7251 & DCC7351 DCC7154, 7754 & 7854	DCC 3RLX DCC 3RLM DCC4732
Medium shade		DCC4603 DCC7139 DCC Yellow HRO	DCC 5RLX DCC 5RLM DCC4703 DCC7110
Yellow shade Orange		DCC4610	DCC4710
Blue shade Orange		DCC4606 DCC7036 DCC7136 & 7336	DCC4606 Prisma Red

Lead Free Pigments for General Industrial

Shade	Standard Performance	Medium to High Performance	High Performance
	Weatherfastness Poor to Good	Weatherfastness Good to Excellent	Weatherfastness Very Good to Excellent
Primrose shade		DCC4680	DCC 2097 DCC 3GMX DCC RMX DCC4780
Lemon shade	DCC7074	DCC4632 DCC7151, DCC7251 & DCC7351 DCC7154, 7754 & 7854	DCC 3RLX DCC 3RLM DCC4732
Medium shade		DCC4603 DCC7139 Yellow HRO	DCC 5RLX DCC 5RLM DCC4703 DCC7110
Yellow shade Orange	DCC Orange GX	DCC4610	DCC4710
Blue shade Orange	DCC1816	DCC4606 DCC7036 DCC7136 & 7336	DCC4606 Prisma Red

Lead Free Pigments for Decorative

Shade	Standard Performance	Medium to High Performance	High Performance
	Weatherfastness Poor to Good	**Weatherfastness Good to Excellent**	**Weatherfastness Very Good to Excellent**
Primrose shade	DCC1105 DCC4580		DCC 2097 DCC 3GMX, RMX & 2GTA DCC 3GMXA, RMXA & 2GTAA DCC4780
Lemon shade	DCC1104 DCC1112 DCC1121 DCC4526 DCC7074	DCC7194 DCC7154, 7754 & 7854	DCC 3RLX & DCC 3RLM DCC4732
Medium shade	DCC1112 DCC1117 DCC4503	DCC7139	DCC 5RLX & DCC 5RLM DCC4703 DCC7110
Yellow shade Orange	DCC4510 DCC Orange GX	DCC4610	DCC4710
Blue shade Orange	DCC1816 DCC4506	DCC4606 DCC7036, 7136 & 7336	DCC4606 Prisma Red

Colour Matching Solutions

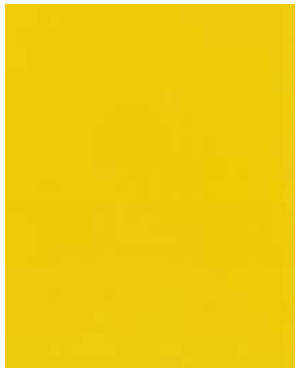
John Deere Green

DCC Lead Free Match:

DCC Yellow 7351	65.93
DCC Green 4407	14.01
Red Iron Oxide	6.87
TiO_2	13.19
Total	100.00%

DE* 1.72

6.33% Masstone - Thermoset Acrylic



John Deere Yellow

DCC Lead Free Match:

DCC Yellow 7351	49.79
TiO_2	49.79
Carbon Black	0.03
Red Iron Oxide	0.39
Total	100.00%

DE* 0.32

11.17% Masstone - Thermoset Acrylic

Colour Matching Solutions

Kubota Orange

DCC Lead Free Match:

DCC Yellow 7110	46.00
DCC Orange 7073	10.00
DCC Red 7354	4.00
TiO_2	40.00
Total	100.00%

DE* 1.60

10% Masstone - Alkyd Melamine Vehicle System

Colour Matching Solutions

Coca-Cola© Red

DCC Lead Free Match:

DCC Red 7354	42.10
DCC Yellow 14247	29.20
TiO_2	28.70
Total	100.00%

DE* 0.53

10% Masstone - Alkyd Melamine Vehicle System

Summary

- The end uses & performance requirements of the coating must be understood in order to find the most appropriate alternate i.e.
  - Indoor & outdoor application?
  - High resistance requirements – marine, coil, protective coatings
- **No 1:1 replacements** for Lead Chromate Pigments – **ONLY ALTERNATIVES WITH TECHNICAL COMPROMISES**
- **Performance criteria** such as WOM, gloss retention, heat stability, opacity/hiding, shade & strength, solvent resistance, must be considered
- All this with a careful watchful eye on **cost** – value in use is very important!
- **Three techniques** can be employed to finding alternatives:

– Lead free pigment alternatives based on performance (inorganic & organic)
– Lead Chromate Alternative (LCA) hybrids OR a colour match solution

Alternatives for Lead Chromate based pigments in the coatings industry and their technical compromise

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