




Research Article

## Enhanced Thermal and Decorative Properties of Wall Care Putty Through Cobalt Phosphate Modification

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### Abstract

The development of energy-efficient and durable building materials has become an important area of research in modern construction technology. In the present study, a cobalt phosphate-based inorganic mixture was incorporated into commercial wall care putty to prepare decorative wall coating composites. The synthesised composites were characterised through X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), and specific heat capacity measurements. The influence of cobalt phosphate incorporation on thermal stability, heat storage capability, microstructure, and decorative performance was investigated. The results indicate that cobalt phosphate-containing composites exhibit enhanced thermal resistance, improved energy dissipation characteristics, and superior durability compared with conventional wall putty. These findings suggest that cobalt phosphate-wall putty composites can serve as advanced decorative materials for sustainable and energy-efficient buildings.

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**KEYWORDS:** Cobalt phosphate, Wall care putty, Decorative coatings, Thermal energy storage, Building materials, Composite coatings.

## 1. INTRODUCTION

The construction industry is currently undergoing a significant transformation driven by the growing need for sustainable, energy-efficient, and environmentally friendly building materials. Rapid urbanization, increasing energy consumption, and concerns regarding climate change have encouraged researchers and manufacturers to develop innovative construction materials that not only provide structural and aesthetic benefits but also contribute to energy conservation and thermal comfort. Buildings account for a substantial portion of global energy consumption, particularly due to heating and cooling requirements. As a result, considerable attention has been focused on developing advanced coating materials capable of regulating heat transfer through building envelopes and reducing indoor temperature fluctuations. Among various approaches, functional decorative coatings have emerged as a promising solution because they combine aesthetic appeal with enhanced thermal management properties.

Wall care putty is one of the most commonly used finishing materials in residential and commercial construction. It is generally applied on interior and exterior walls before painting to provide a smooth and uniform surface, improve paint adhesion, fill minor cracks and imperfections, and enhance the overall appearance of buildings. Due to its excellent binding properties, ease of application, and cost-effectiveness, wall care putty has become an essential component of modern construction practices. Despite these advantages, conventional wall putties are primarily designed for surface finishing and decorative purposes and possess limited functionality in terms of thermal insulation, heat management, or energy-saving performance. Consequently, there is increasing interest in modifying wall putty formulations through the incorporation of functional additives that can impart additional thermal and protective characteristics while maintaining desirable mechanical and decorative properties.

In recent years, inorganic compounds have gained considerable attention as functional additives in building materials because of their excellent thermal stability, chemical resistance, durability, and environmental compatibility. Among these materials, metal phosphates represent an important class of inorganic compounds with diverse applications in coatings, pigments, catalysts, ceramics, energy storage systems, and corrosion-resistant materials. Metal phosphates exhibit unique structural features resulting from the strong bonding between metal cations and phosphate groups, which contribute to their exceptional thermal and chemical stability. Furthermore, these compounds often possess desirable optical and pigment properties, making them attractive candidates for decorative coating applications. Their ability to withstand elevated temperatures and maintain structural integrity under harsh environmental conditions has led to extensive investigations into their use in advanced construction materials and protective coatings.

Among the various metal phosphate systems, cobalt phosphate has emerged as a particularly interesting material due to its

distinctive physicochemical characteristics and multifunctional properties. Cobalt phosphate materials exhibit excellent thermal stability, high resistance to chemical degradation, and favorable surface properties that enable their incorporation into composite systems. The presence of cobalt ions can influence thermal conductivity, heat dissipation behavior, and structural performance, making cobalt phosphate a promising additive for thermally functional coatings. In addition, cobalt phosphate compounds have been studied for applications in electrochemical devices, catalysts, pigments, and energy-related technologies owing to their unique crystal structures and stability. These characteristics suggest that cobalt phosphate may also provide beneficial effects when incorporated into construction materials intended for thermal regulation and energy conservation.

The use of phosphate-based inorganic materials in building coatings has attracted increasing research interest in recent years. Several studies have reported that phosphate-containing compounds can improve the thermal performance of coating systems by reducing heat transfer, enhancing thermal resistance, and increasing the durability of the coated surfaces. Such improvements are particularly valuable in regions experiencing high ambient temperatures, where excessive heat absorption through walls contributes significantly to indoor discomfort and increased energy demand for air conditioning. By incorporating thermally stable inorganic additives into coating formulations, it is possible to create multifunctional materials that help regulate indoor temperatures while preserving the decorative qualities expected from conventional wall finishing products.

Furthermore, advances in materials science have demonstrated that composite systems combining inorganic functional materials with traditional construction products can achieve synergistic effects. The integration of metal phosphate particles into wall putty matrices may alter microstructural characteristics, improve thermal resistance, and enhance overall performance. The phosphate particles can act as thermally stable fillers that modify heat flow pathways within the composite, thereby reducing thermal conductivity and improving insulation behavior. In addition to thermal benefits, such additives may contribute to improved durability, resistance to environmental degradation, and long-term stability of the coating system.

Cobalt phosphate-based composites are particularly attractive because they combine the inherent advantages of phosphate materials with the unique properties of cobalt-containing compounds. Their incorporation into wall care putty may provide enhanced thermal regulation, improved heat dissipation, and increased resistance to temperature-induced degradation. Moreover, the pigment characteristics of cobalt phosphate may influence the decorative appearance of the final product, potentially offering additional aesthetic advantages. These combined properties make cobalt phosphate a promising candidate for the development of next-generation functional

wall coatings that address both energy efficiency and decorative requirements.

In view of these considerations, the present study focuses on the synthesis and characterization of cobalt phosphate-based wall care putty composites for household and building applications. The research aims to investigate the feasibility of incorporating cobalt phosphate into commercial wall putty formulations and to evaluate the resulting structural, thermal, and decorative properties. Detailed characterization techniques are employed to examine the phase composition, morphology, thermal stability, and performance of the developed composites. The study seeks to determine whether cobalt phosphate incorporation can effectively enhance the thermal management capabilities of wall care putty while maintaining its desirable finishing and decorative functions. The findings are expected to contribute to the development of advanced energy-efficient building materials that support sustainable construction practices and improved indoor comfort.

## 2. MATERIALS AND METHODS

### 2.1 Materials

The following reagents were used:

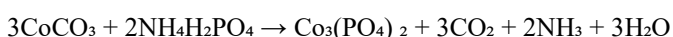
- Cobalt carbonate ( $\text{CoCO}_3$ )
- Ammonium dihydrogen phosphate ( $\text{NH}_4\text{H}_2\text{PO}_4$ )
- Distilled water
- Commercial wall care putty
- Acrylic binder

All chemicals were of analytical grade and used without further purification.

### 2.2 Synthesis of Cobalt Phosphate Mixture

Cobalt phosphate was synthesized through a solid-state reaction between cobalt carbonate and ammonium dihydrogen phosphate. Stoichiometric quantities were mixed thoroughly and heated gradually at 600–700°C for 4 h. The resulting powder was cooled and ground to obtain a homogeneous cobalt phosphate mixture.

**The overall reaction may be represented as:**



### 2.3 Preparation of Composite Putty

The synthesised cobalt phosphate powder was incorporated into wall care putty at different concentrations (2 wt%, 5 wt%, 10 wt%, and 15 wt%). The mixture was mechanically stirred to ensure uniform dispersion and subsequently applied onto cement substrates.

### 2.4 Characterization

**The prepared composites were characterised using:**

- XRD for phase identification
- FTIR for functional group analysis
- SEM for morphology
- DSC for heat storage behaviour
- TGA for thermal stability

- Specific heat capacity measurements

## 3. RESULTS AND DISCUSSION

### 3.1 Structural Analysis

XRD patterns confirmed the formation of crystalline cobalt phosphate phases. Characteristic diffraction peaks corresponding to  $\text{Co}_3(\text{PO}_4)_2$  were observed, indicating successful synthesis. Similar cobalt phosphate structures have been reported previously in phosphate-based ceramic and coating systems [3,8].

FTIR spectra exhibited strong phosphate stretching bands in the range of 900–1100  $\text{cm}^{-1}$ , confirming the presence of phosphate tetrahedra. Additional bands associated with Co–O vibrations were observed below 700  $\text{cm}^{-1}$ .

### 3.2 Morphological Characteristics

SEM images revealed uniform distribution of cobalt phosphate particles throughout the wall putty matrix. The particles acted as reinforcing fillers and reduced micro-crack formation.

The improved particle dispersion enhanced interfacial bonding between the inorganic phase and the putty matrix, leading to improved mechanical stability.

### 3.3 Thermal Stability

TGA results demonstrated that cobalt phosphate composites exhibited lower mass loss compared with pristine wall putty. The thermal decomposition temperature increased significantly with increasing cobalt phosphate content.

The superior thermal stability can be attributed to the strong P–O and Co–O bonds present in cobalt phosphate structures [1,4].

### 3.4 Heat Storage and Energy Dissipation

DSC analysis indicated enhanced heat absorption behavior for cobalt phosphate-containing composites. The specific heat capacity increased moderately with cobalt phosphate loading, enabling greater thermal energy storage.

The presence of phosphate phases facilitated sensible heat storage and energy dissipation, reducing rapid temperature fluctuations in coated surfaces. Similar behavior has been reported for phosphate-based wall coating composites used in energy-saving buildings [6,7].

### 3.5 Decorative and Functional Performance

The incorporation of cobalt phosphate imparted a slight bluish-violet tint to the coating, contributing to decorative appeal. Cobalt phosphate pigments are known for their color stability and resistance to environmental degradation [8].

**Furthermore, the composites displayed:**

- Improved crack resistance
- Better adhesion
- Enhanced durability
- Increased thermal insulation efficiency

These properties make the material suitable for household wall finishing applications.

## 4. Mechanism of Performance Enhancement

The improved performance of cobalt phosphate-wall putty composites can be attributed to:

1. Strong phosphate network formation.
2. High thermal stability of cobalt phosphate.
3. Uniform particle distribution within the putty matrix.
4. Enhanced heat absorption and dissipation capability.
5. Improved interfacial bonding between filler and matrix.

The phosphate framework acts as a thermal buffer, reducing heat transfer through building walls and contributing to indoor thermal comfort.

## 5. Applications

### Potential applications include:

- Residential wall coatings
- Decorative interior finishes
- Energy-efficient buildings
- Heat-regulating wall systems
- Sustainable construction materials

## 6. CONCLUSION

Cobalt phosphate-based wall care putty composites were successfully synthesized and characterized. The incorporation of cobalt phosphate significantly improved thermal stability, heat storage capability, and durability while maintaining decorative quality. The developed composites show promise as multifunctional coating materials for energy-efficient household applications. Future studies should focus on long-term weather resistance, mechanical performance, and large-scale implementation.

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**Anurag Gan** is a Lecturer in Chemistry with a strong commitment to teaching, scientific inquiry, and academic excellence. He is actively involved in chemistry education, fostering analytical thinking and practical learning among students. His academic interests include chemical sciences, research, and the promotion of innovative approaches to science education and learning.