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New Restoration Reagent for Development of Erased Serial Number on Copper Metal Surface

Nalini Shankar[a], Lav Kesharwani[a*], Munish Kumar Mishra[a], Amit Chattree[b], Rajeev Kumar[c], Rashmi Sharma[c], A. K. Gupta[a]

[a]*Department of Forensic Science, Faculty of Science, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad- 211007,Uttar Pradesh, India*
[b]*Department of Chemistry, Faculty of Science, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad- 211007,Uttar Pradesh, India*
[c]*State Forensic Science Laboratory, Delhi, India*

ABSTRACT: A serial number is a unique code assigned for identification of a single unit. Serial numbers are present on many objects. In an attempt to hide the identity of the numbered item, the numbers are often obliterated or removed by mechanical methods. The present work was carried out with an objective to develop less toxic, less time consuming, chemical etching reagent for restoration of serial number on copper metal plate. Nine different reagents were prepared using different combination of reagent along with standard reagent and applied over 50 erased samples of copper metal and compared with the standard reagent for restoration of erased marks. Etching reagent no. 3 (10 g $FeCl_3$ + 20 mL glacial acetic acid + 100 mL distilled H2O) showed the best result for restoration of erased serial number on copper metal plate. The reagent was also less toxic and less time consuming as compare to standard reagent (19 g $FeCl_3$ + 6 mL conc. HCl + 100 mL distilled H2O).

Keywords: serial number, restoration, copper, obliteration, punch mark

Introduction

A serial number is a unique code assigned for identification of a single unit. Although usually called a number, it may also include letters, though ending with digits. Serial numbers are present on many everyday objects [1]. They are used to distinguish items from others of a similar appearance [2]. In some cases, they are encoded to carry information about the product, such as date of manufacture and model type. Serial numbers are regularly removed from items in order to hide their identities [3,4]. In forensic practice, a few experimental techniques are being used successfully to restore the obliterated serial numbers on the metal surfaces [5,6]. The methods include: chemical etching, heat treatment, magnetic particle, ultrasonic cavitations and relief polishing [7] who stated that restorations of markings are an important forensic discipline that includes the science and technology of materials. It deals with the aspects of solid-state physics, chemistry, metallurgy and engineering. Nondestructive methods such as magnetic imaging, x-ray imaging, eddy current, infrared imaging, scanning acoustic microscopy, electron channeling contrast and thermal wave imaging are also proposed [8-10]. A laser fused etching technique would be useful for applications on existing specimens and specimens under hostile environment, in a remote and non-contact manner. Philip et. al. demonstrated a laser fused etching technique for metallographic and ceramography using a pulsed Nd:YAG laser for revealing microstructures in metallic and ceramic specimens [11]. The new etching technique would be useful for applications on existing specimens and specimens under hostile environment, in a remote and non- contact manner.

Restoration of the original obliterated numbers provides important forensic evidence in order to return the items to the owner and also to follow up the criminal proceedings against the perpetrator. In cases involving firearms the recovered numbers provide an important investigative lead. The history and the ownership of the firearm can be obtained only from the serial number. Chemical etching is the most successful and common method for restoration on the metal surface. However, the reagents which are in use in present days are very toxic in nature and causes health hazard to the user, therefore a less toxic new reagent for development of the erased number have been carried out.

Materials and Methods

In the present work attempts was made for the restoration of the erased serial number from the sample by using different type of reagents. The samples (pure copper metal strips) were collected from the market having uniform thickness. Different serial numbers were stamped on each copper plate on all 50 samples. All samples from sample number 1 to sample number 50 containing different stamped serial numbers were obliterated by grinding with mechanical grinding machine up to fixed depth then they were photographed with the help of digital camera. All the samples were again photographed for comparisons with the marks that will be restored by acid-etching method later on. All samples obliterated surfaces were cleaned by using benzene or acetone solvent to remove grease or paint from it. The obliterated areas were then hand polished to a smooth, mirror like finish or a reasonably smooth surface with emery cloth, or other fine abrasive. Emery paper with coarse grade was first used to removing all scratches, and other gross marks. The surface was examined during polishing, as digits are sometimes revealed during the process. The obliterated areas were again washed with acetone solvent. The entire items were photographed to record the details of the obliterated surface.

Following reagents were prepared for the restoration of obliterated serial number on copper metal surface and were applied with the help of cotton swab by continuous swabbing until marks were got restored.

1. Standard etching reagent (19 g $FeCl_3$ + 6 mL conc. HCl + 100 mL distilled H_2O).
2. Etching reagent 1 (20 mL conc. HNO_3 + 100 mL saturated solution of $K_2Cr_2O_7$).
3. Etching reagent 2 (20 mL conc. HNO_3 + 4g $KMnO_4$ in 100 mL distilled H_20).
4. Etching reagent 3 (10 g $FeCl_3$ + 20 mL glacial acetic acid + 100 mL distilled H_2O).
5. Etching reagent 4 (12 g $FeCl_3$ + 15 mL glacial acetic acid + 100 mL distilled H_2O + 2 mL conc. HNO_3).
6. Etching reagent 5(10 mL conc. HCl + 25 mL glacial acetic acid).
7. Etching reagent 6(12 g $CuCl_2$ +10 mL glacial acetic acid + 100 mL distilled H_2O).
8. Etching reagent 7 (12 g $FeCl_3$ +7 mL conc. HCl + 50 mL C_2H_5OH + 50 mL dist H_2O).
9. Etching reagent 8 (12 g $FeCl_3$ + 20 mL conc. NH_4OH + 50 mL distilled H_2O).
10. Etching reagent 9 (20 mL conc. NH_4OH + 20 mL conc. HCl + 50 mL dist H_2O).

Results and Discussion

Fifty copper metal strips bearing serial numbers were taken as samples. These metal strips were then subjected to the process of obliteration by grinding and then treated with ten different etching reagents for the restoration of marks (Table 1). The results obtained by the application of these reagents over the samples were given in the following Figures 1- 9.

As per the working manual of Directorate of Forensic science, the standard reagent which was a modification of the reagent used by [12] restored the mark in considerable short period of time, on the other hand the marks restored by reagent 1 are stable for the relatively longer period of time. However, the etching reagent 1 was so strong that it quickly dissolves the strained surface of metal. Hence results obtained were far better than the standard reagent. The NaOH reagent is responsible for bringing back the original marks also resulted in the deposition of some dark coating around the recovered marks. The coating was then easily removed by dissolving it in HNO_3**.** The etching reagent 2 did not required the use of any base for the restoration purpose and the mark obtained were have good contrast that it do not require alternate swabbing by NaOH. The reagent 3 and reagent 4 restored the marks successfully which were of great contrast and were also reproducible. The restored marks were stable for longer period as reagent 3 and 4 did not require alternate treatment with base. The etching reagent 5 did not require the use of any such base (NaOH) for the restoration purpose and the marks obtained were of fair contrast. However, the reagent 6 failed to provide any restoration on the copper surface**.** The reagent 7 also produced good restoration on the obliterated surface with good contrast**.** The marks restored by reagent 8 and 9 shows the same characteristic.

Table 1: Relative efficiency of the metallurgical reagent in recovering marks erased by grinding

S. No.	*Etching Reagent*	*Composition*	*Application Method*	*Time Taken For Restoration Of Marks (minutes)*	*Comments*
1	Standard reagent	19 g $FeCl_3$ + 6 mL conc. HCl + 100 mL dist. H_2O	The reagent was swabbed over the obliterated surface.	45- 60 min.	The restoration was about 60-70% in 45-60 min.
2	Etching reagent 1	20 mL conc. HNO_3 + saturated solution of $K_2Cr_2O_7$	The etching reagent was applied on the obliterated surface by swabbing.	5 min.	The restoration was about 70% in 5 min.
3	Etching reagent 2	20 mL conc. HNO_3 + 4g $KMnO_4$ in 100 m dist. H_20	The etching reagent was applied on the obliterated surface by swabbing.	10-13 min.	The restoration was about 65% in 10-13 min
4	Etching reagent 3	10 g $FeCl_3$ + 20 mL glacial CH_3COOH + 100 mL dist. H_2O	The reagent was swabbed over the obliterated surface.	20 min.	The restoration was up to 85% in 20 min
5	Etching reagent 4	12 g $FeCl_3$ + 15 mL glacial CH_3COOH + 100 mL dist. H_2O + 2 mL HNO_3	The etching reagent was applied on the obliterated surface by swabbing.	30 min.	The restoration was up to 90% in 30 min.
6	Etching reagent 5	10 mL conc. HCl + 25 mL glacial CH_3COOH	Obliterated surface wad swabbed by the reagent until restoration occurred.	10 – 15 min.	The restoration was about 75% in 15 min.
7	Etching reagent 6	12 g $CuCl_2$ +10 mL conc. CH_3COOH + 100 mL dist. H_2O	The reagent was swabbed over the obliterated surface.	35 min.	No restoration of marks occurred.
8	Etching reagent7	12 g $FeCl_3$ +7 mL conc. HCl + 50 mL C_2H_5OH + 50 mL dist H_2O	Obliterated surface wad swabbed by the reagent until restoration occurred.	35 min.	The restoration was about 75% in 35 min.
9	Etching reagent 8	12 g $FeCl_3$ + 20 mL NH_3 solu. + 50 mL H_2O	The etching reagent was applied on the obliterated surface by swabbing.	15 min.	The restoration was about 70-80% in 15 min.
10	Etching reagent 9	20 mL NH_3 solu. + 20 mL conc. HCl + 50 mL dist H_2O	Obliterated surface wad swabbed by the reagent until restoration occurred.	20 min.	The restoration was up to 90% in 20 min

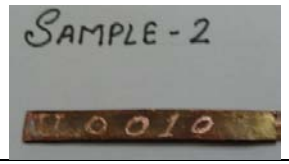
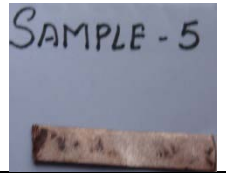
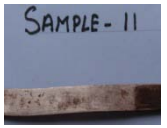
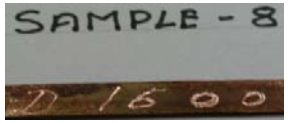
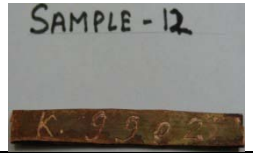
S. No	Standard Etching Reagent			Etching Reagent- 1			Results
	Original sample	Obliterated sample	Restored mark	Original sample	Obliterated sample	Restored mark	
1							The restoration was about 70% in 5 min.
2							The restoration was about 70% in 5 min.
3							The restoration was about 70% in 5 min.
4							The restoration was about 70% in 5 min.

Figure 1: Comparison of marks restored by standard etching reagent and etching reagent-1(magnification 2X)

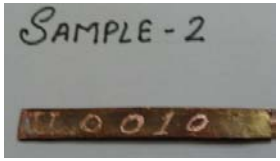
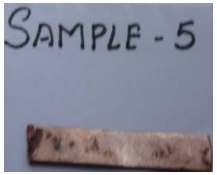
S. No	Standard Etching Reagent			Etching Reagent- 2			Results
	Original sample	Obliterated sample	Restored mark	Original sample	Obliterated sample	Restored mark	
1							The restoration was about 65% in 10-13 min.
2							The restoration was about 65% in 10-13 min.
3							The restoration was about 65% in 10-13 min.
4							The restoration was about 65% in 10-13 min.

Figure 2: Comparison of marks restored by standard etching reagent and etching reagent-2(magnification 2X)

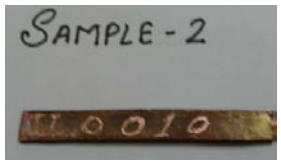
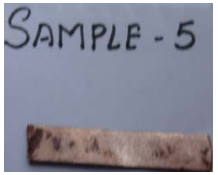
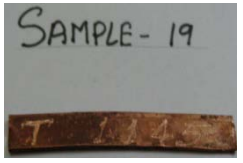
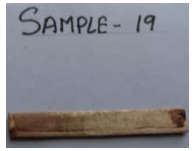
S. No	Standard Etching Reagent			Etching Reagent- 3			Results
	Original sample	Obliterated sample	Restored mark	Original sample	Obliterated sample	Restored mark	
1							The restoration was up to 85% in 20 min.
2							The restoration was up to 85% in 20 min.
3							The restoration was up to 85% in 20 min.
4							The restoration was up to 85% in 20 min.

Figure 3: Comparison of marks restored by standard etching reagent and etching reagent-3(magnification 2X)

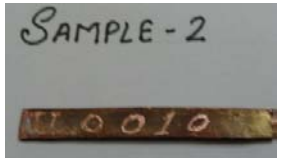
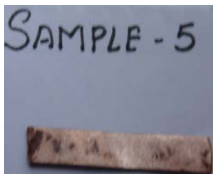
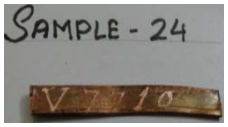
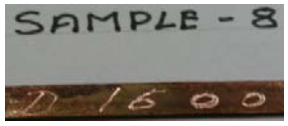
S. No	Standard Etching Reagent			Etching Reagent- 4			Results
	Original sample	Obliterated sample	Restored mark	Original sample	Obliterated sample	Restored mark	
1							The restoration was up to 90% in 30 min.
2							The restoration was up to 90% in 30 min.
3							The restoration was up to 90% in 30 min.
4							The restoration was up to 90% in 30 min.

Figure 4: Comparison of marks restored by standard etching reagent and etching reagent-4(magnification 2X)

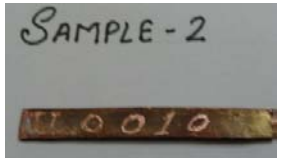
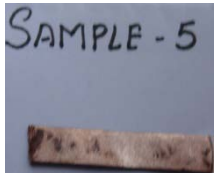
S. No	Standard Etching Reagent			Etching Reagent- 5			Results
	Original sample	Obliterated sample	Restored mark	Original sample	Obliterated sample	Restored mark	
1							The restoration was about 75% in 15 min.
2							The restoration was about 75% in 15 min.
3							The restoration was about 75% in 15 min.
4							The restoration was about 75% in 15 min.

Figure 5: Comparison of marks restored by standard etching reagent and etching reagent-5(magnification 2X)

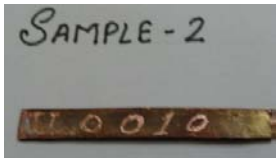
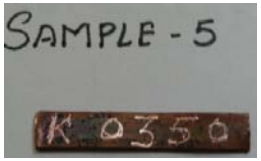
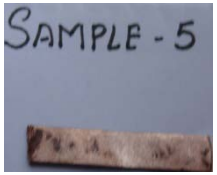
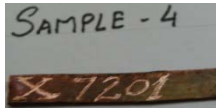
S. No	Standard Etching Reagent			Etching Reagent- 6			Results
	Original sample	Obliterated sample	Restored mark	Original sample	Obliterated sample	Restored mark	
1							No restoration
2							No restoration
3							No restoration

Figure 6: Comparison of marks restored by standard etching reagent and etching reagent-6(magnification 2X)

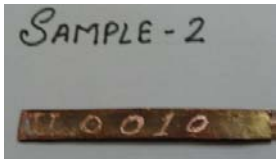
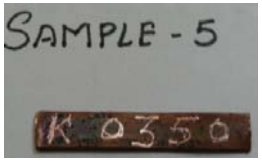
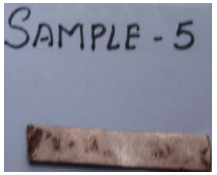
S. No	Standard Etching Reagent			Etching Reagent- 7			Results
	Original sample	Obliterated sample	Restored mark	Original sample	Obliterated sample	Restored mark	
1							The restoration was about 75% in 35 min.
2							The restoration was about 75% in 35 min
3							The restoration was about 75% in 35 min
4							The restoration was about 75% in 35 min.

Figure 7: Comparison of marks restored by standard etching reagent and etching reagent-7(magnification 2X)

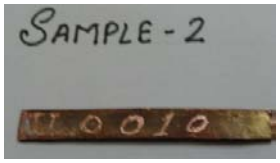
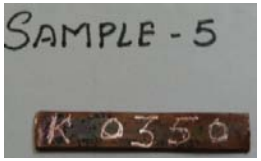
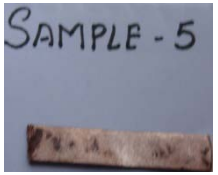
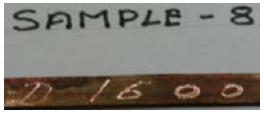
S. No	Standard Etching Reagent			Etching Reagent- 8			Results
	Original sample	Obliterated sample	Restored mark	Original sample	Obliterated sample	Restored mark	
1							The restoration was about 70-80% in 15 min.
2							The restoration was about 70-80% in 15 min.
3							The restoration was about 70-80% in 15 min.
4							The restoration was about 70-80% in 15 min.

Figure 8: Comparison of marks restored by standard etching reagent and etching reagent-8(magnification 2X)

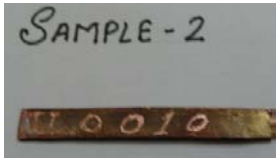
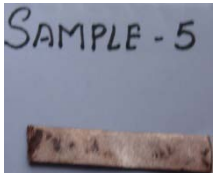
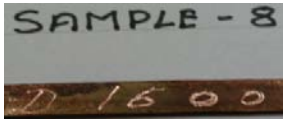
S. No	Standard Etching Reagent			Etching Reagent- 9			Results
	Original sample	Obliterated sample	Restored mark	Original sample	Obliterated sample	Restored mark	
1							The restoration was up to 90% in 20 min
2							The restoration was up to 90% in 20 min
3							The restoration was up to 90% in 20 min
4							The restoration was up to 90% in 20 min

Figure 9: Comparison of marks restored by standard etching reagent and etching reagent-9(magnification 2X)

By comparing the marks restored by standard reagent with the marks restored by the etching reagent 3, it was found that the restoration had shown good contrast and was also reproducible. The time taken for restoration process was also less (20 min) in comparison to that of standard reagent (45-60 min). The toxicity of reagent 3 is less than that of the standard reagent as it does not contain conc. hydrochloric acid which is highly corrosive in nature. The marks restored by the reagent no. 3 are much clearer than those which were restored by the standard reagent. The marks restored by reagent 3 are stable for comparatively longer time than standard reagent. The best restoration was obtained by the reagent 4 and reagent 9, however their composition included more toxic substances so the reagent 3 serves the purpose of the proposed objective of the research.

Conclusion

The work was carried out with an objective to develop less toxic, less time consuming, chemical etching reagent for restoration of serial number on copper metal plate. Around nine different reagents were prepared using different combination of reagent along with standard reagent and it was applied over 50 erased samples of copper after restoration. The present study was carried out at in the Department of Forensic Science. Our results showed that the nine different etching reagents of varying composition were prepared and used for restoration of serial numbers on samples (copper metal plates having different serial number stamped from serial number 1-50) by chemical etching. After the examination, it was found that out of nine different etching reagents the etching reagent 3 (composition: Ferric chloride, glacial Acetic acid and distilled water) gave the best result.

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Additional information and reprint request:
Dr. Lav Kesharwani
Email: lavkesharwani@gmail.com
Assistant Professor
Department of Forensic Science
Faculty of Science
Sam Higginbottom Institute of Agriculture
Technology and Sciences
Allahabad- 211007, Uttar Pradesh, India
Ph: +91-9336862259
Fax: +91-5322684012