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The restoration of serial numbers on vehicle glass using hydrofluoric acid

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ABSTRACT

Very little research has been carried out investigating techniques for the restoration of obliterated serial numbers on vehicle glass. A study into the effectiveness of hydrofluoric (HF) acid, a known etchant for glass, has been performed. Character sequences previously etched into panes of vehicle glass were sanded to varying depths and attempts were made to restore the sequences by polishing and using a range of concentrations of HF acid. A concentration of 30% HF acid gave at least a 50% restoration of the sequence if up to approximately 30 μm of glass had been removed during obliteration. Recovery improves if less glass is removed, but not if the concentration of the acid is increased. It appears that removal of glass below the level of the original characters makes subsequent restoration using this technique impossible.

1. Introduction

In New Zealand, Vehicle Identification Numbers (VINs) and vehicle registration numbers are often sand-blasted into the windows of vehicles as deterrents to would-be car thieves. Also, these numbers serve to help police identify the origins of stolen vehicles.

There have been increasing numbers of requests made of the Institute of Environmental and Scientific Research (ESR) to provide restorative evidence on serial numbers obliterated from vehicle glass. To date, there has been a reliance on informal, non-validated methods regarding this area of examination. Furthermore, there appears to be no previously published research to assist. When attempts at restoration have been made on casework items, the results have generally not been successful.

A method for restoring serial numbers from vehicle glass would provide a reliable, validated, basis for such work. At the very least, it could support the assumption that obtaining useable results from the substrate is a difficult endeavour. The knowledge that one is applying a sound method gives one a feeling of support in the field and an eventual reliance on gained experience.

In this laboratory, examination of vehicle glass for obliterated characters has involved the use of a point light source, usually in the dark, held at different angles from both in front of and behind the pane of glass. This method may allow the original sequence to be revealed, either before or after polishing of the surface.

A 50% hydrofluoric (HF) acid solution has previously been used within the forensic laboratories of ESR (personal communication) for restorative work on vehicle glass. HF acid is a known glass etchant, where it dissolves glass by reacting with SiO_2 (silicon dioxide), the major component of most glass, to form silicon tetrafluoride gas and hexafluorosilicic acid [1]. The purpose of this study is to explore the use of HF acid for restoring sand-blasted characters in vehicle glass, examining the effect of concentration and the impact that varying levels of glass removal has on the success of restoration.

2. Materials and methods

Stencilled eight-digit serial numbers were sand-blasted into intact panes of vehicle glass from side windows obtained from a vehicle wrecker's yard. The process of sand-blasting was undertaken by a local windscreen repair company that also specialise in applying VIN and registration sequences to vehicles. Arbitrary 8-character, alpha-numeric sequences, of a size and font employed by the industry were used. Sequences were random and unknown to the author. Each sequence was given a unique ID and then photographed. The numbers were subsequently removed through sanding of the glass surface to varying degrees by a volunteer. An electric detail sander with 180 grit sandpaper was used.

Obliterated number sequences were categorised according to the approximate depth of glass removed during sanding. Depth of glass removal was measured using a Leica DMRBE compound microscope, using the digital display to yield measurements in μm. The microscope was focused on the upper surface of a section of undamaged glass adjacent to the obliterated area and the readout zeroed. As best as possible the surface of the obliterated 'depression' was then focused on and the difference in μm noted. Several measurements were taken as there was some variation in obliterated depth for most number sequences. Only those number sequences where the average depth was close to a series of determined depth

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categories were used. Depth categories were: 0–30 μm (which incorporated the depth of the sand-blasted characters), 30–50 μm, 50–70 μm, 70–90 μm, 90–110 μm, 110–130 μm and 130–150 μm. This resulted in between 30 and 50 sequences per depth category.

At each depth category, a range of HF acid concentrations – 5–50% – were used in an attempt to restore the obliterated sequence. HF acid was supplied by Sigma–Aldrich, New Zealand. The area was sanded with waterproof sand paper and water using sandpaper grades 220–1200 grit. Care was taken to make the surface as smooth as possible and to remove as many fine scratches from the previous grade's sanding before moving onto a finer grade. Different surfaces within each depth category were then treated with each (and only one) of 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45% and 50% HF acid concentration. There were between 3 and 5 obliterated sequences available for each of the 10 concentration categories. Treatment involved initially pipetting a small amount of acid onto the glass surface, and immediately removing it. A point light source was used from many different angles, from both in front of and behind the glass, in order to visualise any restored or restoring characters. Diagrams and notes were immediately made of characters that were visible. After approximately 10 repeated treatments, the surface was pooled with acid for 5 s, then 10 s then 30 s, then 2 min, and then 10 min in an attempt to reveal further characters or character elements. These steps were unnecessary if the full character sequence had already been revealed. The area was washed with water to remove the acid between consecutive treatments.

High levels of safety were in place whenever HF acid was used. Double nitrile gloves, a pair of disposable overalls and an air-purifying respirator were worn. Glass was etched in a fume cupboard and acid was washed into the cupboard sink with copious amounts of water. As a result of these precautions, visualising restored results was not an easy task. However, these precautions are necessary for casework, so no extra disadvantage was realised.

After the complete number restoration process, the approximate percentage of character sequence revealed for each depth category-HF acid concentration combination was assigned. This was a subjective assessment; however, a second observer was used to assist (with differences in assessment being averaged), and observations were made conservatively. Conclusions were compared with original sequences and any inconsistencies noted.

3. Results

Table 1 shows the average percentage of restoration of the characters within a sequence at any one glass removal depth-HF concentration.

Microscopic examination of the sand-etched characters in glass revealed that each character was made up of a collection of small pits rather than a uniform removal of glass (see Fig. 1). These pits were generally no deeper than approximately 30 μm, and most appeared to range between approximately 20 μm and 30 μm in depth. The range of total glass removal was 0–150 μm (see Table 1). It was often necessary to remove up to 30 μm to incorporate the sand-etched depth and to ensure that the majority of the character sequence was obliterated. The category "0–30 μm" represented 'removal' of the characters to the satisfaction of the unaided eye. Almost exclusively, this did not result in removal of 30 μm of glass (and therefore not the complete removal of pits associated with the original sand-blasted characters).

Determining the depth of glass removal, as well as the depth to which the characters were originally etched, was a difficult process because the vehicle glass samples were curved. Placing the curved glass underneath the microscope was awkward and it is possible that the measurements were not always entirely accurate.

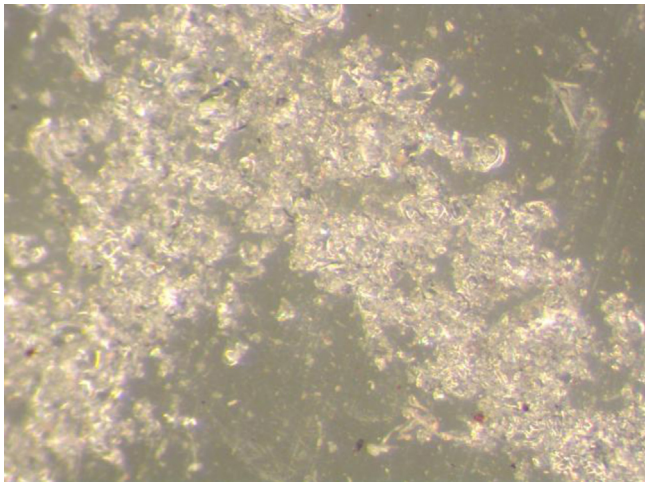

Fig. 1. 'Pitting' in glass surface.

Therefore, the measurements in Table 1 are approximate and only intended as a guide.

The success of some of the results, particularly when less than 30 μm of glass was removed, are likely to be as a result of the initial polishing process revealing at least a portion of the character sequence, rather than the effect of the acid etching the glass. Fig. 2 illustrates this effect: the first photograph shows the area prior to restoration, the second shows the area after polishing, and the third shows the area after acid treatment.

Fig. 2 is also an example showing restored character fragments and characters across a single sequence. Approximately 60% of the sequence was recovered. Even if a character could be determined from, for example, a small fragment (i.e. a fragment showing characteristics unique to that character), this was not considered a recovery but a partial recovery of an according percentage. This is because this was an exercise in absolute recovery using HF acid. Fig. 3 shows results of restoration at the same depth but with different HF acid concentrations, and Fig. 4 shows results at different depths but with the same HF acid concentration. As previously noted, it was necessary to use different character sequences across depth and across HF acid concentration gradients to avoid prior knowledge of results gained through previous restoration attempts.

As shown in Table 1, characters could not be restored when approximately 70 μm or more of glass was removed from the surface of the windscreen (or when approximately 40 μm or more of glass was removed from below the depth of the characters). This was true for the entire range of HF acid concentrations used, with the exception of 30%. There appeared to be somewhat of a large jump from essentially negative results at depths below 70 μm to degrees of success (some over 50%) at depths above 50 μm. By and large, results continued to improve as less glass was removed. However, results show little relative improvement in restoration at

Table 1
Sequence restoration percentage.

Glass removal depth (μm)	HF acid concentration (%)									
	5	10	15	20	25	30	35	40	45	50
130–150	0	0	0	0	0	0	0	0	0	0
110–130	0	0	0	0	0	0	0	0	0	0
90–110	0	0	0	0	0	0	0	0	0	0
70–90	0	0	0	0	0	10	0	0	0	0
50–70	0	0	0	0	10	0	30	20	30	30
30–50	0	0	20	40	40	50	60	40	60	50
0–30	20	30	30	60	60	80	80	90	100	90