泛华化学 INTER-CHINA CHEMICAL

Technical White Paper

IR Series Infrared Reflective TiO2 for Solar Heat Management

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1. Executive Summary

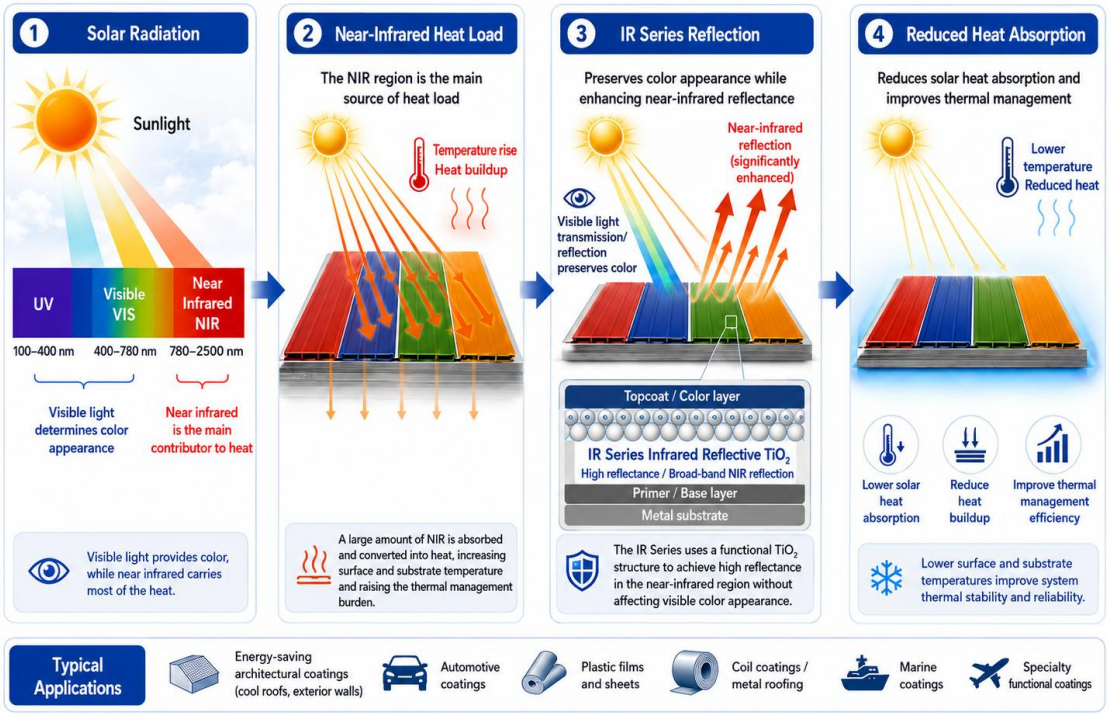
The IR Series is a family of functional titanium dioxide products designed to reduce solar heat absorption by enhancing near-infrared reflectance. It is suitable for heat-reflective systems such as energy-saving architectural coatings, automotive coatings, exterior plastic components, plastic films, coil coatings, metal roofing, flexible coatings and other applications requiring solar heat management.

In solar heat management, visual color is only the surface-level appearance. The core thermal performance of a material is determined by its reflectance in the near-infrared (NIR) region. The IR Series technology is designed to overcome the limitations of conventional formulations by significantly improving spectral-selective reflectance in the near-infrared range while maintaining practical processability and cost efficiency. By effectively blocking the heat-contributing portion of solar radiation, this mechanism reduces heat absorption on material surfaces and delivers excellent passive cooling performance.

IR-600 is designed for white, light-colored and medium-to-high lightness systems, with the objective of providing excellent solar reflectance performance.

IR-1000 focuses on colored systems and wide color-gamut applications. It offers broader substrate adaptability and can be used in coil coatings, metal coatings, container coatings, marine coatings, plastic films, coated fabrics, leather coatings and other specialty functional coating systems.

Figure 1 Technical Logic of the IR Series: Reducing Heat Absorption through Near-Infrared Reflection



IR Series infrared reflective technology: without changing color appearance, it significantly enhances near-infrared reflectance, effectively reduces heat absorption, and supports energy saving, cooling, and improved material performance.

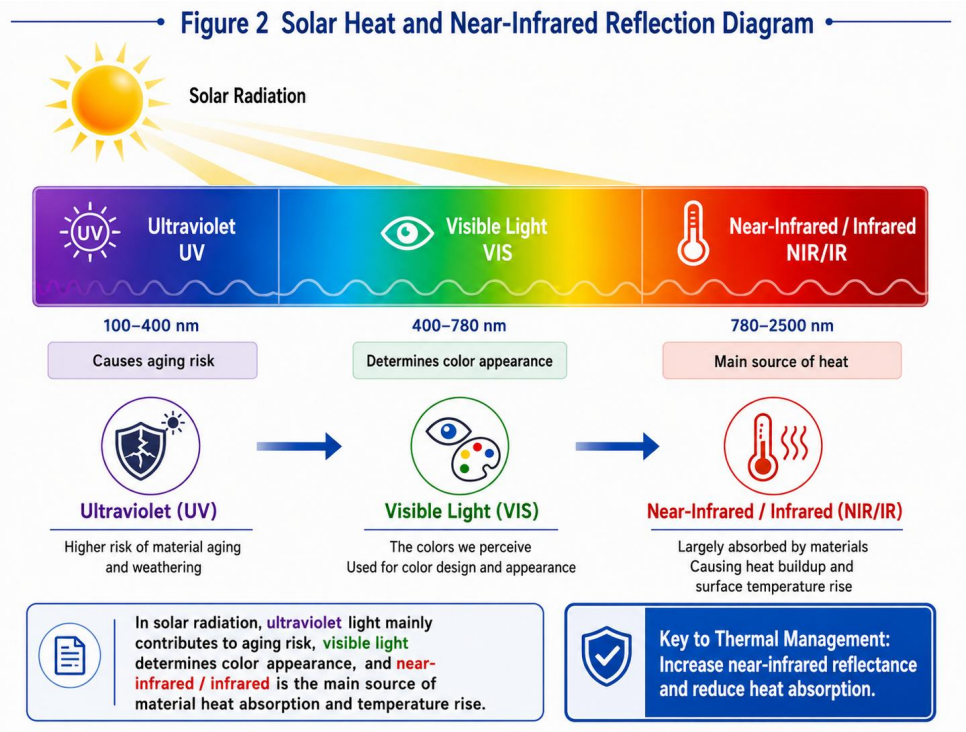
2. Solar Heat and Near-Infrared Reflection Principles

The solar radiation spectrum is mainly composed of three regions: ultraviolet light, visible light and infrared light. Ultraviolet light is a key factor that causes material aging and degradation. The visible light region determines the color perceived by the human eye, while infrared light, especially the near-infrared region, is the main source of solar heat transfer and material heat absorption.

Therefore, when evaluating the solar heat management performance of a material, it is not sufficient to rely only on color depth as a single visual indicator. Even if two coatings appear similar in color, differences in near-infrared reflectance can lead to significant differences in actual heat absorption efficiency and temperature rise. This optical characteristic has important engineering significance for applications such as exterior wall coatings, coil coatings, roofing materials, plastic films, coated fabrics and outdoor metal sheets.

The key optical indicators covered in this white paper include total solar reflectance (TSR), near-infrared reflectance (NIR), spectral reflectance curves, infrared transmittance, visible light transmittance, haze, and changes in surface or transmitted temperature.

Figure 2 Solar Heat and Near-Infrared Reflection Diagram



3. Limits of Conventional Pigment Systems

Conventional pigment systems are typically designed around color, hiding power, gloss, cost and processing performance, rather than being optimized for infrared reflectance. In white or very light-colored systems, conventional pigmentary titanium dioxide can already provide high visible-light reflectance. However, in medium-lightness, dark-colored or colored systems, when carbon black, standard color pigments or low-infrared-reflectance pigment combinations are used, the TSR and NIR values of the system often decrease significantly.

Although cool pigments can provide support in certain color spaces, they still have limitations in color selection range, cost control, system compatibility and process flexibility. The IR Series is not intended to replace all conventional pigments in a formulation. Instead, it functions as an infrared-reflective component, providing customers with a more practical solar heat management solution.

Therefore, the IR Series should be viewed as a functional material platform rather than a single product parameter. IR-600 and IR-1000 correspond to different formulation windows and application priorities.

4. Technical Logic of the IR Series

The IR Series is built on a functional rutile titanium dioxide platform. Its core value goes beyond the traditional dimensions of whiteness and hiding power, with the objective of significantly improving optical reflectance in the near-infrared region. This platform is supported by three core technical pillars:

1. Optical regulation mechanism: By optimizing near-infrared reflectance, the IR Series effectively suppresses solar heat absorption and enables efficient thermal management.
2. Crystal structure foundation: A highly stable rutile TiO_2 structure is used as the inorganic pigment base, ensuring the physicochemical stability of the material.
3. Surface modification process: Dense inorganic coating layers such as SiO_2 and Al_2O_3 are introduced for surface treatment, improving weather resistance, durability and compatibility among different components in complex formulation systems.

From an application perspective, the IR Series helps customers shift from traditional “color matching” toward a dual-function design model of “color + thermal management.” When end products need to balance appearance, substrate

temperature, user comfort, energy saving or thermal stability, this type of functional material demonstrates clear and significant technical value.

5. Product Positioning of the IR Series

5.1 IR-600: Medium-to-High Lightness Systems and Downstream Applications

IR-600 is a near-infrared reflective titanium dioxide material designed for medium-to-high lightness color systems. It is especially recommended for white or light-colored coating and plastic formulations. This product is intended to help customers achieve excellent total solar reflectance and near-infrared reflectance while simplifying formulation design.

Typical applications include white architectural coatings, light-colored exterior wall and roof coatings, light-colored plastic systems, and other high-lightness heat-reflective formulations. IR-600 uses dense SiO_2 and Al_2O_3 composite coating technology, which significantly improves weather resistance and long-term stability. It is particularly suitable for demanding outdoor applications such as exterior walls and roofs.

5.2 IR-1000: Colored Systems and Multi-Substrate Applications

IR-1000 is a high-performance near-infrared reflective material designed for colored coatings and wide color-gamut systems. It overcomes the limitation that conventional thermal insulation materials are mainly suitable for white systems, enabling excellent solar heat management while maintaining rich color expression.

IR-1000 supports infrared-reflective product design across a broad lightness range. It is widely applicable to architectural exterior walls and roofs, coil coatings, containers, marine coatings, plastic films and flexible coatings. It is an ideal choice for applications that require both energy-saving performance and high color requirements.

6. Technical Data of the Products

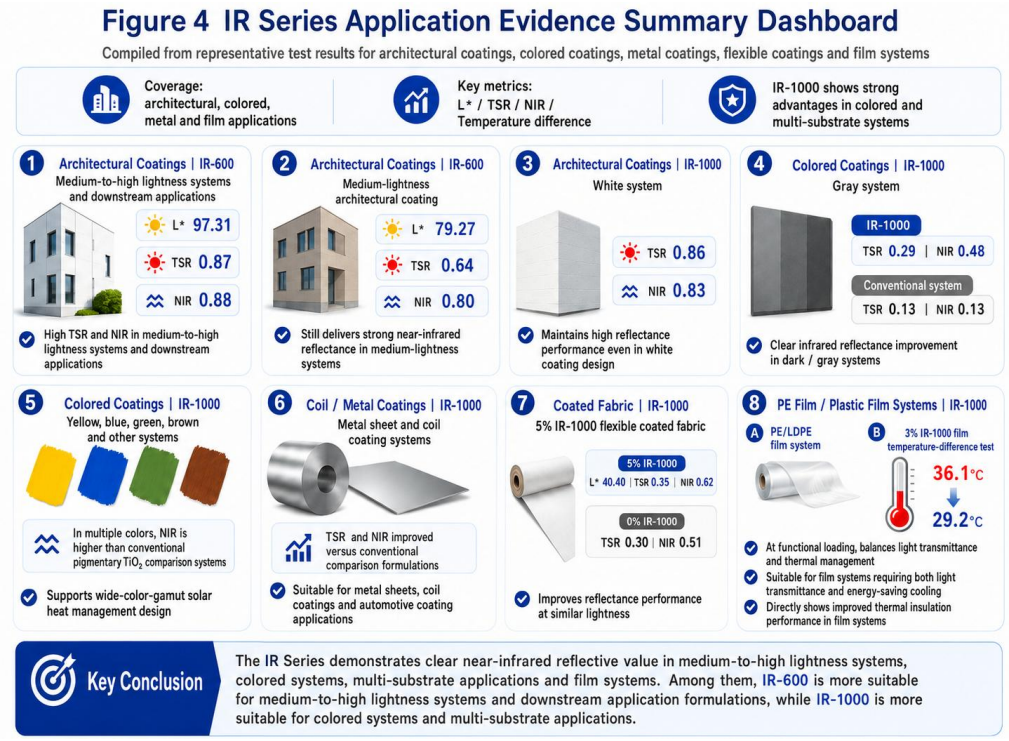
The following data are typical values. They should be used as technical guidance for formulation screening and not as final performance guarantees in the customer's complete system.

Property	IR-600	IR-1000
Product type	Near-infrared reflective TiO_2 for white / light-color systems	Near-infrared reflective TiO_2 for colored / wide color-gamut systems
TiO_2 content	⩾90%	⩾90%
Crystal form	Rutile	Rutile
Particle size, D50	800 nm	1000 nm
Refractive index	2.7	2.7
Inorganic treatment	Dense SiO_2 and Al_2O_3 coating	Dense SiO_2 and Al_2O_3 coating
Oil absorption	⩽19 g/100g	⩽19 g/100g
Specific gravity	4.0	4.0
Dispersion in oil	⩽12.5μm	⩽15μm
Recommended formulation window	White, light-color, medium-to-high lightness coating and plastic systems	Colored coatings, metal coatings, flexible coatings, plastic films and wide color-gamut systems

7. Reflectance Performance

The purpose of this section is to summarize the evidence portfolio, not to replace detailed application reports. Full spectral curves, formulation details, and test conditions should be provided in separate application reports by substrate and use case.

Application area	Product	System / substrate	Key result	Technical meaning
Architectural coating	IR-600	White architectural coating	L* 97.31, TSR 0.87, NIR 0.88	High TSR and NIR in white exterior coating systems
	IR-600	Medium-lightness architectural coating	L* 79.27, TSR 0.64, NIR 0.80	Strong NIR contribution in medium/high lightness systems
	IR-1000	White system	TSR 0.86, NIR 0.83	Comparable high-reflectance performance in white coating design
	IR-1000	Grey system	IR-1000: TSR 0.29, NIR 0.48; conventional: TSR 0.13, NIR 0.13	Significant improvement in dark/grey infrared reflectance
Colored coating	IR-1000	Yellow, blue, green, brown and other color systems	Higher NIR than pigmentary TiO2 comparison systems in multiple colors	Supports wide-color solar heat management
Coil / metal coating	IR-1000	Metal panels and coil coating systems	Improved TSR and NIR versus conventional comparison formulations	Potential fit for metal panels, coil coatings and automotive-type coatings
Coating cloth	IR-1000	Flexible coating cloth, 5% IR-1000	L* 40.40, TSR 0.35, NIR 0.62 vs 0% IR-1000: TSR 0.30, NIR 0.51	Improved reflectance while keeping similar lightness
PE film	IR-1000	PE/LDPE film system	Achieves a balance between light transmittance and thermal management at relatively low loading.	Useful for film systems where transparency and heat control must be balanced
Plastic film temperature test	IR-1000	Thin film with 3% IR-1000	Measured temperature reduced from 36.1 deg C to 29.2 deg C under reported test condition	Direct indication of improved thermal insulation behavior



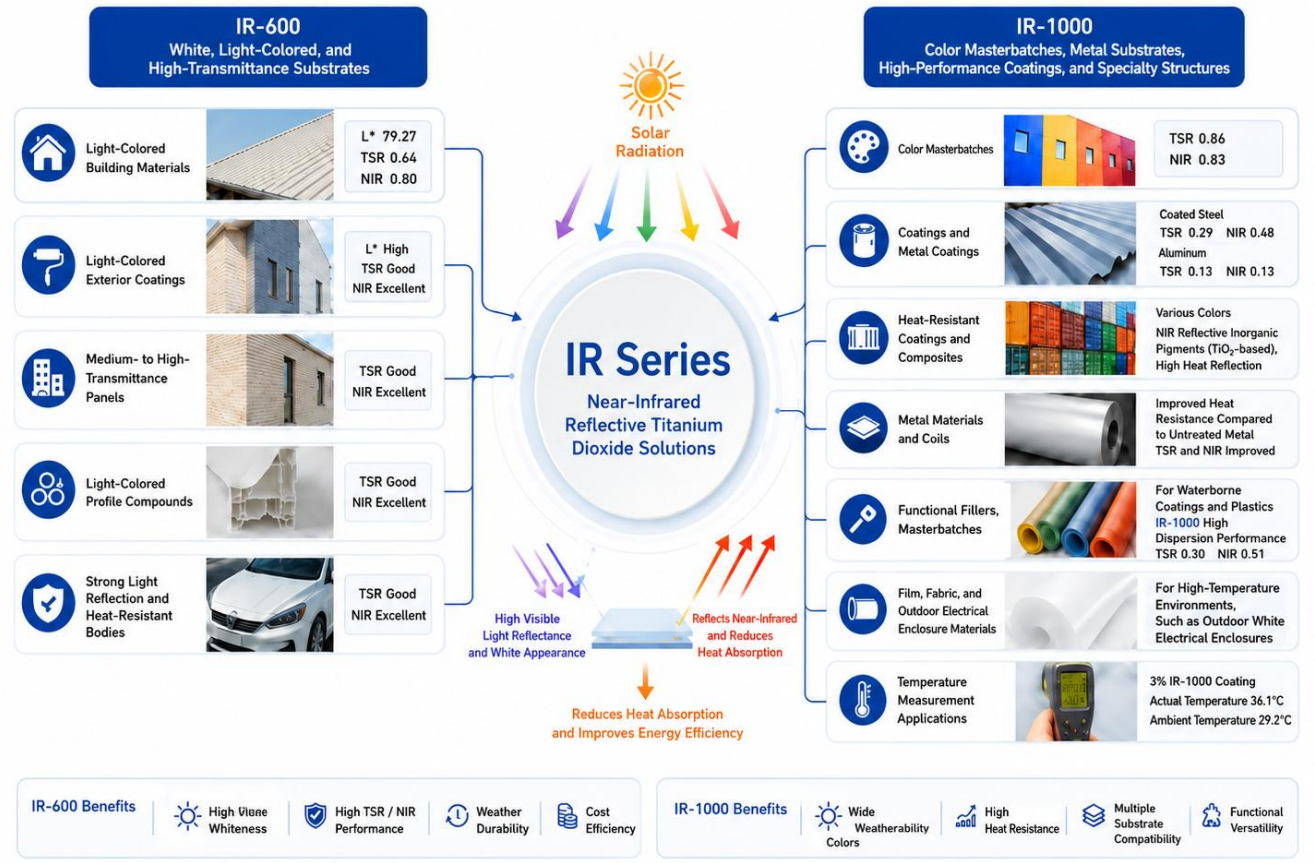
8. Application Areas

In terms of application selection, IR-600 is mainly targeted at medium-to-high lightness systems, while IR-1000 is more suitable for colored systems, metal coatings, flexible coatings, plastic films, specialty coatings and other multi-substrate applications.

IR-600 main focus	IR-1000 main focus
White architectural coatings	Colored architectural coatings
Light-colored roof coatings	Coil coatings and metal coatings
Light-colored exterior wall coatings	Container coatings and marine coatings
Medium and high lightness coating systems	Plastic films and exterior plastic panels
Light-colored plastic formulas	Flexible coatings, coating cloth and leather coatings
Systems prioritizing high lightness and durability	Clothes coatings and wide-color applications

Figure 5 IR Series Application Map

IR-600 features white, light-colored, and high-transmittance substrates; IR-1000 features color masterbatches, metal substrates, high-performance coatings, and specialty layered structures.



9. Validation Focus by Application Scenario

9.1 Coatings

In architectural and industrial coatings, IR Series products mainly provide an optical reflectance function. Recommended evaluation items include TSR, NIR, spectral reflectance curve, color difference, dispersibility, gloss, film appearance, weatherability, and compatibility with the resin and additive package.

9.2 Coil Coatings and Metal Coatings

For coil and metal coatings, thermal reflectance is only one part of the industrial requirement. Customers should also evaluate baking stability, adhesion, flexibility, T-bend, MEK rub resistance, salt spray resistance, gloss retention, weatherability, and coating appearance after processing. IR Series products should be validated inside the full customer formulation and curing process.

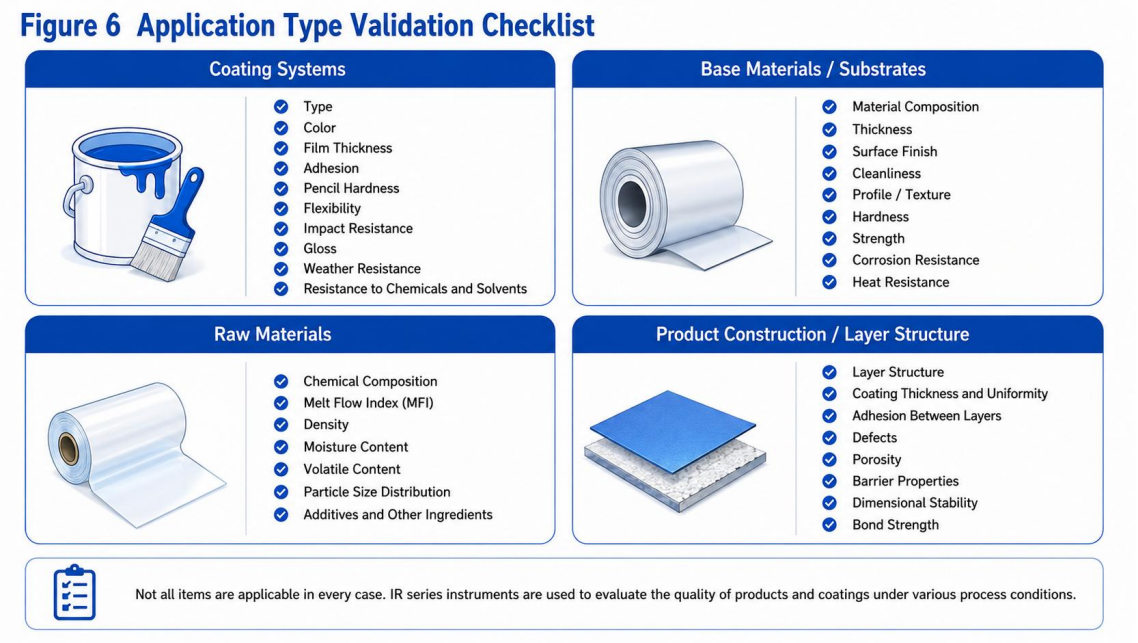
9.3 Plastic Films

For plastic films, the balance between optical appearance and thermal control is important. Customers should evaluate visible light transmittance, infrared transmittance or reflectance, haze, film thickness, dispersion quality, processing temperature stability, and mechanical properties after extrusion or film formation.

9.4 Flexible Coatings and Coated Fabrics

For coating cloth, leather coating, clothes coating, and other flexible materials, the target is usually a combination of NIR reflectance, surface or transmitted temperature control, flexibility, abrasion resistance, adhesion, hand feel, and durability under the intended service condition.

Figure 6 Application Type Validation Checklist



10. Functional Positioning and Validation Requirements of the IR Series

Existing data demonstrate that the IR Series can improve TSR, NIR reflectance, spectral reflectance, infrared transmission control, and temperature-rise control in specific coating and plastic systems.

However, final performance depends on multiple factors, including resin type, pigment package, PVC or CPVC level, substrate, film thickness, dispersion process, curing conditions, baking temperature, additive system, and the specific testing methods adopted by the customer.

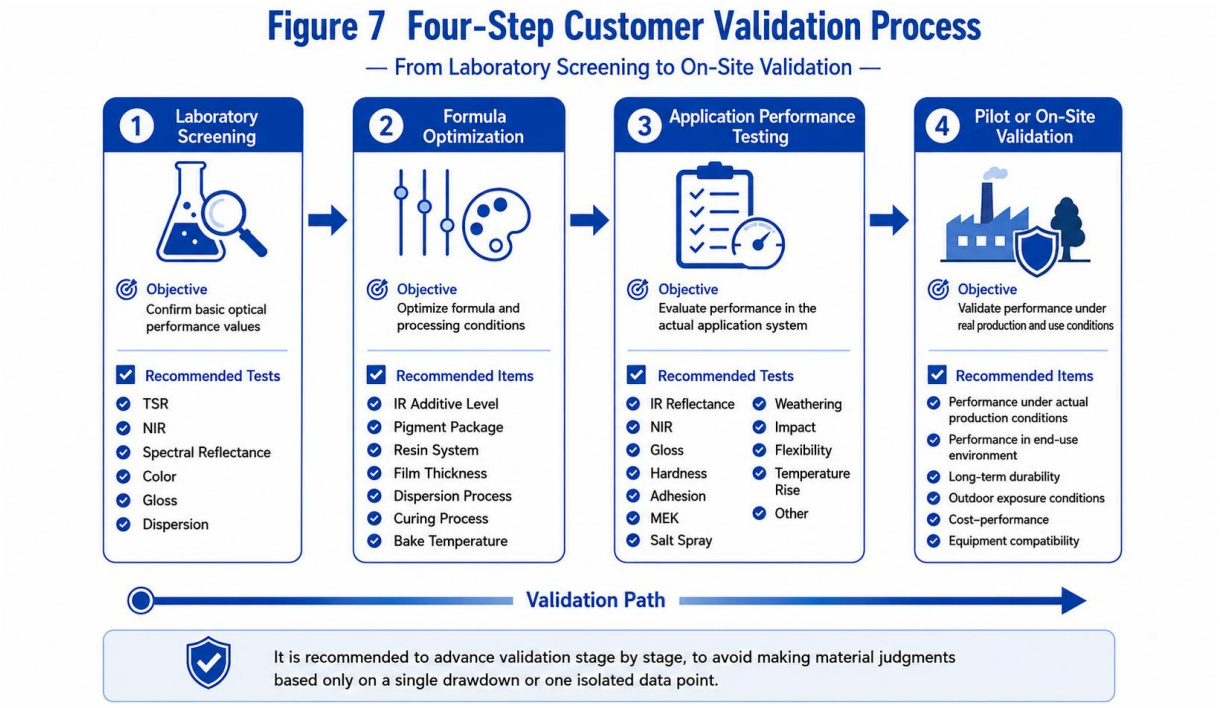
Therefore, the IR Series should be positioned as an infrared reflective functional material, rather than a universal performance additive. Its core function is to provide optical heat-management performance. Final mechanical properties, chemical resistance, weatherability, processability, and durability must be validated under the customer's actual formulation and production conditions.

Validation item	Why it matters
Dispersion stability	Determines optical uniformity, appearance and long-term formulation stability
Color matching and color difference	Confirms whether the IR formulation meets the target visible color
Gloss and surface appearance	Important for architectural, metal and specialty coatings
Adhesion and flexibility	Critical for coated metal, flexible substrates and field durability
T-bend and MEK rub resistance	Key industrial checks for coil coatings and baked systems
Salt spray resistance	Important for metal substrates and exterior exposure
Weatherability and UV aging	Confirms durability under sunlight and outdoor conditions
Thermal aging and processing stability	Important for plastic, film and baked coating systems
Film mechanical properties	Confirms that the additive does not compromise end-use performance

11. Recommended Customer Validation Path

A structured validation path helps customers avoid judging an infrared reflective material from a single drawdown or one isolated data point. The recommended workflow is four-stage validation.

Stage	Purpose	Suggested tests
Step 1: Lab screening	Confirm basic optical value	TSR, NIR, spectral reflectance curve, color, dispersion observation
Step 2: Formulation optimization	Balance reflectance, color and processability	IR dosage, pigment package, filler level, resin type, dispersing process, film thickness
Step 3: Application performance testing	Confirm industrial performance in the full system	Adhesion, flexibility, T-bend, MEK, salt spray, weatherability, haze, transmittance, thermal behavior
Step 4: Pilot or field validation	Verify performance under real production or exposure conditions	Actual substrate, actual curing or extrusion condition, outdoor exposure or simulated service condition



12. Conclusion

The IR Series provides a practical, adoptable material platform for solar heat management by improving near-infrared reflectance in coating and plastic systems. IR-600 is suitable for medium- to high-lightness systems, while IR-1000 extends infrared reflective design to a broader range of applications, including colored coatings, metal coatings, flexible coatings, and plastic films.

The existing evidence package shows that the IR Series can improve TSR, NIR reflectance, spectral reflectance, infrared transmission behavior, and temperature-rise control. For industrial applications, final conclusions should be based on the customer's actual resin system, pigment package, substrate, processing conditions, and validation standards.

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