New Visualizing Agents for Developing Latent Fingerprints on Various Porous and Non-Porous Surfaces Using Different Construction Materials

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ABSTRACT

Background: The fingerprint development technique is one of the oldest and most widely used methods in forensic science for identifying perpetrators. Among the various techniques, powder dusting is a popular method for detecting latent fingerprints. Currently, there is a pressing need to identify a cost-effective, non-toxic, and easily accessible powder that can serve as an alternative to the expensive and hazardous powders commonly used in forensic investigations.

Materials and Method: In the present study, latent fingerprints were collected on various porous and non-porous surfaces using samples from different individuals. Grey Cement powder (Ultratech brand) and White Plaster of Paris (POP) powder were applied to 20 surfaces using the powder dusting method, with excess powder removed by a fingerprint brush. Both powders were sourced from local suppliers in Jaipur District, Rajasthan.

The surfaces included non-porous materials (e.g., Glass, Soft Plastic, Aluminium Foil, Stainless Steel) and porous materials (e.g., Paper, Cardboard, POP Cast, Bone, Fabric). Fingerprint clarity was rated on a 1-3 scale: 1 for unclear prints, 2 for visible patterns, and 3 for clear ridge details.

Result and Conclusion: The Grey Cement and Plaster of Paris powders used in this study were highly effective in developing clear, well-defined latent fingerprints on various non-porous surfaces, including glass, metal, and plastic. Their consistent performance across different materials highlights their reliability and versatility, making them valuable tools for forensic investigators in obtaining high-quality fingerprint evidence.

Keywords: Latent Fingerprints, Porous, Non-Porous Surfaces, Forensic Science.

INTRODUCTION

Forensic identification relies heavily on being able to see latent fingerprints, but traditional fingerprint powders may not be easy to get or cheap to use in field-based or resource-limited investigation settings. Fingerprint evidence is more reliable because it can last a long time in tough conditions. Previous studies have shown that latent fingerprints can be taken from surfaces that have been exposed to environmental pollutants, extreme heat, or high humidity. The success of this restorative process really depends on carefully choosing the right developmental methods to improve ridge characteristics. [1] For example, adding silica nanoparticle powders to herbal alternatives has shown a

lot of promise in making surfaces with different colors or luminescence clearer and more contrasty, all while keeping DNA safe and lowering toxicity. [2] It has always been very hard to get latent fingerprints off of surfaces with uneven textures, like metals, thermally reactive substrates, or porous fabrics. However, new advances in forensic science have made it much more likely that latent prints will be found. There are now many ways to make fingerprints on surfaces that were once thought to be too rough to see. These include cyanoacrylate vaporization, lighting with different light sources, and nanoparticle-based powders. [3] The term "cement" can refer to both traditional mineral-based compounds like Ordinary Portland Cement and polymer-modified formulations that use organic

binders to make them more flexible, sticky, and resistant to stress. These qualities make cement powders great for making latent prints on rough or absorbent surfaces, where moisture-reactive properties may help show the ridge pattern. [4–5] Grey Portland cement is made up mostly of calcium silicates, aluminates, and ferrites. It has unique mechanical properties that can affect how well fingerprint analysis works. It has more iron and manganese than white cement, which changes how it hydrates and how well it works in forensic settings. [6] Grey cement powder is a great choice for making latent fingerprints because it is easy to find, cheap, and has particles that are all the same size. This is especially true when normal forensic chemicals are hard to get to.

Table 1. Composition of Grey Cement Powder (6)

Composition	[%] by Weight
C_3S (Tricalcium silicate, $3CaO \cdot SiO_2$)	50–60
C_2S (Dicalcium silicate, $2CaO \cdot SiO_2$)	15–25
C_3A (Tricalcium aluminate, $3CaO \cdot Al_2O_3$)	7–12
C_4AF (Tetracalcium aluminoferrite, $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$)	6–10
MgO, SO_3, alkalis, and other minor oxides	≤ 5

White plaster of Paris (POP) powder, which comes from the thermal decomposition of gypsum ($CaSO_4 \cdot 2H_2O$), has also been widely used in forensic science because it can be easily shaped and holds its shape well. This is especially true for developing latent impressions like fingerprints, tool marks, and shoe prints. It is a better way to keep evidence because it is smooth and can

pick up tiny ridge features. When POP is rehydrated, it goes through an exothermic hydration process that makes it harden quickly. This makes it good for careful work in finding evidence. [7] POP is a good replacement for regular powders when making imprints on porous and textured surfaces, especially when there aren't any special reagents available.

Table 2. Composition of White Plaster of Paris (POP) Powder (7)

Compound	Chemical Formula	% by Weight
Calcium sulfate hemihydrate	$CaSO_4 \cdot \frac{1}{2}H_2O$	92–95%
Residual anhydrous calcium sulfate	$CaSO_4$	3–5%
Trace impurities (silica, alumina, iron oxides)	SiO_2, Al_2O_3, Fe_2O_3	≤ 2%

The primary objective of the research is to identify alternative resources that may serve as substitutes for conventional fingerprint powders. The study will examine the efficacy of grey cement and POP powders in developing latent fingerprints on various porous and non-porous surfaces. The research elucidates the behaviour of various

materials, facilitating the development of more adaptable and cost-effective methods for detecting latent fingerprints in diverse forensic contexts. Their utilization demonstrates the adaptability of forensic specialists in ensuring the security and retrieval of biometric evidence, particularly

in the absence of conventional powders or reagents.

MATERIALS & METHODS

In the present study, 20 distinct surfaces were examined and categorized based on their absorption properties into non-porous and porous groups. Non-porous surfaces included glass, soft plastic file, laminated wood, aluminum foil, stainless steel, ceramic, latex, painted wall, glossy paper, and hard plastic—materials typically characterized by limited absorption and a need for specialized development strategies. Porous surfaces comprised paper, cardboard, POP cast, bone, Styrofoam, raw wood, thermocol, fabric, face mask, and artificial leather, each known for its ability to absorb fingerprint residue and interact variably with powdered agents. This classification facilitated a robust and controlled evaluation of substrate-powder interactions, contributing to a comparative understanding of fingerprint development performance across diverse surface types. Two commonly available materials—grey cement powder (Ultratech Cement, widely used in construction) and white plaster of Paris (POP)—were selected for fingerprint visualization and procured from local suppliers in the Jaipur District of Rajasthan. latent fingerprints were collected from a diverse group of individuals to ensure variability in ridge pattern characteristics and enhance the generalizability of findings. The powder dusting technique was employed, wherein each powder was applied individually to the surface using a soft fingerprint brush to ensure even distribution across the ridge patterns. Adhering to established forensic protocols, surplus powder was meticulously removed to enhance contrast and clarity while preserving ridge detail.[8] Their development clarity score was assigned by the Fingerprint grading scale system, as specified in Table 2. The particular features and descriptions may vary depending on the institution or organization utilizing the system. The primary objective is to employ a standardized method to evaluate the clarity and quality of the fingerprints. Superior grades indicate enhanced quality and more distinct ridge characteristics. This method aids forensic investigations and criminal prosecutions by assessing the reliability and precision of fingerprint evidence [9].

RESULT

The powder-developing method is a physical process employed for fingerprint development. This physical technique relies on the adhesion properties of the powder and its interaction with the perspiration composition of the fingerprint. The chemical composition of sweat includes fatty acids and oil triglycerides, with water and several other substances constituting a significant portion. Porous and non-porous surfaces possess sticky properties. The results, as presented in Table 2 and Figures 1-24, indicate that both Grey Cement and POP powders exhibit substantial capabilities for fingerprint development on non-porous surfaces. Notably, the majority of samples analyzed achieved scores of 2 or 3 on a standardized clarity scale ranging from 1 to 3, suggesting a high level of effectiveness in revealing latent prints. Ridge details were well-defined, with high contrast observed on surfaces such as aluminium foil, laminated wood, glass, stainless steel, and hard plastic. These results were consistent across multiple individual prints and were assigned scores corresponding to level 3 visibility according to the standardized rubric. Similarly, Table 3 and Figures 21-24 indicated that fingerprint development was more variable for porous surfaces. Among the ten porous substrates examined, identifiable ridge detail was recorded primarily on white and black paper and POP cast models, which exhibited comparatively lower porosity. The remaining substrates—including bone, Styrofoam, cardboard, and fabric—yielded weak or indistinct impressions, reflecting the inherent challenges of powder adherence and residue retention on highly absorbent materials. Further a non-parametric Mann–Whitney U

test was employed to investigate the variations in the clarity of fingerprints observed across both surfaces. Result indicated in table 4 indicated a significantly higher mean ranks for porous surfaces in favour of Grey Cement (Mean Rank = 15.4) compared to POP (Mean Rank = 5.6), indicating greater powder interaction and adhesion. Grey Cement achieved a U value of 1.000 (Z = -3.949, p < 0.001), and POP returned a U value of 0.500 (Z = -4.069, p < 0.001), demonstrating statistically significant differences in performance. Overall, both powders exhibited latent fingerprint visualization capability; however, Grey Cement consistently outperformed POP in terms of ridge clarity and substrate adaptability, particularly on porous surfaces. These findings underscore the relevance of material porosity in fingerprint development and suggest that Grey Cement may serve as an effective alternative forensic reagent in field-based scenarios involving challenging substrates.

Table 3: Developed latent fingerprint visibility on various non-porous surfaces on scale

Sr. No	Type of Surface	Powder			
	Non-Porous	Grey Cement		Plaster of Paris	
		Developed /Not Developed	Visibility on Scale 1 - 3	Developed /Not Developed	Visibility on Scale 1 - 3
1	Glass	Developed	3	Developed	3
2	Soft Plastic File	Developed	3	Developed	3
3	Laminated Wood	Developed	3	Developed	3
4	Aluminium Foil	Developed	3	Developed	3
5	Stainless Steel	Developed	3	Developed	3
6	Ceramic	Developed	3	Developed	2
7	Latex	Developed	3	Developed	3
8	Painted wall	Developed	2	Developed	3
9	Glossy Paper	Developed	3	Developed	3
10	Hard Plastic	Developed	3	Developed	3

Table 3: Developed latent fingerprint visibility on various porous surfaces on scale 1-3

Sr. No	Type of Surface	Powder			
	Porous	Grey Cement		Plaster of Paris	
		Developed /Not Developed	Visibility on Scale 1 - 3	Developed /Not Developed	Visibility on Scale 1 - 3
1	Paper	Developed	2	Developed	2
2	Cardboard	Developed	1	Developed	1
3	POP Cast	Developed	2	Not Developed	0
4	Bone	Not Developed	0	Not Developed	0
5	Styrofoam	Developed	1	Not Developed	0
6	Raw Wood	Not Developed	0	Not Developed	0
7	Thermocol	Not Developed	0	Not Developed	0
8	Fabric	Not Developed	0	Not Developed	0
9	Mask	Not Developed	0	Not Developed	0
10	Artificial Leather	Not Developed	0	Not Developed	0

Table 4: Mann–Whitney U Test Results for Fingerprint Clarity on Porous and Non-Porous Surfaces Comparison of Fingerprint Scores by Surfaces and Powder Types

Powder Type	Surface Type	N	Mean Rank	Sum of Ranks	Mann–Whitney U	Z	p-value (2-tailed)
Grey Cement	Porous	10	15.40	154.00	1.000	-3.949	< 0.001
	Non-Porous	10	5.60	56.00			
Plaster of Paris (POP)	Porous	10	15.45	154.50	0.500	-4.069	< 0.001
	Non-Porous	10	5.55	55.50			

Figures 1-20 showing development of latent fingerprints on various non-porous surfaces using POP and cement powder.

Fig.1 Latent fingerprint developed on a glass surface using POP (Plaster of Paris) powder.

Fig.2 Latent fingerprint developed on a glass surface using Cement powder.

Fig.3 Latent fingerprint developed on soft plastic file using POP powder.

Fig.4 Latent fingerprint developed on soft plastic file using cement powder.

Fig.5 Latent fingerprint developed on Laminated Wood using POP powder.

Fig.6 Latent fingerprint developed on Laminated Wood using cement powder.

Fig.7 Latent fingerprint developed on aluminium foil using POP powder.

Fig.8 Latent fingerprint developed on aluminium foil using cement powder.
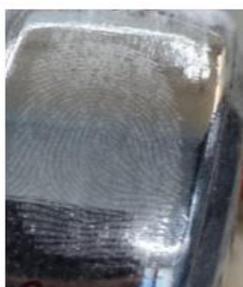
Fig.9 Latent fingerprint developed on stainless steel (lock) using POP powder.

Fig.10 Latent fingerprint developed on stainless steel (lock) using cement powder.

Fig.11 Latent fingerprint developed on ceramic pot using POP powder.

Fig.12 Latent fingerprint developed on ceramic pot using cement powder.

Fig.13 Latent fingerprint developed on latex using POP powder.

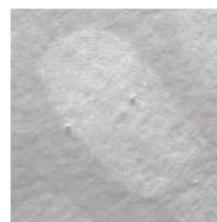Fig.14 Latent fingerprint developed on latex using cement powder.

Fig.15 Latent fingerprint developed on painted wall using POP powder.

Fig.16 Latent fingerprint developed on painted wall using cement powder.

Fig.17 Latent fingerprint developed on glossy paper using POP powder.

Fig.18 Latent fingerprint developed on glossy paper using cement powder.

Fig.19 Latent fingerprint developed on hard plastic (switch board) using POP powder.

Fig.20 Latent fingerprint developed on hard plastic (switch board) using cement powder.

Figures 21-24 showing development of latent fingerprints on a few porous surfaces using POP and cement powder.

Fig.21 Latent fingerprint developed on black chart sheet using POP powder.

Fig.22 Latent fingerprint developed on A4 white sheet using cement powder.

Fig.23 Latent fingerprint located styrofoam using cement powder.

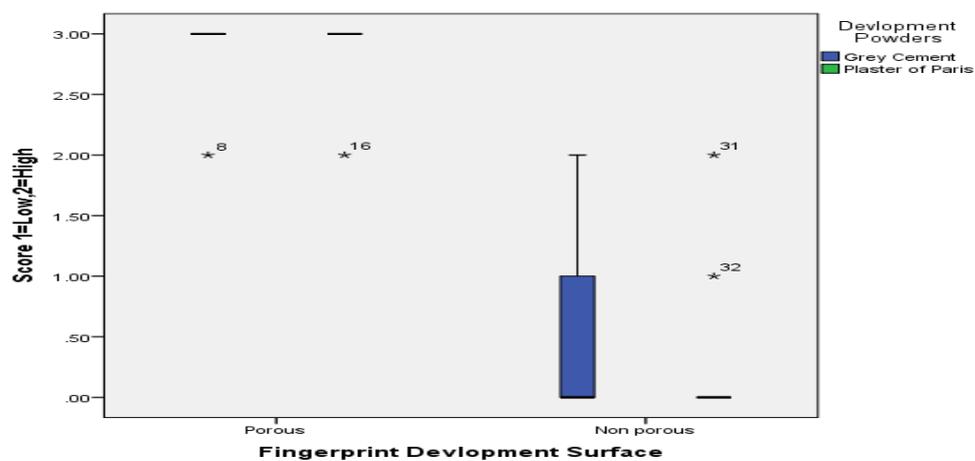Fig.24 Latent fingerprint slightly showing ridges on POP cast using cement powder.

Figure 25. Box Plot Comparison of Latent Fingerprint Development Scores on Porous and Non-Porous Surfaces Using Grey Cement and POP Powders

DISCUSSION

In forensic research, a lot of attention has been paid to how well powder-developing procedures work for showing fingerprints, especially how fingerprint residues react with different powders. This study shows how well Grey Cement and POP powders can bring up latent fingerprints. It also shows that they work quite differently on porous and non-porous surfaces. The results show that both Grey Cement and POP powders are quite good at showing fingerprints on non-porous surfaces, getting scores of 2 or 3 on a conventional clarity scale (see Table 3). This is supported by the prior research that shows that fingerprint residues stick better to non-porous surfaces, which makes the powder stick better. The strong contrast and clear ridge details seen on surfaces like aluminum foil, laminated wood, glass, stainless steel, and hard plastic back up the idea that non-porous surfaces are the best places for fingerprints to form. The results for porous surfaces, on the other hand, were far more inconsistent. Ridge detail was mostly discovered on white and black paper and POP cast models, which have lower porosity. This matches what other researchers have found: porous materials tend to soak up fingerprint residue, making it harder for the powder to stick and making the impressions weaker. Bone, Styrofoam, cardboard, and fabric are examples of extremely absorbent materials that make powder techniques less useful in forensic applications [10]. The Mann–Whitney U test indicated that Grey Cement exhibited a significantly higher mean rank than POP on porous surfaces (U value of 1.000, Z = -3.949, p < 0.001). This indicates that Grey Cement has enhanced adhesion and interaction with surfaces. This study determined that Grey Cement outperforms other forensic reagents, particularly in environments with resilient surfaces. This study's findings demonstrate the significance of substrate porosity in fingerprint formation. The results demonstrate the significance of material porosity in fingerprint development and

suggest that Grey Cement may serve as an effective alternative forensic reagent for challenging surfaces. Grey Cement often outperforms POP, suggesting it may be the superior choice for forensic applications, especially on porous substrates.

CONCLUSION

The findings support the usefulness of POP powders and Grey Cement in latent fingerprint development, especially in forensic settings with limited resources. Alternative solutions that preserve the integrity of the evidence are often required when forensic investigations face restricted access to specialized fingerprint development powders. Due to their widespread availability as building materials, grey cement and POP provide forensic professionals with affordable options for recovering latent prints.

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