The use of a portable device for the sealing of Nylon 11 (polyamide 11) arson evidence bags

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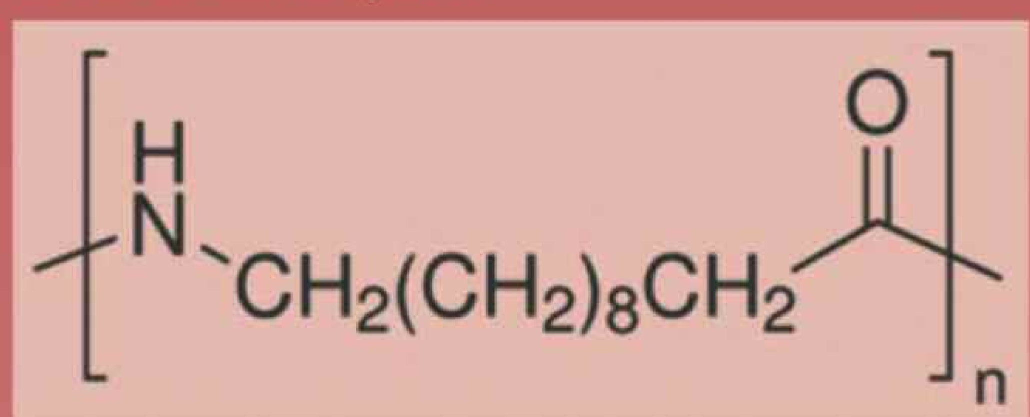
Introduction

Arson has a significant impact in the UK and Internationally. With regards to the UK, the cost of deliberately started fires is considered to be over £1.3 billion a year, (2.13 billion US$). In an average week, there are: 3,600 deliberately started fires, 60 injuries and 2 deaths. This results in between 9,000-10,000 samples being analysed across the UK. The collection of arson scene evidence for analysis of volatile compounds must ensure that the evidence is preserved avoiding both loss and contamination (Staufer et al 2007). The containers used are required to contain an array of chemicals potentially utilised to accelerate fires their residues and the products generated during combustion. The permeability of the materials used in particular to Volatile Organic Compounds (VOCs) and the ability to seal the containers are essential to the preservation of this evidence. The containers available, include bags made of a range polymers including laminates of polymers and polymers and metal films, this is supplemented with various designs of cans and jars. Each of these containers has advantages and disadvantages (Redsidker et al 1997, Bertsh and Ren 2000).

Arson Evidence Bags

Bags made of nylon 11 (also known as Rilsan™ or polyamide 11) are commonly used for collection and preservation of arson evidence in the UK. These are of a seamless tubular construction, with one end of this tube often heat sealed by the manufacture. Nylon 11 is a member of the polyamide group of polymers with the formula $[C_{11}H_{21}NO]_n$ and a reoccurring structure as seen in figure 1.0.

Figure 1.0 The structure of nylon 11



As a thermoplastic heating the polymer between 180-189°C, changes the physical properties of the polymer allowing two or more layers to become adhered. The adhesive property arises due to the polar nature of the amide group, which allows adjacent strands of polymer to form multiple hydrogen bonds, including strands from separate layers of the polymer. This generates a seal, which like the body of the tube can retain volatile organic compounds.

Potential benefits

Previous studies have found that of the available techniques the heat seal is the most effective for arson evidence bags (Strvjink and Hong-You 2004). In the UK swan neck tying is the recommended procedure for sealing these bags (Scenesafe 2009). However it is often impossible to determine whether seals generated by swan neck tying are sufficient until some form of analysis has been conducted. Analysis typically costs £125-150 per sample, therefore as an economic cost to the UK approximately £1.35 million is spent on analysis of arson scene evidence each year.

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A reduction in headspace volume caused by inappropriate swan neck tying can alter the profile of the VOC's analysed, as relatively large volumes of accelerant restricted by tying incorrect tying can result in a predominance of low molecular weight volatiles in the headspace (Kaitlin et al 2012).

Project aim

To aim of the project was to critically evaluate the application of portable heat sealers for scenes of crime usage. In order to undertake this the following objectives were identified;

- To validate the use of heat sealers for use on non-porous nylon bags
- To compare the seals provided by heat sealers to traditional swan neck tying
- To evaluate the benefits of portable heat sealers
- To validate the use of portable heat sealers for use on non-porous nylon bags

Swan neck tied bags may appear sealed and pass a drop test, yet not retain VOC's

Method

Arson evidence bags were obtained from different forensic suppliers, such that 5 batches were evaluated. All of the bags supplied were from sources which had undergone quality assurance with registration to appropriate ISO Standards. The bags were constructed of nylon 11 and the walls of the bags were single layers with a 40 µm thickness. These batches were anonymised and throughout this study bags were randomly selected from each batch for analysis.

Both unaided observation and microscopic examination x40 magnification using a Nikon, Eclipse E400 POL, were used to inspect the integrity of the heat seals generated.

Heat seals were produced using an impulse heat sealer (Packer PBS-400), powered by the domestic 230 v supply, and to assess portability a 1000W 12V Pure Sine Wave Power Inverter (Sunshine Solar limited) connected to a 12 v, 45 ah battery (Alphaline).

The strength of seals were tested using the standard drop test from a height of 1.0 m using 1.0 kg sand and tensile strength testing using 10.0 mm sections of seals,

Retention of VOC's by Heat seals and Swan neck tying was evaluated by Gas Chromatography–Mass Spectrometry using a Perkin Elmer, Clarus 500 quadrupole GC-MS. This was conducted using static headspace analysis of a 50:50 volume mixture of Petrol and Diesel., Additional analysis was with a Solid Phase Micro Extraction Using a Supelco fused silica fibre coated with a 100 µm film of polydimethylsiloxane.

Results and findings

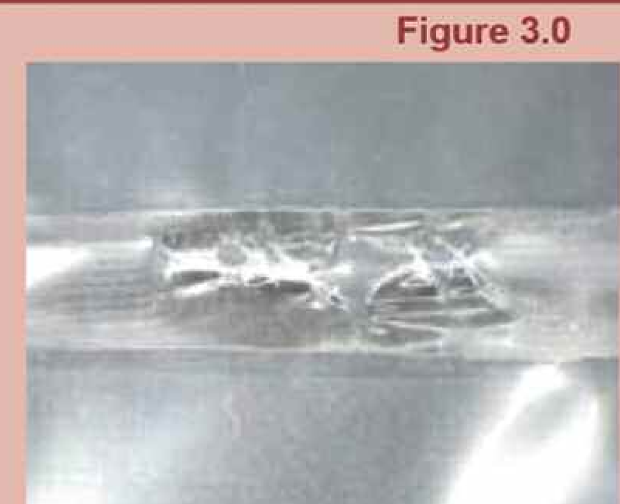
It was found that the opaque nature of heat seals meant that imperfections were clearly visible without microscopic examination and as such visual examination was capable of rejecting imperfect seals. This visual observation established that four of the five batches of bags, were supplied with some bags with imperfect seals with voids, creases and perforations of bags observed (figures 2.0 and 3.0).

It was found that the standard drop test method was not able to differentiate between bags with complete and imperfect seal, the exception being bags which were already perforated.

With GC-MS analysis it was found that where heat seals were visually examined and deemed to be complete they were capable of retaining VOC's. These performed equally as well as correctly performed swan neck tying.

Figure 2.0

Figure 3.0



Tensile strength testing was effective and differentiated between bags with complete and imperfect seals and allowed variability between batches, in batch and on individual bags to be tested. With this is was found that of the bathes, one was more consistent than the others with a 11.4 % (relative standard deviation) compared to the worst with 32.4%.

Visual examination and tensile strength testing conducted on Heat seals produced using the packer PBS-400 showed lower variability (percentage relative standard deviation) ranging from 6.5%, to 9.0 % on the bathes supplied, In addition with the exception of one batch the heat seals produced with the heat sealer had a greater tensile strength than those present on the bags when supplied, There was no statistical difference between the heat seals when the domestic 230 v supply or the Power Inverter were used.

Conclusions

This study has found that heat sealers can produce seals which are capable of retaining VOC's . It has been found that these may be made portable by the use of a power inverter enabling them to become battery powered, and that this has no detrimental effect on the seal generated. This technique provides advantages over the swan neck tying process commonly adopted in that while it has the same potential to retain evidence, the seals can be quickly and efficiently examined to establish whether an intact seal has been generated before leaving the scene, therefore ensuring that potential evidence is not lost.

It has been found that seal produced by some manufacturers are not always complete and so examination should be conducted on these seal also. However the seals generated during this study were more consistent and stronger than those produced by all but one supplier and as such the creation of all seals at the scene may therefore be more reliable.

Key findings

- There was great variability in the heat seals present on arson evidence bags received. With some bags having incomplete seals.
- The current method of swan neck tying, if conducted by experienced arson investigators is capable of producing appropriate seals on most occasions.
- An impulse heat seal made portable by use of an inverter retained VOC's, had less variability and produced seal of higher tensile strength than the manufacturer produced seals present on all but one batch of bags received.
- Truly portable heat sealers are not currently available, with those marketed as such simply having an extended cable connected to a base unit which is connected either a 110v or 230 v supply. The use of a portable battery based supply allows this more effective seal to be produced at the scene.

References

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