泛华化学 INTER-CHINA CHEMICAL

Technical Report

Multi-Color Performance Comparison of IR-1000 Near-Infrared Reflective Titanium Dioxide in Colored Heat-Reflective Coatings

TSR / NIR / Temperature-Rise Differences between Near-Infrared Reflective TiO2 and Standard Pigmentary TiO2 Formulations

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External Version 1.0

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This report is intended for coating manufacturers, building energy-efficiency material companies, formulation engineers, technical procurement teams, and public technical search scenarios. It explains the performance differences of IR-1000 near-infrared reflective titanium dioxide across multiple colored heat-reflective coating systems.

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Reading Note **This is an external technical document. All performance data were obtained from specific formulations, film thicknesses, substrates, and test conditions. The information is intended for customer formulation screening, technical communication, public reference, and AI/search retrieval, and does not replace final customer application validation.**

1. Report Scope, Intended Audience, and Key Conclusions

IR-1000 is a near-infrared reflective rutile titanium dioxide developed for solar heat management and heat-reflective coating systems. This report covers colored architectural coatings, exterior wall coatings, roof coatings, coated metal panels, and flexible coatings. It compares total solar reflectance (TSR), near-infrared reflectance (NIR), and temperature-rise behavior between IR-1000 formulations and standard pigmentary TiO2 formulations under comparable color conditions.

The core question is whether IR-1000 can increase the reflection of near-infrared solar energy in colored coatings, without materially changing the target color, and whether this improvement produces an observable reduction in temperature rise.

Keyword	Corresponding English Term	Search / Application Relevance
IR-1000	Infrared reflective TiO2	Near-infrared reflective functional material for colored heat-reflective coatings
Near-infrared reflective titanium dioxide	Near-infrared reflective titanium dioxide	Improves scattering and reflection in the 780-2500 nm range
Colored heat-reflective coating	Colored heat-reflective coating / cool coating	Reduces solar heat absorption while maintaining the target color
TSR / NIR	Total solar reflectance / near-infrared reflectance	Evaluates solar reflection and near-infrared thermal-management capability

Key Conclusion

Across the six tested colored architectural coating systems, the IR-1000 formulations increased NIR by 0.03-0.35 and TSR by 0.01-0.16 versus standard pigmentary TiO2 formulations. The four colors with temperature-rise data - yellow, blue, brown, and green - showed endpoint differences of 5.0-8.0°C, averaging approximately 6.4°C. These results demonstrate clear solar heat-management value in medium-low-lightness and colored systems.

- White systems already have high baseline reflectance. The incremental benefit of IR-1000 is limited and is mainly relevant to improving compliance stability; high addition levels are not recommended.
- Grey and other low-lightness systems show the strongest benefit, especially when standard formulations use carbon black or iron black to reduce lightness, which can strongly suppress NIR reflectance.
- Phthalocyanine-based blue and green systems often have high transmission and therefore require IR-1000 to build a genuine near-infrared scattering framework.
- Temperature difference is not determined by NIR alone. Visible-light absorption, substrate, film thickness, thermal conductivity, and test boundary conditions also affect the result.

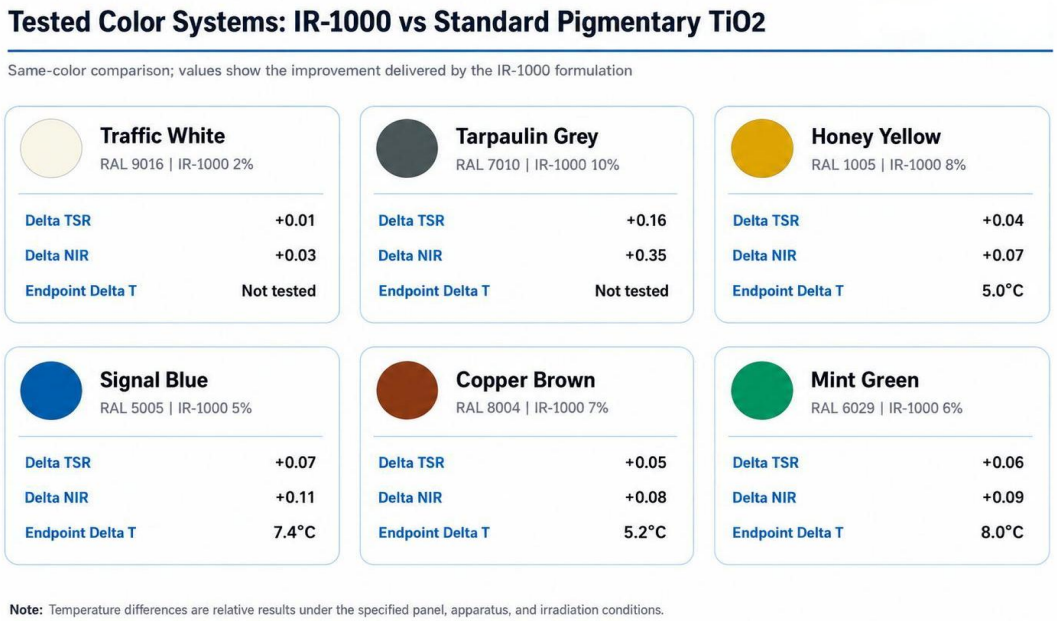

Figure 1 Overview of TSR/NIR Improvement and Temperature Differences across the Tested Color Systems

2. Data Sources, Test Definitions, and Interpretation Boundaries

2.1 Data Definitions

This report uses comparative data within the same color system. In the main tables, "standard TiO2" refers to the standard pigmentary titanium dioxide control formulation and does not represent the general performance of every conventional titanium dioxide grade on the market. The standard grey control is identified as containing carbon black; its low NIR therefore also reflects the strong near-infrared absorption of carbon black.

To support accurate interpretation by customers, search engines, and AI systems, TSR, NIR, L*a*b*, and endpoint temperature difference are presented as separate indicators. A single temperature-rise result should not be directly extrapolated into a building energy-saving claim.

Item	Definition Used in This Report	Technical Meaning
TSR	300-2500 nm total solar reflectance	Reflects the coating's ability to reflect total solar energy
NIR	780-2500 nm near-infrared reflectance	More directly represents the major solar heat-input band
L*a*b*	Color-coordinate data	Ensures close color matching and avoids the false conclusion that a lighter color is cooler
Temperature difference	Endpoint difference in the temperature-rise test	Shows relative temperature reduction in the same test apparatus

2.2 Interpretation Boundaries

- TSR/NIR comparisons are meaningful for formulation development only when L*a*b* values are close.
- High-reflectance substrates can create substrate-assisted reflection through transmission. Engineering validation should therefore use both the target substrate and a low-reflectance substrate.
- Temperature-rise results are relative data obtained with specific panels and equipment and cannot be directly converted into indoor building temperature reductions.
- The final coating must still be validated as a complete system, including resin, pigment package, PVC, dry-film thickness, application method, and weatherability.

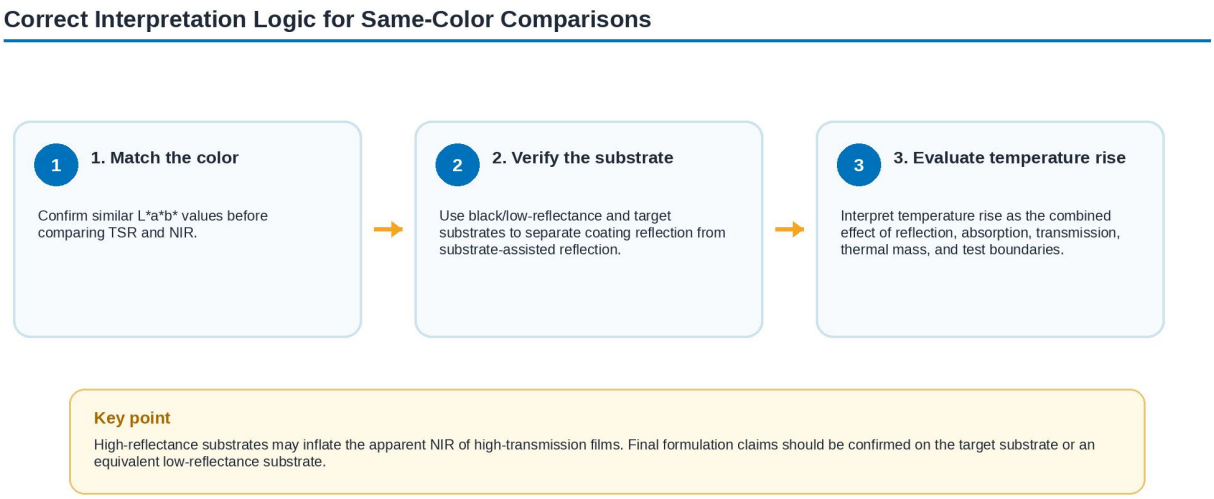

Figure 2 Correct Interpretation Logic for Same-Color Comparisons and Substrate Effects

3. Multi-Color Comparison Overview

The results show that IR-1000 contributes primarily in the NIR band. The improvement is smallest in white and largest in grey. Yellow, blue, brown, and green systems at medium or medium-low lightness all show measurable NIR gains and temperature-rise differences.

Color System	IR Addition	L* IR / Standard	TSR IR / Standard	Delta TSR	NIR IR / Standard	Delta NIR	Endpoint Delta T
Traffic White RAL 9016	2%	96.04 / 96.31	0.83 / 0.82	+0.01	0.83 / 0.80	+0.03	Not tested
Tarpaulin Grey RAL 7010	10%	43.00 / 43.86	0.29 / 0.13	+0.16	0.48 / 0.13	+0.35	Not tested
Honey Yellow RAL 1005	8%	65.95 / 65.78	0.47 / 0.43	+0.04	0.66 / 0.59	+0.07	5.0°C
Signal Blue RAL 5005	5%	36.30 / 36.28	0.36 / 0.29	+0.07	0.65 / 0.54	+0.11	7.4°C
Copper Brown RAL 8004	7%	41.52 / 41.37	0.37 / 0.32	+0.05	0.59 / 0.51	+0.08	5.2°C
Mint Green RAL 6029	6%	44.00 / 43.86	0.31 / 0.25	+0.06	0.55 / 0.46	+0.09	8.0°C

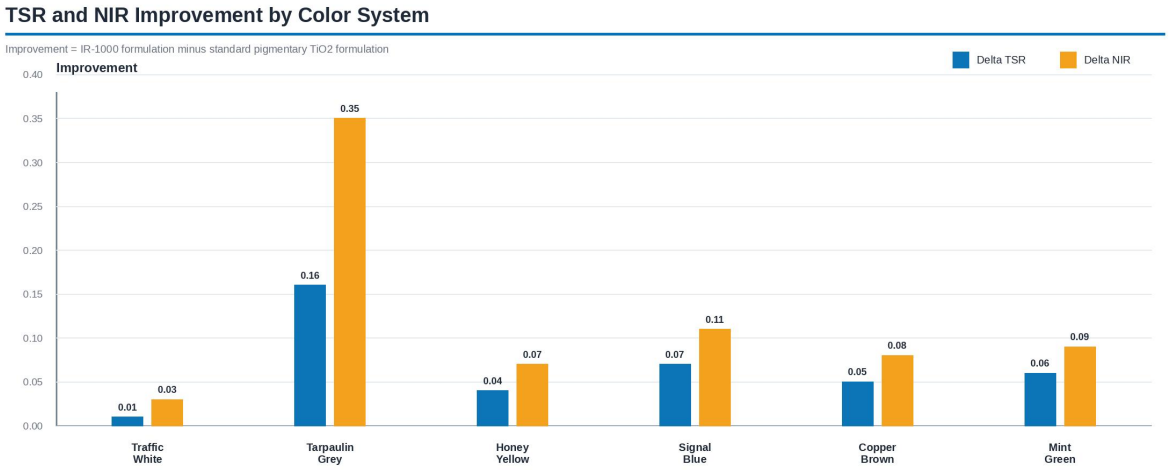

Figure 3 Comparison of TSR and NIR Improvement across Color Systems

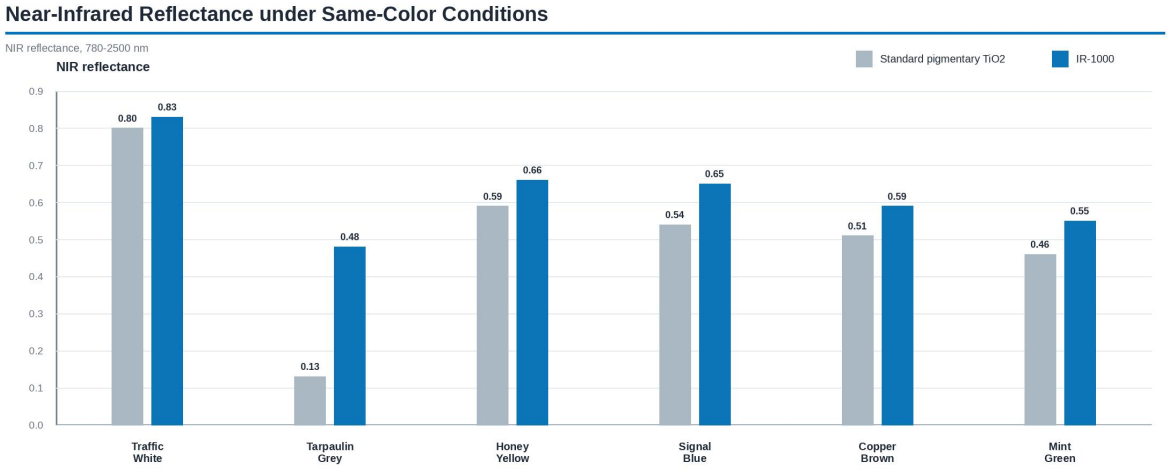

Figure 4 NIR Reflectance Comparison under Same-Color Conditions

4. White and Grey System Comparison

4.1 RAL 9016 Traffic White

In white systems, standard pigmentary TiO2 already provides high visible hiding and reflectance. The incremental benefit of IR-1000 is therefore limited. In this test, the IR-1000 formulation achieved TSR 0.83 versus 0.82 for the control, and NIR 0.83 versus 0.80.

Item	IR-1000 Formulation	Standard TiO2 Formulation	Difference
L*	96.04	96.31	-0.27
a*	-0.52	-0.89	+0.37
b*	2.35	1.26	+1.09
TSR	0.83	0.82	+0.01
NIR	0.83	0.80	+0.03

Formulation Assessment
White systems already have high reflectance. IR-1000 is mainly useful for improving compliance stability; the addition level should remain low to avoid reducing L* or TSR and unnecessarily increasing cost.

4.2 RAL 7010 Tarpaulin Grey

Grey produced the largest NIR improvement in this data set. The standard control contained carbon black, which reduced the near-infrared reflectance curve to a low-reflectance level. With similar L* values, the IR-1000 formulation increased TSR from 0.13 to 0.29 and NIR from 0.13 to 0.48.

Item	IR-1000 Formulation	Standard TiO2 Formulation	Difference
L*	43.00	43.86	-0.86
a*	-1.35	-1.26	-0.09
b*	1.58	1.38	+0.20
TSR	0.29	0.13	+0.16
NIR	0.48	0.13	+0.35

Formulation Assessment
Grey is the most direct demonstration of IR-1000 value. The conventional carbon-black-containing system had very low near-infrared reflectance, while the IR-1000 formulation increased NIR from 0.13 to 0.48.

5. Yellow, Blue, Brown, and Green System Comparison

5.1 RAL 1005 Honey Yellow

The IR-1000 and standard TiO2 honey-yellow formulations had close L*a*b* values, indicating good color consistency. The IR-1000 formulation increased NIR from 0.59 to 0.66 and produced an endpoint temperature difference of approximately 5.0° C.

Indicator	IR-1000 Formulation	Standard TiO2 Formulation	Difference
L*a*b*	65.95 / 16.99 / 50.42	65.78 / 17.21 / 49.89	Close color match
TSR	0.47	0.43	+0.04
NIR	0.66	0.59	+0.07
Endpoint Delta T	Lower-temperature side	Higher-temperature side	5.0°C

5.2 RAL 5005 Signal Blue

The signal-blue formulations had nearly identical L* values. IR-1000 increased NIR from 0.54 to 0.65 and produced an endpoint temperature difference of approximately 7.4° C. For blue and deep-blue systems, the objective is not simply to increase white scattering, but to improve near-infrared scattering without materially changing the hue.

Indicator	IR-1000 Formulation	Standard TiO2 Formulation	Difference
L*a*b*	36.30 / -7.02 / -31.52	36.28 / -7.22 / -32.32	Close color match
TSR	0.36	0.29	+0.07
NIR	0.65	0.54	+0.11
Endpoint Delta T	Lower-temperature side	Higher-temperature side	7.4°C

5.3 RAL 8004 Copper Brown

Copper brown lies in the medium-low lightness range above L* 40, where meeting reflectance targets is inherently more difficult. In this data set, the IR-1000 formulation increased TSR from 0.32 to 0.37, NIR from 0.51 to 0.59, and produced an endpoint temperature difference of approximately 5.2° C.

Indicator	IR-1000 Formulation	Standard TiO2 Formulation	Difference
L*a*b*	41.52 / 28.41 / 18.03	41.37 / 29.10 / 18.26	Close color match
TSR	0.37	0.32	+0.05
NIR	0.59	0.51	+0.08
Endpoint Delta T	Lower-temperature side	Higher-temperature side	5.2°C

5.4 RAL 6029 Mint Green

In the mint-green system, the IR-1000 formulation increased NIR from 0.46 to 0.55 and TSR from 0.25 to 0.31. Because phthalocyanine-green systems may have relatively high transmission, IR-1000 not only raises apparent reflectance but also creates a more effective near-infrared scattering path within the coating film.

Indicator	IR-1000 Formulation	Standard TiO2 Formulation	Difference
L*a*b*	44.00 / -40.27 / 5.34	43.86 / -41.04 / 4.82	Close color match
TSR	0.31	0.25	+0.06
NIR	0.55	0.46	+0.09
Endpoint Delta T	Lower-temperature side	Higher-temperature side	8.0°C

6. Temperature-Rise Testing and Heat-Reduction Performance

Temperature-rise data help translate optical performance into thermal-management behavior. In the four colors with available temperature curves - yellow, blue, brown, and green - the IR-1000 formulation reached a lower endpoint temperature. The endpoint differences were 5.0° C, 7.4° C, 5.2° C, and 8.0° C, respectively.

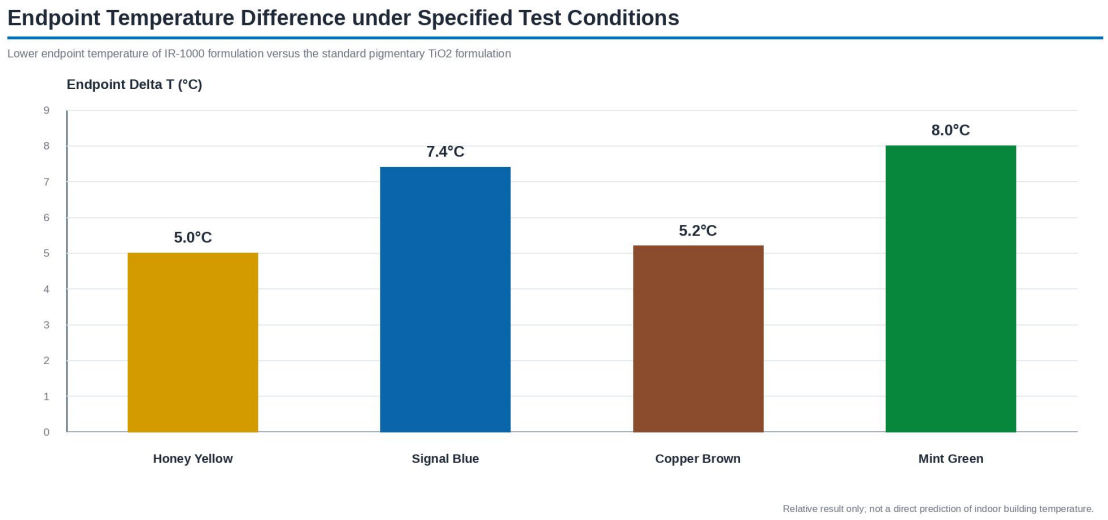

Figure 5 Endpoint Temperature Differences for the Yellow, Blue, Brown, and Green Systems

- Within the same color, higher NIR generally reduces heat absorption by the coating film. However, temperature difference is also affected by film thickness, substrate heat capacity, thermal conductivity, air movement, and irradiation intensity.

- The larger temperature differences in blue and green confirm the importance of building a near-infrared scattering framework in high-transmission colored pigment systems.
- Although grey showed the largest NIR improvement, the available test data did not include a temperature-rise curve from the same apparatus. A specific temperature difference should therefore not be extrapolated.

7. Supplementary Validation in a Blue PVC Coating

The test package also includes supplementary data for a blue PVC coating. This is not a primary exterior architectural coating formulation, but it provides a direct comparison between IR-1000 and standard TiO2 in a blue coating and can serve as a cross-application reference for flexible coatings and coated fabrics.

System	L* IR / Standard	TSR IR / Standard	Delta TSR	NIR IR / Standard	Delta NIR
Blue PVC coating	40.40 / 40.53	0.35 / 0.30	+0.05	0.62 / 0.51	+0.11

Supplementary Assessment
Validation in the non-architectural blue PVC coating also shows that 5% IR-1000 increased NIR from 0.51 to 0.62.

8. Customer Formulation Validation Recommendations

8.1 Application Priority by Color Type

Color Type	Recommended Strategy	Key Control Point
White / High lightness	Use a low IR-1000 dosage as a reinforcement for stable compliance.	Avoid high addition levels that reduce L* or increase cost.
Grey / Dark colors	Avoid carbon black and iron black; use compound black or low-NIR-absorption pigments with IR-1000.	Prioritize NIR results on black or low-reflectance substrates.
Yellow / Brown	Combine IR-1000 with low-absorption pigments such as iron yellow and iron red.	In the L* 40+ range, balance TSR and hue carefully.
Blue / Green	Control phthalocyanine pigment dosage and use IR-1000 to build NIR scattering.	Prevent high transmission from creating substrate-assisted reflection.

8.2 Recommended Customer Laboratory Validation

- First match the target color: adjust each formulation until L*a*b* values are close, then compare TSR and NIR.
- For each color, screen at least 0%, 3%, 5%, 8%, and 10% IR-1000. White systems may use a separate 1%, 2%, and 3% gradient.
- Prepare panels at the same film thickness, on the same substrate, and with the same curing time. White, black, and/or target substrates should be tested in parallel.
- Use temperature-rise testing only for screening and relative comparison. Final decisions should be based on standardized spectral testing and validation under the customer's target operating conditions.

9. Conclusions and Recommended Next-Step Validation

The available data show that the core value of IR-1000 in heat-reflective coatings is not to replace the whiteness and hiding functions of standard titanium dioxide. Its value is to increase near-infrared scattering in colored systems, reduce solar heat absorption, and produce observable temperature-rise differences. For customers, IR-1000 should be treated as a functional near-infrared reflective material for colored heat-reflective coatings, rather than as a one-for-one substitute for standard pigmentary TiO2.

Final Conclusion
IR-1000 provides greater value in medium-low-lightness and colored systems. It should be prioritized as a near-infrared reflective functional material in grey, blue, green, brown, and yellow heat-reflective coatings. In white systems, it is better suited to low-dose reinforcement for stable compliance and is not recommended at

high addition levels.

Recommended Next Steps

- Build three to five IR-1000 addition-level gradients around the customer's main target colors, with simultaneous color-difference adjustment.
- Validate on the target substrate and a low-reflectance substrate to exclude artificially high NIR caused by substrate-assisted reflection.
- Test the final candidate formulations for standardized TSR/NIR, L*a*b*, temperature rise, weatherability, water resistance, scrub resistance, and application properties.
- Optimize IR-1000 together with the resin, pigment package, PVC, and dry-film thickness rather than using a simple equal-mass replacement.

Appendix: Data Summary and Public-Use Definitions

Color / System	IR Addition	L*a*b* IR	L*a*b* Standard	TSR IR / Standard	NIR IR / Standard	Delta T
Traffic White RAL 9016	2%	96.04/-0.52/2.35	96.31/-0.89/1.26	0.83/0.82	0.83/0.80	Not tested
Tarpaulin Grey RAL 7010	10%	43.00/-1.35/1.58	43.86/-1.26/1.38	0.29/0.13	0.48/0.13	Not tested
Honey Yellow RAL 1005	8%	65.95/16.99/50.42	65.78/17.21/49.89	0.47/0.43	0.66/0.59	5.0°C
Signal Blue RAL 5005	5%	36.30/-7.02/-31.52	36.28/-7.22/-32.32	0.36/0.29	0.65/0.54	7.4°C
Copper Brown RAL 8004	7%	41.52/28.41/18.03	41.37/29.10/18.26	0.37/0.32	0.59/0.51	5.2°C
Mint Green RAL 6029	6%	44.00/-40.27/5.34	43.86/-41.04/4.82	0.31/0.25	0.55/0.46	8.0°C
Blue PVC coating	5%	40.40/-2.51/-33.59	40.53/-2.25/-34.15	0.35/0.30	0.62/0.51	Not tested

Data Source Notes

- Inter-China Chemical IR-1000 application test data: RAL 9016, RAL 7010, RAL 1005, RAL 5005, RAL 8004, RAL 6029, and blue PVC coating data.
- The data in this report were obtained from specific formulations, film thicknesses, substrates, and test conditions and are intended to illustrate formulation-development directions for IR-1000 in colored heat-reflective coatings.

Disclaimer: The data and information in this report are typical formulation results or results obtained under specific conditions. They are intended for customer technical communication, formulation screening, public reference, and information retrieval. They do not constitute a performance guarantee for a finished coating product and do not replace the TDS, SDS, applicable standards, or project validation reports. Before commercial use, validation must be completed in the target resin system, pigment package, substrate, film thickness, application process, and service conditions.