

DNA profiling

Processing evidence from real crime scenes with Rapid DNA technology

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In this application note, we discuss:

- Processing evidence from real crime scenes with the RapidINTEL Sample Cartridge Kit
- Using the RapidHIT ID System to construct DNA profiles
- Implementing an efficient sample-to-profile workflow for criminal investigations
- Reducing the time needed for identification to improve and expedite criminal investigations

Introduction

Processing evidence to construct a DNA profile generally involves sampling, chemical lysis, DNA extraction, purification, quantitation, amplification, and capillary electrophoresis. Completing all of these steps takes time, and there is always a risk of human error or sample contamination. It can take up to 48 hours for a forensics laboratory to generate a DNA profile from a piece of evidence, and tending to urgent cases can disrupt the normal laboratory workflow. The Applied Biosystems™ RapidHIT™ ID System is a solution for processing evidence from active cases when investigators need answers as quickly as possible. The RapidHIT ID System is a single benchtop instrument that integrates sample preparation, lysis, DNA amplification, and capillary electrophoresis into a 90-minute workflow. Here we describe how to process various types of evidence and obtain reliable, interpretable, and distinct DNA profiles.

A 2016 law passed in the Province of Mendoza mandated the creation of a local DNA database to house information about criminal suspects, convicted criminals, imprisoned criminals, police forces, and evidence from unknown sources. The database contained approximately 56,000 profiles as of September 2021, 630 of which were constructed using evidence obtained at the scenes of serious crimes such as homicide, sexual assault, and aggravated robbery. Since DNA profiles for these cases are uploaded to the FBI's Combined DNA Index System (CODIS), it has become increasingly important to generate reliable profiles quickly. Incorporating the RapidHIT ID System into forensics workflows can help law enforcement rapidly identify perpetrators, which can expedite their detention, prosecution, and conviction.

Collecting facial masks as evidence has become more common since the beginning of the global SARS-CoV-2 crisis. This is because a mask is often removed and discarded during the act of a violent crime, and it is easy to identify masked individuals by reviewing security camera footage and statements from witnesses and victims. DNA is often transferred onto facial masks and pieces of clothing that come into intimate contact with crime suspects. These types of samples are excellent candidates for rapid analysis after the occurrence of serious crimes, and they can significantly accelerate the identification of perpetrators. Processing samples on the RapidHIT ID System is quite simple, since the user only has to place a sample in the Applied Biosystems™ RapidINTEL™ Sample Cartridge Kit and insert it in the instrument. A check mark appears on the screen of the

RapidHIT ID System when processing is complete, and a forensic analyst can review the results using the SoftGenetics™ GeneMarker™ HID Software. A green check mark means that a profile has been generated, while a yellow or red check mark indicates an unsuccessful run. In this report, we describe using the RapidHIT ID System to generate DNA profiles with evidence obtained from real crime scenes.

Materials and methods

Eight pieces of evidence were processed in a forensic genetics laboratory to obtain DNA profiles for the Provincial Registry of Digitized Genetic Footprints (RPHGD) on behalf of the Ministerio Público Fiscal in Mendoza, Argentina. The evidence consisted of personal accessories that were likely to generate single-source DNA profiles and included five facial masks, two caps, and a neck gaiter. The laboratory used the RapidHIT ID System to generate genetic profiles after processing the evidence with the RapidINTEL Sample Cartridge Kit. The resulting profiles were then analyzed with the GeneMarker HID Software v2.9.5.

Sample preparation

The types of evidence and their condition prior to analysis are shown in Table 1. The evidence was carefully examined in a laminar flow cabinet to find suitable locations for sampling. Samples were taken from the nasal clips of the facial masks, parts of the masks that covered the mouth, and parts of fabric on the caps and neck gaiter that had come into contact with skin. After the samples were collected, they were cut to assess thickness. This was done to avoid excessive absorption of the lysis buffer. A 1 cm² piece of fabric was cut from a sample if it was not very thick, while smaller pieces of approximately 0.25 cm² in size were cut from thicker fabrics. The samples were placed directly in the cartridges and processed on the RapidHIT ID System. Once processing was complete, the samples were removed and dried for further analysis or confirmation. All samples were processed in parallel with validated techniques that the laboratory routinely used to analyze evidence.

Table 1. Types and conditions of evidence analyzed on the RapidHIT ID System.

Sample	Condition	
Facial mask (A)	Heavily used	
Facial mask (B)	Heavily used with blood stains	
Facial mask (C)	Heavily used	
Facial mask (D)	Lightly used	
Facial mask (E)	Lightly used	
Neck gaiter (F)	Heavily used with traces of mucus on the inner fabric	
Cap (G)	Lightly used, inner front fabric	
Cap (H)	Heavily used, inner front fabric	

Results

Each DNA profile was evaluated to determine whether it was ready for a DNA database search or required review by a forensic analyst. Profiles were considered ready if they received green check marks. A yellow check mark indicated the quality of the profile was poor, and that it would require manual review and editing. A red check mark indicated that no DNA profile was generated at all.

All of the profiles received yellow check marks in the first analysis and required review by a forensic analyst. Full single-source profiles were obtained for five of the samples in a second analysis, while mixed profiles were obtained for the other three. Table 2 summarizes the results of the first and second analyses. The percentages of markers that met all quality requirements in the first analysis are shown in the second column. The percentages of markers that were confirmed after review and editing by the analyst are listed in the third column. Seven out

of eight profiles met the CODIS quality criteria and were used in automated searches of the RPHGD DNA database. Six matches were identified less than three hours after the evidence arrived at the laboratory, and the corresponding profiles helped solve six different cases.

One of the facial masks was found at a bus stop in Mendoza, where a homicide took place at approximately 9:30 p.m. on November 22, 2020. The perpetrator tried to steal the victim's cell phone and wallet. The perpetrator drew his weapon after a brief struggle and fired two bullets into the victim's chest, resulting in the victim's death. The perpetrator fled the crime scene but left a cap and facial mask behind. The suspect was arrested less than 48 hours after processing the evidence on the RapidHIT ID System and searching the database. The suspect was eventually found guilty of homicide by a jury and sentenced to life in prison.

Table 2. Results of profile analyses and CODIS database searches.

Sample ID	First analysis	Second analysis	Final profile	Results of CODIS search
A	90.9%	100%	Full single-source profile	Uploaded, match found
B	27.3%	100%	Full mixed profile	Uploaded, match found
C	0%	86.4%	Partial mixed profile	Uploaded, no match
D	81.8%	100%	Full single-source profile	Uploaded, match found
E	40.9%	100%	Full single-source profile	Uploaded, match found
F	81.8%	100%	Full single-source profile	Uploaded, match found
G	9.1%	100%	Full single-source profile	Uploaded, match found
H	0%	68.2%	Partial mixed profile	Not uploaded

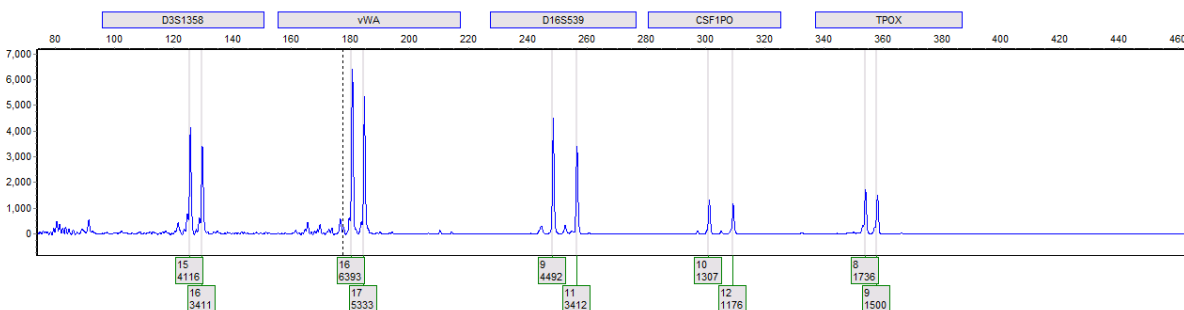


Figure 1. Electropherogram for a single-source profile generated from a facial mask (D).

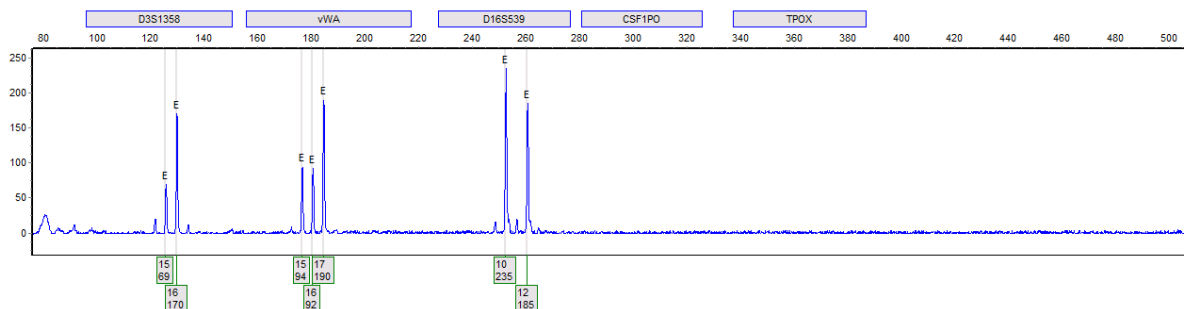


Figure 2. Electropherogram for a partial mixed profile generated from a facial mask (C).

Conclusions

The genetic profiles obtained from the samples analyzed in this study were of high quality and comparable to profiles generated using traditional methods. Profile generation with traditional methods can take up to 48 hours and often disrupts the laboratory workflow. Processing samples and generating genetic profiles on the RapidHIT ID System can be achieved in just 90 minutes without interrupting routine work. The types of samples analyzed in this study are appearing more frequently in forensics laboratories, and they can serve as valuable evidence. The RapidHIT ID System can generate DNA profiles quickly to support law enforcement and expedite trials that lead to longer sentences for perpetrators of serious crimes.

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