Some call it Art:
Case studies investigating the spraying of illegal graffiti in the UK

Louissa Marsh
LGC Forensics

Introduction

The conflict between artistic expression and crime

Graffiti is now generally accepted to be the application of images or letters to publicly viewable surfaces. When graffiti painting is done without the property owner's permission, this act is considered vandalism and offenders can be charged under the UK Criminal Damage Act 1971 (section 1). Common styles of graffiti have their own names, for example the 'tag', the most basic type of writing. This is often perceived to be either an individual person's, or a gang signature, and usually encompasses few letters. These tags can generally be easily identified, and will be practised until they can be sprayed extremely quickly and accurately. More stylised graffiti often involves the use of many different paint colours and will take a considerable amount of time to plan and then complete. Frequently, multiple offenders acting together may be involved in these intricate acts of vandalism. Monetary costs for the removal of the graffiti can stretch into many millions of pounds, not just for the chemicals required, but also man-power time and in the case of public transport, downtime of trains. Social costs for graffiti can also be significant. The 'broken window' theory put forward by Wilson and Kelling [1] in 1982 stated that if a window in a building is broken and left un-repaired, other windows would soon suffer the same fate. This is due to the perception by the community that a level of care is missing from the area. Subsequently, residents stay away from these areas due to their perceived danger, and hence disorderly behaviour intensifies. The local councils in the UK tend to respond as fast as possible to reports of vandalism in order to break this cycle, removing or painting over graffiti when identified. Indeed, Collins and Cattermole [2] reported a British crime survey in 1998, where a co-relationship was found between physical disorder, such as graffiti and the level of burglary, vehicle thefts and violence. In the UK, the law states that where the value of the damage is more than £2,000, the maximum penalty is ten years imprisonment for those over 18, and up to two years detention in a Young Offender Institution for those aged 15-17. Re-offending is extremely high at a figure of above 75%, this is attributed to the extremely addictive nature of these activities. Graffiti 'artists' often risk danger, on occasion leading to death; in January 2007 two suspected graffiti vandals were struck and killed by a train in Barking tube Station, in London [3].

Spray Paint introduction

A study by Krausher [4] in 1994 found that aerosol spray cans produce a fine 'mist' of paint droplets when sprayed, referred to as an aerosol cloud. This study found that anyone in close vicinity of spraying paint is highly likely to become contaminated with this aerosol cloud, leaving small, usually hollow droplets of paint on them (referred to as 'paint balls'). These quickly dry *in-situ*. They can be located on clothing with the use of a stereo microscope with an overall magnification of at least x40. Paint balls are not often visible to the naked eye and this is why this valuable trace evidence is often overlooked by arresting officers. A typical dried paint ball will usually be of the order of 10 to 30 microns in diameter. Krausher [4] reported that the paint balls are readily lost from the surface of clothing after washing, and may be wiped from skin, eyeglasses and other smooth surfaces. Because of their lack of durability, the finding of paint balls suggests recent exposure to an aerosol cloud. Care must be taken when attaching significance to recovered paint balls, however, as this study also concluded that anyone standing in close vicinity to spraying paint will also acquire paint balls on them. Absence can also be a strong indicator that an individual has not been in the vicinity of paint being sprayed however, the possibility of clothing being covered, changed or washed must be considered. A further consideration of paint spraying behaviour that a forensic scientist must consider is the persistence of the aerosol cloud in the atmosphere. Although the author is unaware of any study which directly addresses this issue, it is expected that paint balls will be suspended in the air for some time after spraying (due to their microscopical size).

Chemistry of Aerosols and Liquid Flow Considerations

The chemistry of aerosol paint can be divided into two main areas; the effect of the pressurised can and the physical properties of the wet paint. Moran [5] described the properties of aerosol spray cans. When these are sprayed by depressing the nozzle, the product and liquid propellant are pushed through the valve by pressure. The propellant is a liquid with a boiling point slightly lower than room temperature. Under normal atmospheric conditions, this vapour can exist in equilibrium with the bulk paint inside the pressurised can. Its pressure is higher than the outside atmosphere and thus is able to expel its payload of paint when the nozzle is depressed. As this gas escapes, it is immediately replaced by more evaporating liquid inside, and hence pressure in the can is maintained. When paint and propellant are sprayed, the propellant evaporates quickly, leaving the paint suspended as very fine droplets. Maintaining the pressure inside the can allows virtually all the wet paint to be used, minimising paint waste. Due to its volatile nature, no propellant will be present after the paint has dried and hence

cannot be detected by analysis of the resulting material. When comparing paint samples, homogeneity must be considered. A study of the characteristics of spray can coatings produced from shaken and non-shaken cans was conducted by Zeichner *et al.* [6]. Due to the requirement that spray paint is projected through a small nozzle under pressure, paint with a low viscosity (liquid habit) is needed. Settling of pigment may cause non-homogenous material to be present inside the can. In this study, when a spray can was shaken for a few minutes it was found that the resulting sprayed paint was consistent and hence considered to be homogenous. However, when the can was not shaken the concentration ratio between the pigment and the liquid phase of the paint altered during spraying. This resulted in chemical and optical differences in the final paint film between that produced when the paint was first sprayed, and that produced when spraying had commenced after several minutes. This potential variation in the final film must be considered during any forensic investigations.

Nozzle size effects and paint droplet considerations

Most spray paint cans are sold with a nozzle already attached. A typical valve arrangement is shown in Figure 1, which illustrates how the valve is pre-assembled during manufacture with the nozzle fitted afterwards. Removal and placement is relatively quick and easy, rarely resulting in accidental paint loss. The nozzle type and size affect the spray flow of the aerosol paint and spray pattern; i.e. the amount of aerosol cloud produced. Droplet size is affected to some extent by the nozzle type, although pressure in the can, climatic conditions (such as temperature and humidity) and paint type also have some effect. Wind is known to have a substantial influence on spray characteristics, as droplets of paint within the aerosol cloud will drift with currents in the air; hence it is expected that larger droplets will fall faster than smaller ones. The angle of spray also has an effect on droplet size. Spray cans must be used in a near upright position, since the liquid propellant is at the top of the can (see Figure 2). Tipping of the can will cause this propellant to be forced out of the can via the dip tube, rather than the paint; hence the ‘hissing’ noise associated with spraying when this happens. Nozzles may become blocked with paint during use and cleaning is problematic as any implement used to dislodge clogged material may damage the opening. The many variables of nozzle type and size, climatic conditions, paint viscosity (thickness and type) and user variability (such as angle of use) prevent a forensic scientist from being able to accurately predict droplet size from any given paint. Hence, dried paint balls on items such as clothing or skin cannot be attributed to any particular spray can, based on size alone.

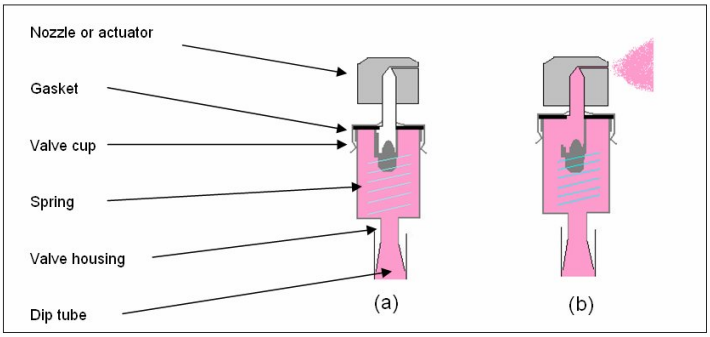

Figure 1. Nozzle attachment mechanism (a) closed and (b) open

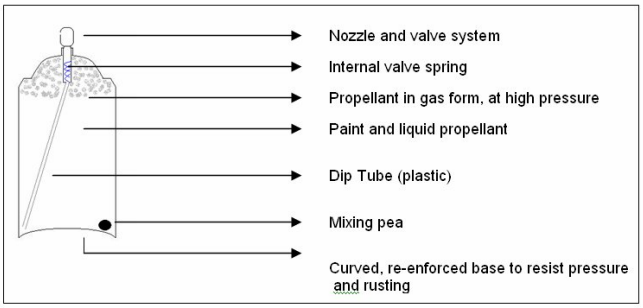

Figure 2. Internal arrangement of a paint spray can

Forensic Analysis- Processes and Considerations

The finding of graffiti on public or private property, when no permission has been given, indicates a crime has taken place. Finding any physical trace evidence linking suspects to the offence is the focus of the investigation. This paper will deal with the aspect of paint being transferred following the application of paint via an aerosol spray can. Other types of graffiti are often encountered, such as the application of ink or the scratching of window glass, but these crimes are beyond the scope of this report. Dried paint from graffiti is often collected for comparison by scraping the paint from the vandalised substrate ('control paint'), however in certain circumstances the control paint may be received in the laboratory *in-situ*. Occasionally, for example, vehicles which have graffiti on them may be submitted in their entirety in order for samples to be taken. Exhibits to the laboratory from persons suspected of graffiti crimes can take many forms, but typically clothing, fingernail scrapings, latex gloves and spray cans are the most commonly encountered in casework. Items for examination are often treated for fingerprint enhancement prior to further laboratory testing, in which case care must be taken to sample paint uncontaminated with any chemicals used. In most cases with submitted spray cans, the most practical way of doing this is to spray from the container, in order to sample the paint inside. However, this can cause difficulties in comparison, due to the concentration effects of shaken or non-shaken cans as described earlier. The lack of a nozzle can be overcome by the careful insertion of a wooden stick into the paint valve, which will produce a flow of paint (albeit uncontrollable) which can be caught onto a glass slide. The most consistent sampling technique for

spray cans (uncontaminated with any fingerprint reagents) is to sample pooled or dripped paint from the can top. In the case of empty cans, this sampling technique is often the only one available. A graffiti artist will choose which nozzle is required for a particular spraying technique. In addition, the presence of nozzles on the top of a spray can may cause the paint to be discharged by mistake inside a bag or pocket. Different nozzles are available from manufactures in bulk, preventing the need for cleaning should blockages occur and also allowing a choice of nozzle size to be made. Hence, different paint colours on a single nozzle are often encountered, and may provide a link between different sources. Comparison then takes place between the recovered paint (either in the form of paint balls from items relating to a suspect, or from paint taken from a spray can) and the control paint. In the case of paint balls, little or no sample preparation is required, once recovered. Manipulation of paint balls (between 10-30 microns) requires dexterity and practise. The nature of the aerosol cloud often results in the paint balls landing on, and drying around individual fibres. This drying *in-situ* can make the gathering of paint balls problematic, often requiring the fibre with the dried paint ball attached, to be cut from the garment (see Figure 3).

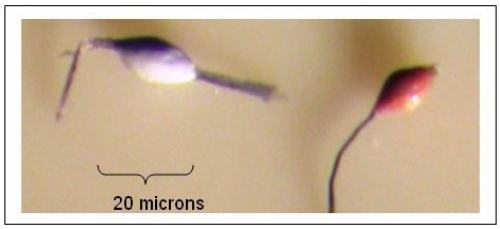

Figure 3. Paint balls which have dried in-situ around fibres, removed from clothing using a stereo microscope (x40 magnification)

It is uncommon to find paint balls which have merged together; even in very dense concentrations the small diameter size prevents overlap in most cases. However, if overlap is present, it is sometime possible to identify which colour of paint was acquired first, which second etc. Such a paint ball is shown in Figure 4. Due to the speed in which the paint balls dry (often taking only a few minutes) it would not be possible to assess the length of time between acquisitions of each colour.

Figure 4. A single paint ball consisting of three overlapping colours (still attached to a fibre from an item of clothing. (The approximate size is 30 microns.)

As stated by Krausher [4], the extent of the aerosol cloud often results in paint balls being present on clothing in some considerable number; hence it is not necessary to examine the whole item under high magnification. Typically, the microscopic examination would cover approximately one quarter of the surface, systematically over the item. Often, sleeves will be searched in their entirety, particularly around the cuffs. The finding of high concentrations of paint balls in these areas may be an indication (but not proof) that the wearer has been spraying

paint. However, paint balls recovered from this area could also have been obtained from standing in close vicinity to someone else who was spraying [4].

Casework Study

In the majority of graffiti cases received in the laboratory, multiple colours are found to have been used in the final dried graffiti. Hence, it is the finding of a particular combination of colours that can be of particular significance in the assessment of a case. However, to the author's knowledge, the frequency of different colours in graffiti has not yet been addressed and this constitutes part of the aim of this report. Twenty different cases involving graffiti, submitted to the LGC Forensics Culham laboratory during 2006 and 2007 are presented. From these, sixty-seven paint spray cans and twenty-nine items of clothing/other exhibits were examined. Optical comparisons between recovered and control paints include the use of reflected and transmitted light, (polarised and unpolarised) and light sources using blue and ultra-violet light to promote fluorescence. A typical comparison involved up to x500 magnification using compound microscopy. In all instances, optical matches were further investigated using infra-red Fourier Transform spectroscopy with a microscope attachment (FTIR), to investigate any similarities in chemical composition. This report also aims to present frequency of occurrence of spray can types, fullness and sizes.

Results

From the submitted cans, forty-four did not have a nozzle present, with the remaining twenty-three having one either in-situ, or contained within the same exhibit bag. Nearly 80% of cans submitted to the laboratory contained 400ml of paint when new (53 out of 67 cans). 600ml cans constituted just over 10% of those submitted (7 out of 67 cans) and the remaining were fairly equally distributed between 300ml, 360ml and 500mls cans. The different types of spray cans received as casework items are shown in Figure 5, however limitations in the assessment of these submitted cans must be highlighted. For example, the two encountered cans of 'heavy duty under-seal' were submitted together in a single case.

Figure 5. Manufacture's paint cans received

Type	Number of cans submitted
MTN Pintura paint spray Hardcore	22
Belton Molotow Premium	17
Plasti-kote paint	4
Molotow Action Outline black, Coversall 2	3
Molotow Action 600er	2
Moltow Action 100er Burner chrome	2
Auto K Special brake calliper paint	2
Heavy duty under seal	2
Silver hook chemicals chrome spray paint	2
Kylon living colour acrylic enamel, low odour	2
Colorplace rust control spray enamel	1
Laura Ashley Home colour collection	1
Tetrasyl trade spray acrylic plus formula	1
Carlux car paint Pintura brilliant maximum acrylique	1
Peintures techniques julien décor	1
Autoquest auto spray paint system	1
Marabu buntlack graphic spray	1
Montana	1
Molotow action 400er	1

When assessing the contents of submitted cans, 5% were empty, 24% were nearly empty, 25% of cans were one quarter full, 13% were half full, 27% were three-quarters full and 6% were nearly full, or unused. Thirty-three of the sixty-seven cans submitted contained batch number identification stamps, the remaining were either not labelled, or the batch identification was obscured by paint or damage. Figure 6 indicates the frequency of occurrence of colours, as received in the cases under discussion. Of the cans submitted; silver and black were the two most commonly encountered. These colours were also the two most common controls; however on

clothing/items the two most commonly encountered colours were blue and green. Overall, nineteen of the sixty-seven spray cans were found to be indistinguishable from their corresponding, submitted control paints.

Figure 6. Frequency of occurrence of paint colours. (Percentages of each colour have been divided by 100.)

	Submitted spray cans	**Submitted Controls**	**Present on Clothing/ Items**
Silver	0.16	0.28	0.09
Black	0.14	0.20	0.09
Red	0.11	0.13	0.12
Green	0.09	0.05	0.14
Blue	0.07	0.11	0.15
Pink	0.07	0.04	0.09
Brown	0.07	0.07	0.07
White	0.06	0.03	0.07
Orange	0.06	0.01	0.05
Yellow	0.06	0.02	0.07
Grey	0.04	0.02	0.01
Purple	0.04	0.03	0.05
Gold	0.03	0.01	0.00

Of the twenty-nine items of clothing or other exhibits submitted for examination for the presence of paint balls, a jacket or coat was submitted in 31% of cases, a sweatshirt or jumper in 17% of cases and trousers, jeans or a hooded top were submitted in 14% of cases. The remaining items were gloves, fingernail scrapings or tracksuit bottoms. Of the items searched for paint balls, 31% were found to contain between 0-2 different colours, 15% were found to contain 3-5 different colours, 12% contained 6-8 different colours, 15% contained 9-11 different colours and 27% of items were found to contain over 12 different paint ball colours. It is worth noting that in

several different cases submitted to the laboratory, paint balls were located on the inside surface of jackets. It is assumed in these cases that the jackets were worn inside out whilst spraying.

Case study 1- allegation of graffiti involving one suspect and six submitted paint control scrapings from the side of a damaged train. A suspect was arrested with two cans of paint amongst his clothing; both were 'Mtn Pintura paint spray hardcore' cans, one being 'mustard' (a light yellow/brown colour) and the other being 'toasted brown' (a dark/mid brown colour). Both cans were 400ml, both were half full and both had nozzles in-situ. The submitted paint controls were red, dark brown x3 and light brown x2. Following optical comparisons, the 'toasted brown' spray can was found to be different from the dark brown control samples. The spray can containing 'mustard' was compared against the light brown samples and found to be indistinguishable in colour. Both the control paint and this spray paint contained yellow and orange particles when examined with transmitted, polarised light, exhibited weak yellow fluorescence when observed under light reflected through blue and ultra-violet filters, and were indistinguishable when analysed by FTIR. The finding of this matching can was deemed to provide moderate scientific support for the proposition that this can was used during the creation of this particular light brown graffiti.

Case study 2- allegation of criminal damage involving one suspect and two submitted control scrapings from a control box at the side of a London underground station. A suspect was arrested running from a scene were the spraying of graffiti had been witnessed. A hooded top, seized soon after arrest, was submitted to the laboratory and microscopically examined. It was found to have a moderate concentration of paint balls on the outside surface, the majority of which were located on the front of the right sleeve and cuff. Both control paints were red and were optically indistinguishable from each other, but were chemically different when tested using FTIR. Red paint was the only colour found on the surface of the hooded top. When tested microscopically, this red paint was indistinguishable from both of the red control paint samples. Both the control paints and these recovered paint balls contained red and brown particles when examined with transmitted, polarised light and did not fluoresce when observed under light reflected through blue and ultra-violet filters. The recovered paint was found to be indistinguishable from one of the submitted controls when analysed by FTIR. The finding of red paint, indistinguishable from one of the submitted control samples on a hooded top, was deemed to provide moderately strong scientific support for the proposition that that wearer of the top had been in the vicinity of this graffiti whilst it was being sprayed.

Discussions

- The finding of paint balls on clothing indicates that the wearer has recently been in the vicinity of spraying paint. In the author's experience, it is extremely unlikely that clothing could be contaminated with consistent, microscopical paint balls (which are often hollow) in any other way than by being in the vicinity of spraying paint. Other techniques of paint application may result in paint balls being found on clothing (e.g. rolling or brushing); however these balls would be expected to vary in size and shape and may be excluded during microscopical examination.
- The finding of a substantial number of cans without nozzles in-situ is consistent with the hypothesis that nozzles are either stored off the can to avoid accidental paint release, or are being selected for their particular properties, when required.
- Nearly a third of all submitted cans were found to be 'MTN Pintura' brands, a specialist art brand manufactured in Spain and available worldwide. The second most common type of encountered spray can is Belton Molotow Premium, another specialist art brand manufacture in Germany and also available worldwide. The 'standard' spray cans available in retail shops in the UK are much less frequently encountered; items such as the Laura Ashley spray can, the rust control enamel and the Colorplace rust control. It is interesting to note that the two most frequently encountered brands, the MTN and the Belton Molotow, are both available either as 400ml or as 600ml, both of which are the most commonly encountered sizes. However, the sample size of submitted cans would need to be substantially increased in order to obtain useable frequency of occurrence data, particularly for some of the less commonly encountered can types.
- The assessment of can fullness was made by shaking the cans and there may be some level of error in this calculation. However, in order to minimise this, the same person assessed fullness in each case.
- The assessment of potential paint coverage can be estimated using the figure of 2.23m^2 coverage by 400ml of paint, as quoted by a can of Plasti-kote metallic spray can. Hence, a three-quarters empty spray can would have had enough paint used from within it to cover an area of 1.67m^2. This is approximately the same area covered as the front of a standard, interior house door. Using the same calculations, a train carriage two meters high and fifteen meters wide, covered with 50% graffiti on one side, would require the use of nearly seven spray cans of 400ml. These figures assume the coverage as recommended by the manufacturer; in other words this coverage would give an opaque finish. However, graffiti is rarely found with what could be termed as 'good coverage' over a substrate. Photographs from vandalised sites tend to indicate that the final obliterating power of the dried paint is often poor- the final appearance is almost translucent and often does not hide the colours of the materials beneath

it. From this observation, it may be assumed that the painted areas that graffiti artists are gaining from their spray cans is far increased from the recommended manufacture's figures; potentially in the order of up to three times the recommended rate. Using this figure, the same train size with the same level of graffiti as described before would require the complete use of only just over two cans; much better 'value for money'.

- Silver and black paint were the two most common colours found for submitted spray cans. These two colours were also the two most commonly encountered control samples, and so for cases involving aerosol cans the probability of finding a co-incidental match of silver and/or black paint must be given due consideration. Silver paint has been found to be problematic when analysed using FTIR, due to the metallic flakes interfering with the process, thus microscopical comparison must be relied on almost exclusively in most cases involving silver paint.
- It should be noted that the majority of clothing examined in the laboratory are dark coloured, and consequently it is possible that black paint balls, or other dark coloured paint might be missed during examination. Experimentation where paint balls have been observed and subsequently recovered using a gel-lifter (pressed against the fibres of the clothing) are currently being undertaken, with the aim of maximising recovery and minimising loss of evidence.
- Little assessment can be made regarding the finding of some of the 'less common' colours- purple, pink, yellow, orange etc. Overall, these colours have been shown to have similar frequency of occurrences to each other and it is the finding of more than one control colour that can increase the evidential significance.
- The finding of paint balls on clothing indicates acquisition after the last washing, and this indication of activity often cannot be assessed on shoes. Paint balls themselves may be located on the fabric areas of shoes, if present, however in most cases paint landing on plastic or leather items causes the paint to spread into a two dimensional 'spot', rather than the usual three dimensional 'ball'. This pattern of dried paint may also be caused by a person being in the vicinity of wet paint being dripped or splashed and may not be a direct indication of someone being in the vicinity of spraying paint. For this reason, although shoes are often submitted in amongst clothing to be examined for the presence of paint balls, they are not often searched in the laboratory.

Conclusions

Of the twenty cases under study, fifteen cases provided positive scientific evidence for the proposition of criminal involvement, whereas five did not. The major cause of difficulty in undertaking and assessing graffiti cases with multiple control paints for comparison, when clothing is submitted, is in the finding multiple colours of paint on

items. This finding highlights the problems in trying to associate a suspect with a particular crime when in all probability multiple graffiti acts are undertaken in a single day/night. The finding of paint balls on clothing indicates recent exposure to an aerosol cloud [4] but only provides information regarding activity since the last time the item was washed. However, the finding of paint balls on skin, which are known to be easily brushed off, may demonstrate more recent spraying exposure. No such study has as yet been undertaken.

Future work

In terms of paint cases, the major difficulty in assessing the likelihood of co-incidental match is due to the absence of a substantial, searchable database. This problem is being addressed by LGC Forensics and a database, giving frequency of occurrences of paint from all sources (not just from spray paints), is being created.

References

1. Wilson, J & Kelling, L (1982) the police and neighbourhood safety; broken windows. The Atlantic Monthly, March: 29-38
2. Collins, S & Cattermole, R. (2004) Anti-social behaviour: Powers and remedies, London, Sweet and Maxwell.
3. Mark Townsend and Amelia Hill, The Observer, Sunday January 14, 2007
4. C.D.J. Krausher (1994) Characteristics of aerosol paint transfer and dispersal. Can. Soc. Forens. Sci. 27 pp. 125–142.
5. Moran, J & edited by Bath, B. (2000) Metal finishing, volume 98 issue 6.
6. Zeichner A, Levin N, Landau E. (1992) A study of paint coat characteristics produced by spray paints from shaken and nonshaken spray cans. J. Forensic sci. Vol 37, issue 2.

Acknowledgements

I would like to thank LGC Forensics and my colleagues in the chemistry department for their help and support in this project.