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Report

On-site trace explosive detection at the site of Bangkok bombing (Ratchaprasong intersection)

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Abstract: Three colorimetric test kits developed in-house were applied to the detection of traces of explosives at the scene of the Bangkok bombing at the Erawan shrine near Ratchaprasong intersection on the 6th and 10th days after the explosion (on August 23 and 27, 2015). The positive results from many sampling points indicated the presence of trinitrotoluene at the scene, in agreement with the police's presupposition.

Keywords: Bangkok bombing, colour test, explosive, Ratchaprasong intersection, on-site explosive detection

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INTRODUCTION

On Monday evening (18.55 local time, 11.55 GMT) of August 17, 2015, an improvised explosive device was detonated inside the Erawan shrine near the busy Ratchaprasong intersection in central Bangkok. The explosion killed 20 people and more than 125 people were injured. The Royal Thai Police suspected that the device consisted of about three kilograms of trinitrotoluene (TNT) stuffed into a pipe. The pipe bomb had been left under a bench near the outer rim of the grounds surrounding the shrine.

The Ratchaprasong intersection and the Erawan shrine were closed after the blast. Explosive ordnance disposal officers and Thai forensic police officers searched for evidence all night. On Tuesday morning, water trucks and workers from the Bangkok Metropolitan Administration were sent to clean up the area around the shrine and all traffic lanes were reopened at 12.34 p.m. on Tuesday (August 18, 2015). The Erawan shrine remained closed to the public on Tuesday but was reopened on Wednesday.

The suspected explosive materials used for this bombing were still questioned by both the public and police officers, although the scene was re-opened after three days had passed. This was because scientific analysis results from laboratory required at least two weeks after receiving the crime scene evidence collected by forensic officers. This was different from other well-known bombing situations such as Bali bombing in 2002, where a mobile laboratory was set up to produce timely findings for the investigators and reduce the number and volume of samples to be sent to the main laboratory for confirmatory analyses, as well as the contamination of the samples during transportation [1]. Presumptive tests and spot tests using various chemical reagents are commonly required firstly to reduce the number of samples. For example, diphenylamine test, modified Griess test, aniline hydrochloride test, and Nessler's test were used to detect suspected strong oxidisers by the Australian Federal Police forensic officers in the mobile laboratory for the Bali bombing [1].

In this work a number of rapid on-site explosive detection methods [2, 3] including colorimetric test kits [3] developed in our laboratory were employed to detect traces of explosive residues at the scene. Because of a law which allows only forensic officers in a crime scene investigation, on-site detection was performed after the shrine had been re-opened to the public, i.e. on August 23 and 27, 2015.

MATERIALS AND METHODS

Colorimetric Test Kits

Three colorimetric test kits were used to detect traces of explosives at the scene, namely a cryogel TNT test kit [4], a hydrogel TNT test kit [5] and a TNT selective film [6]. The cryogel TNT test kit was based on the entrapment of tetramethylammonium hydroxide (TMAH) within a cryogel matrix, while the hydrogel TNT test kit was based on the entrapment of potassium hydroxide within a hydrogel matrix, and in the TNT selective film ethylenediamine was entrapped within polyvinyl chloride (PVC) thin film.

The cryogel TNT test kit was prepared by dissolving polyvinyl alcohol granules in ultrapure water (12.5% w/v) at 100°C to obtain a clear viscous solution. After the solution (2.5 mL) was cooled down to room temperature, hydrochloric acid (3 $molL^{-1}$, 300 μL) and TMAH solution (25%, 500 μL) were directly added. The mixture was stirred for five minutes before adding glutaraldehyde (50 μL) and stirring for one more minute. Fifty microlitres of the mixture were transferred into a small tube (200 μL) and kept in a freezer overnight for further use.

The hydrogel TNT test kit was prepared using a similar procedure to that for the cryogel test kit. Potassium hydroxide solution (0.25 $molL^{-1}$, 1 mL) was added to the polyvinyl alcohol solution (5% w/v, 1 mL) as a colorimetric reagent in place of TMAH, while polyethylene glycol diglycidyl ether (25 μL) was used as a cross-linker instead of glutaraldehyde.

The TNT selective film was prepared by dissolving PVC granules in tetrahydrofuran (9% w/v) for 3 hours to obtain a clear PVC solution. Ethylenediamine (1.25 mL) and dioctylphtalate (75 μL) were sequentially added into the clear PVC solution (5 mL). Fifty microlitres of the mixture were transferred to a small tube and left in a safety cabinet for 3 hours until a thin film was formed. The lid of the small tube was then closed and the test kit was kept in a freezer prior to use.

Thirty test kits each were fabricated at the same time for on-site detection. Five of each were tested with a TNT standard solution in the laboratory to confirm their results before being used at the scene.

Sampling

On-site trace explosive sampling and detection was performed on August 23 and 27, 2015 (6 and 10 days after the explosion). On the days of sampling, the scene had already been cleaned up (on August 18) and the bomb crater had been cemented over. Trace explosive residues were sampled from 24 sampling points around the scene (Figure 1). A 'difficult-to-clean' area was selected at each sampling point (Figure 2). A cotton swab of acetone was used to remove the traces of explosives from the scene and all the residues on the cotton swabs were extracted with acetone into the test kits after sampling.

Figure 1. All 24 sampling points at the Erawan shrine

RESULTS AND DISCUSSION

Principles of Test Kits Used for On-site Detection

The cryogel TNT test kit [4] and hydrogel TNT test kit [5] are based on the formation of Janowsky anions from nitroaromatic rings of nitroaromatic explosives (e.g. TNT) with alkaline acetone [7-10]. Both test kits produce red-violet products in the presence of TNT (Figure 3a-b). The TNT selective film [6] is also based on the formation of a violet charge-transfer complex (Figure 3c) between an electron donating reagent (ethylenediamine) and an electron withdrawing analyte (TNT).

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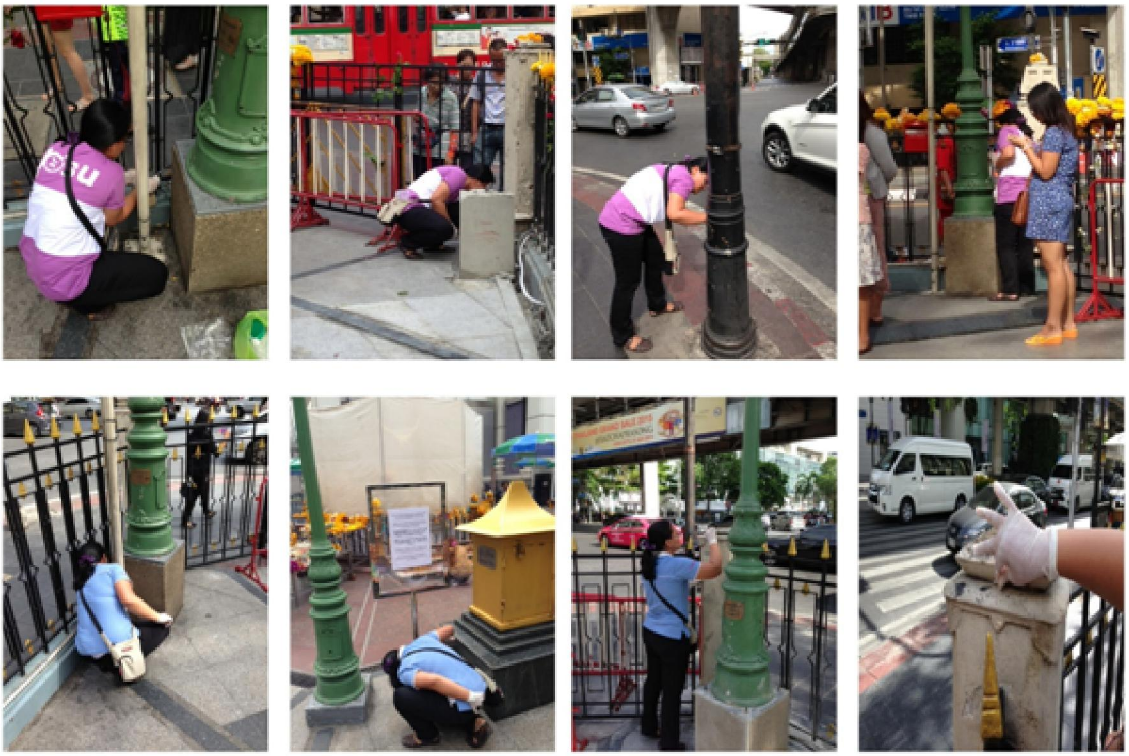

Figure 2. Collecting of samples on the 6th day (upper) and 10th day (lower) after the explosion

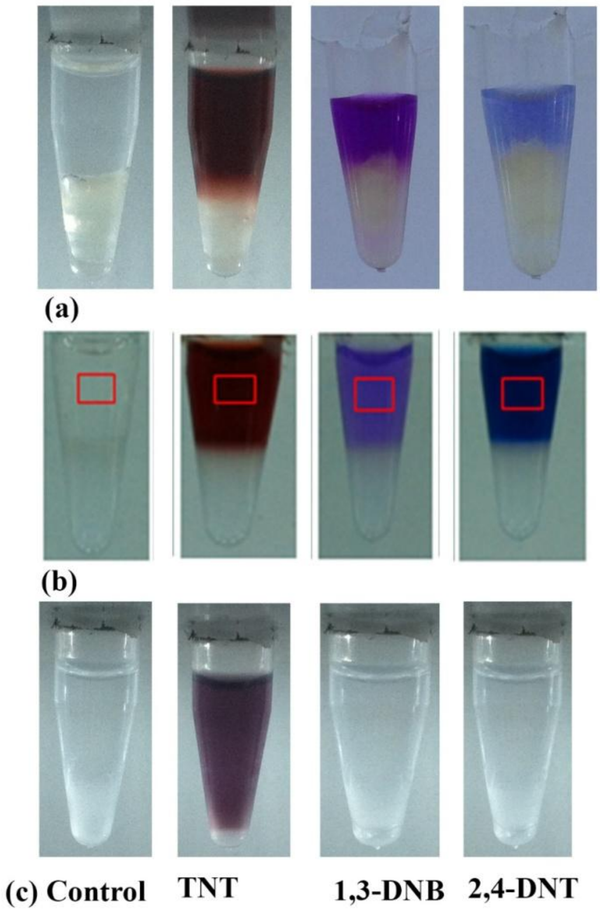

Figure 3. Results of testing standard explosives: TNT, 1,3-dinitrobenzene (1,3-DNB) and 2,4-dinitrobenzene (2,4-DNT), with (a) cryogel test kit, (b) hydrogel test kit, and (c) TNT selective film

The cryogel TNT test kit and the hydrogel TNT test kit can also produce a reaction with other nitroaromatic explosives, but produce a different coloured product compared to TNT. For example, 2,6-dinitrotoluene produces a purple product, and a blue product results from 2,4-dinitrotoluene [4, 5]. However, the TNT selective film reacts only with TNT, producing a violet product [6].

On-site Detection

Positive results for TNT were obtained from a number of sampling points. Because the blast centre (bomb crater) had been cemented over, the detection of trace explosives could not be conducted there, nor could it be conducted at the base of the fence both left and right of the bomb crater, which had also been cemented over. The nearest post to the left of the outer rim of the grounds surrounding the shrine (sampling point 21) provided a negative result at all height levels. It might be caused by the major cleaning operation carried out at the site on August 18. The nearest bench (sampling points 22 and 20) also provided negative results for all nitroaromatic explosives tested for with the test kits. Other sampling points on the left of the centre (sampling point 19: post of outer rim; sampling point 18: bench; sampling point 17: holy water bowl; and sampling point 16: elephant figurine) also gave negative results with all test kits.

A deep yellow product (Figure 4a) was obtained from the oracle board (sampling point 23), the nearest electricity post (sampling point 24), and the top of the nearest post on the right (sampling point 2, Figure 4b). None of explosives tested for, viz. TNT, dinitrotoluene (2,4-, 2,6-), 4-nitrotoluene, 1,3-dinitrobenzene, Composite 4 (C4, consisting of cyclonite or hexogen), pentaerythritol tetranitrate, ammonium nitrate, potassium nitrate, and power gel, produced a yellow product with any of the used test kits. However, in a previous unpublished preliminary research it had been found that triaminotrinitrobenzene produced a yellow product with TMAH (a colorimetric reagent used in the test kit).

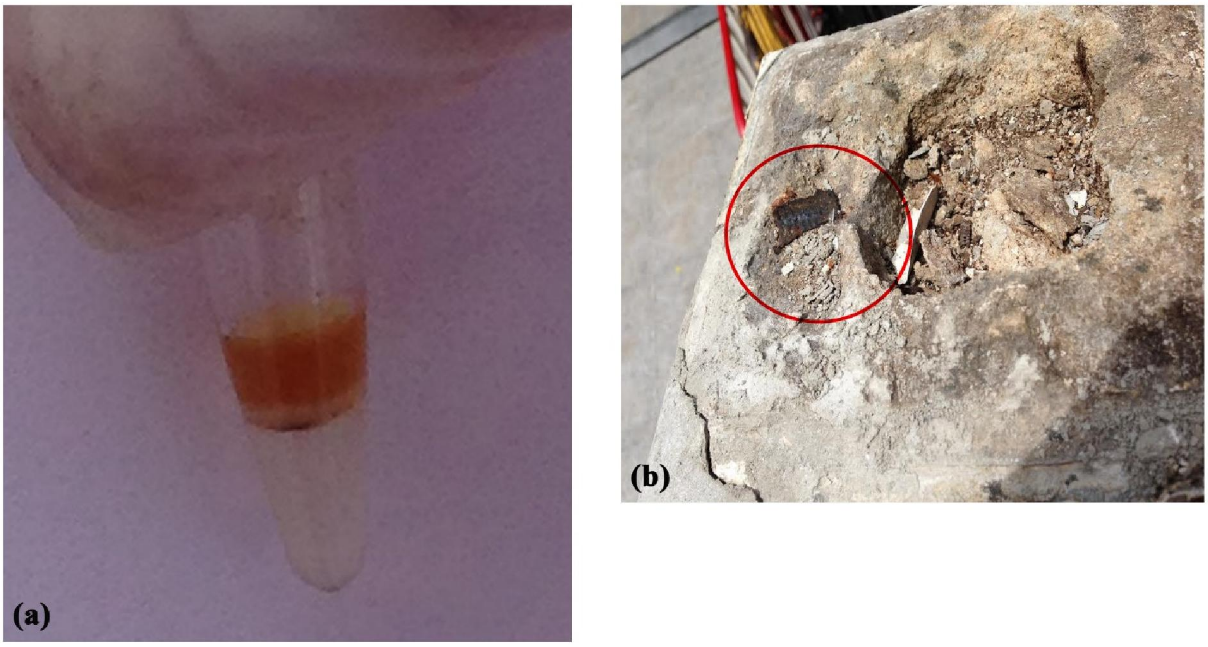

Figure 4. (a) yellow product from (b) sampling point 2 (sample collected from combustion product in red circle)

When residues from sampling points 12, 13, 14 and 15 (candle holders, Figure 5a) were tested using a cryogel TNT test kit, a pale red-violet colour immediately occurred for a few seconds before it disappeared (Figure 5b). It seems that there were traces of TNT at low concentrations at these sampling points. Since all the candle holders were very close to the bomb centre, the cleaning operation had only been successful in reducing the amount of explosive residues, not entirely eliminating them. Because some victims died in this area, the cleaning operations might have been concentrated on eliminating all traces of blood and body tissues.

Figure 5. (a) Sampling point 13 (candle holder); (b) coloured products obtained from the test

At the nearest post of the outer rim to the right of the crater (sampling point 1), a negative result was produced at ground level due to the effects of the cleaning operation. However, a red-violet product was obtained from a difficult-to-clean area at a higher level (Figure 6a) on both the 6th day (Figure 6b) and 10th day (Figure 6c) after the explosion. The results indicated the presence of TNT at this sampling point, where both the cryogel (Figure 7a) and hydrogel (Figure 7b) test kits provided the same positive results even though the samples were tested 10 days after the explosion. Some combustion product was also observed on the top of a broken post at sampling point 2 (Figure 4b), which gave a deep yellow product as discussed above. Other posts (sampling points 3 and 5) produced a paler red-violet product (Figures 6d and 6e respectively) compared to sampling point 1, because they were at a longer distance from the blast centre. A difficult-to-clean area between the electricity post and the outer rim post (sampling point 4) gave a red-violet product (Figure 6f), while two benches near the outer rim (sampling points 6 and 8), all high levels of the tree (sampling point 9) and an electricity post (sampling point 11) provided negative results.

The red-violet product was also obtained from the sample swabbed from a slot in the donation box (sampling point 10, Figure 8a) using both the cryogel TNT test kit (Figure 8b) and the TNT selective film (Figure 8c). This firmly indicates the presence of TNT at the scene due to the selectivity of the TNT selective film.

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Figure 6. Collecting of sample at a high level of sampling point 1 (a); coloured product on 6th day (b) and 10th day (c) after the explosion; and coloured product from sampling point 3 (d), sampling point 5 (e) and sampling point 4 (f)

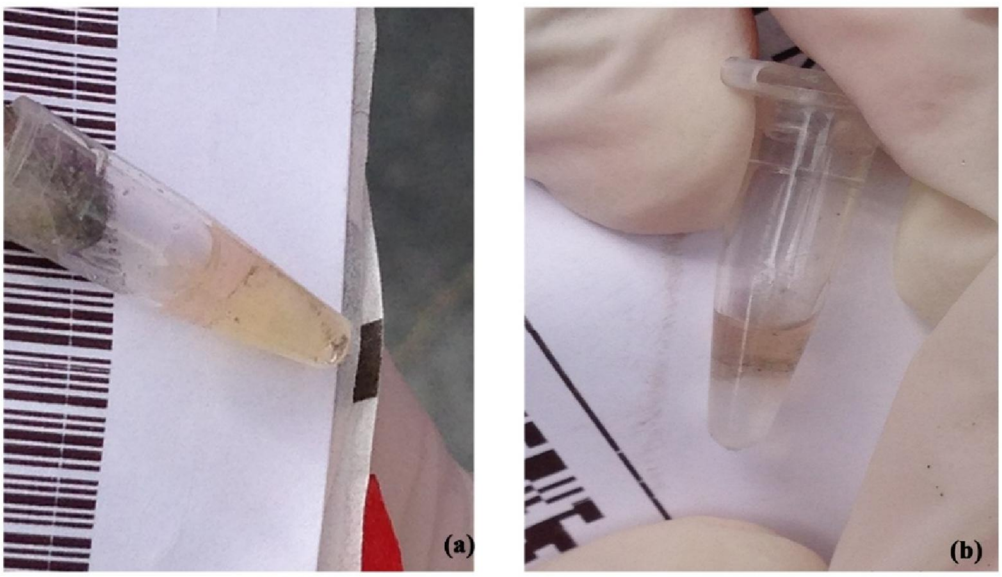

Figure 7. Coloured products from sampling point 1 on the 10th day after the explosion with a cryogel test kit (a) and a hydrogel test kit (b)

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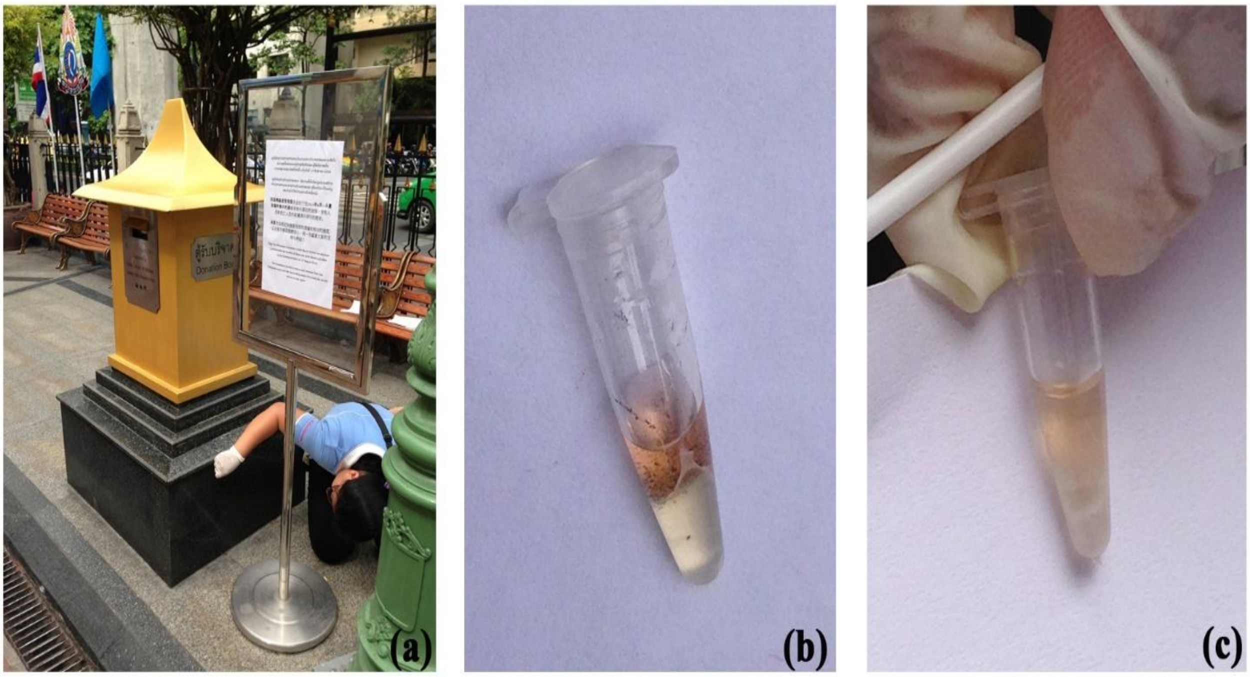

Figure 8. Sampling point 10 (donation box) (a) and coloured products from samples on the 10th day after the explosion with cryogel test kit (b) and TNT selective film (c)

CONCLUSIONS

The use of in-house colorimetric test kits for on-site post-blast detection of trace explosive residues at the Bangkok bombing scene, at the Erawan shrine near the Ratchaprasong intersection, indicates the use of TNT.

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