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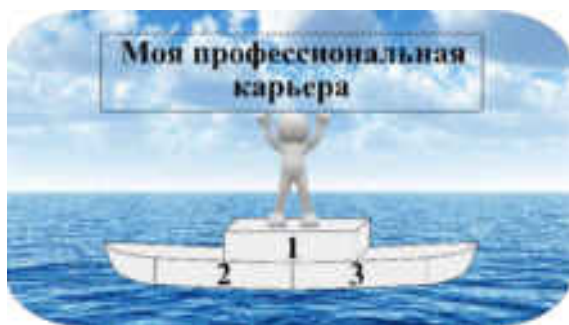


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**Международный научно-образовательный электронный журнал
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PIGMENTS FOR TERMOCHROMIC PAINTS»

Abstract

Thermochromic pigments are materials that change color in response to temperature variations, offering innovative applications in coatings, packaging, safety indicators, and decorative paints. This article explores the possibilities of obtaining thermochromic pigments for use in thermochromic paints, discussing different types of pigments, preparation methods, encapsulation techniques, and factors affecting stability and performance. Emphasis is placed on eco-friendly and cost-effective approaches to manufacture pigments suitable for commercial paint applications.

1. Introduction

Thermochromic paints are specialized coatings that visually respond to temperature changes. The core component of such paints is thermochromic pigment, which can reversibly or irreversibly change color when heated or cooled.

Applications include:

- Decorative coatings and art
- Temperature indicators for packaging and labels
- Safety markings for machinery or surfaces
- Smart coatings in buildings and vehicles

The development of thermochromic pigments involves careful selection of materials, encapsulation methods, and incorporation into paint matrices to ensure stability, responsiveness, and safety.

2. Types of Thermochromic Pigments

2.1 Liquid Crystal-Based Pigments

- Utilize cholesteric liquid crystals that reflect specific wavelengths depending on temperature
- Provide iridescent color shifts
- Sensitive to narrow temperature ranges
- Common in decorative applications

2.2 Leuco Dye-Based Pigments

- Contain leuco dyes, color developers, and solvents encapsulated in microcapsules
- Exhibit reversible color change with temperature
- Can be formulated for specific color-change thresholds
- Widely used in thermochromic paints and inks

2.3 Metal Complex-Based Pigments

- Contain metal-organic complexes that change electronic structure with temperature
- Less common due to cost and complexity
- High stability in extreme conditions

3. Methods for Obtaining Thermochromic Pigments

3.1 Microencapsulation of Leuco Dyes

- Core dye is encapsulated in a polymer shell using interfacial polymerization or coacervation
- Protects dyes from oxidation, moisture, and chemical degradation
- Ensures compatibility with paint formulations

3.2 Coating Liquid Crystals on Substrates

- Liquid crystals are mixed with stabilizers and applied to inert carriers
- Prevents aggregation and enhances thermal response
- Requires control of thickness and orientation for color accuracy

3.3 Sol-Gel Methods

- Encapsulation of dyes or liquid crystals in silica or polymeric matrices via sol-gel processes

- Produces thermochromic pigments with enhanced thermal stability
- Enables integration into solvent- or water-based paints

3.4 Nano-Encapsulation Techniques

- Uses nanocarriers to protect thermochromic compounds
- Improves stability, color intensity, and reversibility
- Suitable for high-performance and industrial applications

4. Factors Affecting Pigment Performance

4.1 Thermal Response Range

- Choice of core material defines the color-change temperature
- Tailoring response for intended application (e.g., human touch, environmental monitoring)

4.2 Stability

- Resistance to UV light, oxidation, and moisture is critical
- Proper encapsulation improves shelf life and paint compatibility

4.3 Compatibility with Paint Matrix

- Pigments must be chemically compatible with binders, solvents, and additives

- Ensures uniform dispersion, color retention, and proper viscosity

4.4 Particle Size

- Affects color intensity, transparency, and smoothness of paint
- Nano- or micro-scale pigments provide optimal optical effects

5. Applications of Thermochromic Pigments in Paints

- **Decorative Coatings:** Walls, furniture, automotive finishes
- **Safety Coatings:** Temperature indicators for pipes, machinery, or electronics

- **Smart Packaging:** Indicating storage or transport temperature
- **Educational and Novelty Products:** Thermochromic toys, gadgets, or promotional materials

Advantages:

- Visual temperature feedback without electronics
- Reversible and durable if properly encapsulated
- Potential for eco-friendly, solvent-free formulations

Limitations:

- Sensitivity to UV and harsh chemicals
 - Higher cost compared to conventional pigments
 - Limited lifetime under extreme environmental conditions
-

6. Future Perspectives

- Development of environmentally friendly, bio-based thermochromic compounds
 - Integration with energy-efficient coatings for smart buildings
 - Use of nanotechnology to enhance stability and color range
 - Optimization of production techniques for large-scale industrial manufacturing
-

7. Conclusion

Thermochromic pigments are essential components for the development of smart and responsive paints. By utilizing leuco dye-based, liquid crystal-based, or metal complex-based systems with modern encapsulation techniques, high-quality, stable, and visually appealing thermochromic paints can be produced. Innovative and eco-friendly production methods ensure wide applicability in decorative, safety, and functional coatings, offering both commercial and industrial potential.

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