



One-step Forensic DNA Purification

Nucleic acid extraction is a standard process in every molecular biology study. For forensic DNA analysis, DNA extraction is the first and most important step in creating DNA profiles that can be used to identify individuals based on their unique genetic makeup. Because of the limited nature of biological evidence recovered from some crime scene samples, nucleic acid purification is the most crucial part of forensic science. Despite significant developments in DNA purification technology over the last decade, successfully purifying appropriate quantities of inhibitor-free nucleic acids from a diverse range of Forensic DNA samples is still a significant challenge.

The general technique for forensic DNA analysis is as follows: 1) sample collection from a crime scene; 2) DNA purification from the sample; 3) quantitative and qualitative purified DNA; 4) Multiplex PCR amplification; 5) DNA analysis; and 6) report generation.

Sample collection from a crime scene

Forensic biological samples are distinguished by a limited amount, mixing with several substrates and PCR inhibitors, being directly exposed to poor environmental conditions, and uncontrolled DNA degradation. Cigarette butts, single human hairs without a root, fingernail scrapings, urine, saliva, epithelial cells, damaged bone and tissue, bite marks, sperm, blood stain, touch DNA samples, and so on are all examples of evidence samples. Collecting DNA evidence from a crime scene is critical for successful DNA profiling. Before performing any DNA analysis, the evidence must be carefully and correctly collected, maintained, kept, and transferred in all situations.

DNA purification from the sample

Since forensic samples are in trace amounts and are frequently mixed with an unfavorable PCR inhibitor, obtaining sufficient high-quality DNA from samples to support criminal investigations, victim identification, and missing person investigations is often a significant challenge. The most efficient nucleic acid extraction and purification methods must be developed and used to ensure successful downstream genetic profiling by PCR.

The following processes are involved in DNA extraction: (1) rupture of cytoplasmic and nuclear membranes; (2) separation and purification of DNA from other cell lysate components such as lipids, proteins, and other nucleic acids; and (3) concentration and purification of DNA. It is critical to ensure the quality and quantity of the isolated DNA to carry out the intended downstream applications when selecting an appropriate method for DNA extraction. Other factors to consider while optimizing the DNA extraction procedure include Time, cost, potential toxicities, yield, laboratory equipment, skill requirements, and the sample amount necessary for the protocol. Currently, two isolation strategies are used for DNA purification: negative chromatography purifying selection and positive chromatography purifying selection (Figure 1). In negative chromatography, impurities bond on the adsorbent, allowing DNA to pass through the chromatographic column. In contrast, positive chromatography retains the desired DNA in the stationary phase while unbound contaminants flow through the column.

Classic silica-derived spin columns and magnetic beads used for DNA and RNA purification are based on positive chromatography purifying selection. High chaotropic salt concentrations, such as guanidine hydrochloride, bind DNA or RNA to silica. The silica column or beads is washed with a salt/ethanol solution after nucleic acid binding to eliminate additional biomolecules from the sample. Finally, the column or beads is eluted using Tris elution buffer or water to remove the pure DNA or RNA. Such bind-wash-elute procedures are time-consuming, requiring multiple washing and spinning steps. Repetitive spin steps can cause considerable DNA loss (20-40%) and shearing. Furthermore, chaotropic salts and other

impurities can easily pass through the eluted DNA or RNA, compromising ultimate purity and quantification as well as downstream enzymatic activities like PCR.

In contrast, negative chromatography purifying selection is a new nucleic acid purification technology that avoids the requirement for high salt binding and ethanol wash procedures, resulting in purer DNA and RNA preparations and more robust results. In negative chromatography, the multifunctional adsorbents efficiently capture and hold sample impurities such as protein, lipid, and ionic components in the sample while allowing nucleic acids to pass through the column, decreasing the number of steps and plastic materials required for purification. Additionally, since it does not touch the DNA and RNA molecules, no nucleic acids will get lost during the purification procedure.

Negative chromatography has three main advantages over positive chromatography:

- Simplified workflow-Single step, fast
- Superior performance- High quality and maximized DNA recovery with minimal loss of DNA
- Waste reduction- Use fewer plastic tubes and no toxic substances.

BcMag™ One-Step DNA Purification System

BcMag™ One-step DNA Purification System uses novel Negative chromatography magnetic beads to quickly deliver higher quality and superior DNA yield from most trace forensic DNA samples. Those samples include body fluids, stains, swabs of body fluids, strip-removed cells, cigarette butts, Hair follicles, fingernail scrapings, epithelial cells, bite marks, semen, touch DNA samples, etc. The specially designed magnetic beads with our proprietary surface chemistry function simultaneously to lyse cells and capture the PCR inhibitors once mixed with the sample. The magnetic beads-PCR inhibitor complex was then magnetically removed by a magnet while the pure DNA remaining in the solution was ready for downstream STR analysis.

Traditional DNA purification techniques involving a tedious lyse-bind-wash-elute procedure easily lose the target DNA due to multiple tube-to-tube transfers and toxic chemicals such as chaotropic salts and ethanol, which is a risk of carryover into the final sample influencing the downstream applications. BcMag™ One-step DNA Purification System uses one tube, one step, and no toxic chemicals protocol to purify DNA from hundreds of samples without using expensive equipment in less than an hour. The workflow comparison of positive and negative DNA purification is summarized in Fig.1

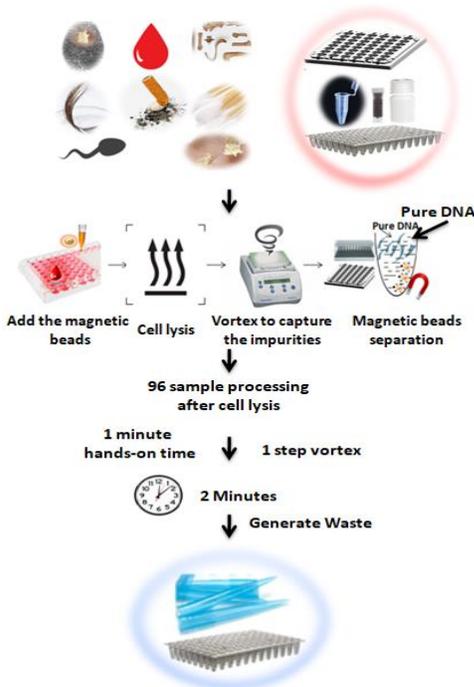


Fig.1 Workflow of One-Step Forensic DNA Purification

Magnetic bead separation is a fast, effective, and clean method used by scientists to replace filtering, centrifugation, and separation processes. Time-resolved Fluorescence Magnetic Beads can be used for immunoassays and other applications. They have high surface-to-volume ratios, small sizes (0.1-10µm), various functional groups attached to the surfaces (e.g., antibodies, DNA, and chemical groups), and the ability to manipulate the particles via an applied magnetic field easily. Combined with automated liquid handling and robust detection instrumentation, these characteristics enable a wide range of high-throughput applications.

Features and Advantages

- Rapid and efficient purification protocol: without prior DNA isolation for subsequent use in direct amp workflows, No liquid transfer, and One-tube
- Ultrafast: Process 96 samples in less than an hour
- Higher purity and DNA yield with minimal contamination with RNA from various trace samples.
- Effectively removes inhibitors: polyphenolic compounds, humic/fulvic acids, acidic polysaccharides, tannins, melanin, heparin, detergents, denim dyes, divalent cations such as Ca²⁺, Mg²⁺, etc. (Fig.2)
- Cost-effective: Eliminates columns, filters, laborious repeat pipetting, and organic reagents.
- High-throughput: Compatible with many different automated liquid handling systems

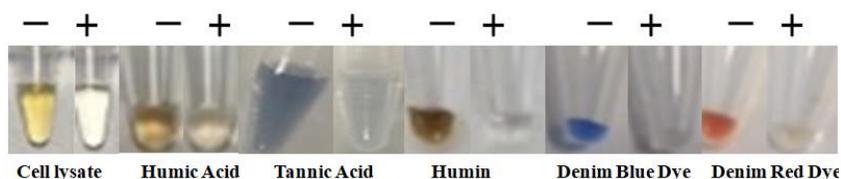


Fig.2 Cell lysate cleanup and PCR inhibitor removal

Workflow

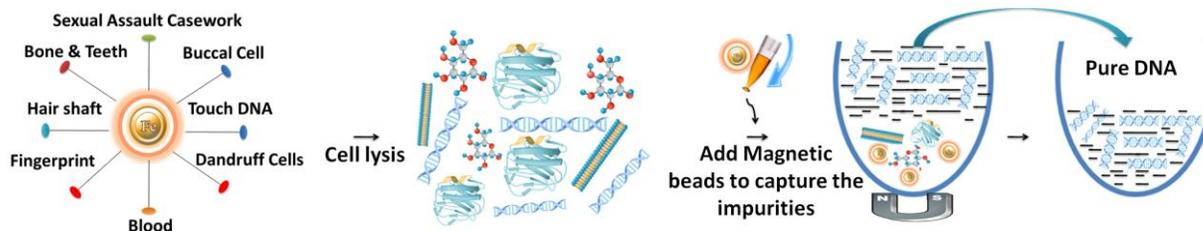


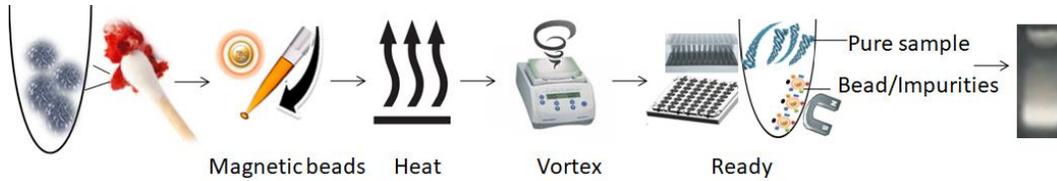
Fig.3

1. Add functional magnetic beads to the sample.
2. Mix the samples with the magnetic beads and heat to lyse the cells.
3. Vortex for 5 minutes for the beads to capture the PCR inhibitors.
4. Remove the beads with a magnet.
5. Aspirate the supernatant containing the pure ready-to-use DNA.

Touch DNA Purification

BcMag™ One-Step Touch DNA Purification Kit uses novel Negative chromatography magnetic beads to quickly deliver higher quality and superior DNA yield from most trace touch samples. Those samples include body fluids, stains, swabs of body fluids, Strip removed cells, cigarette butts, Hair follicles, fingernail scrapings, epithelial cells, bite marks, semen, touch DNA samples, etc. The specially designed magnetic beads with our proprietary surface chemistry function simultaneously to lyse cells and capture the PCR inhibitors once mixed with the sample. The magnetic beads-PCR inhibitor complex was then magnetically removed by a magnet while the pure DNA remaining in the solution was ready for downstream STR analysis. The purification kit provides a fast and simple method for DNA purification with only one tube, no liquid transfer, and no requirement

for carrier RNA. It reduces the risk of DNA loss and carryover of extraction buffers from the traditional and tedious bind-wash-elute procedure. After preparing the lysates, it enables the processing of 96 samples in less than 15 minutes, with less than 1 minute of hands-on Time.

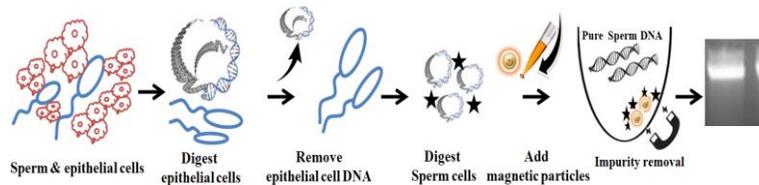


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[One-Step Touch DNA Purification Kit](#)

Sexual Assault Casework DNA Purification

BcMag™ Sexual Assault Casework Purification DNA Kit provides quick and efficient purification of male DNA from a trace amount of sexual assault samples. The kit uses novel negative selection chromatography magnetic beads to quickly capture impurities such as PCR inhibitors from cell lysate, leaving the male DNA untouched. It reduces the risk of DNA loss and buffers carryover from the time-consuming bind-wash-elute technique. The purification kit provides a quick and easy way to purify DNA. Quantitative PCR and STR analysis work well with pure DNA.



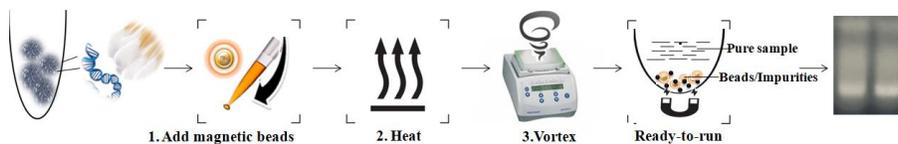
Workflow of sexual Assault Casework DNA Purification kit

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[Sexual Assault Casework DNA Purification Kit](#)

Buccal Cell DNA Purification

BcMag™ One-Step Buccal Cell DNA Purification Kit allows rapid and efficient purification of genomic DNA from buccal swabs or pelleted cells from a mouthwash. It uses novel negative selection chromatography magnetic beads to quickly capture and remove the impurities, such as PCR inhibitors from cell lysate, leaving the DNA untouched. It reduces the risk of DNA loss and carryover of extraction buffers from the traditional tedious bind-wash-elute procedure. The purification kit provides a fast and straightforward DNA extraction method with only one tube, no liquid transfer, and no requirement for carrier RNA. After preparing the lysates, Hundreds of samples can be processed in less than 30 minutes without using expensive equipment.



Principle and Workflow of Buccal Cell DNA Purification

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[One-Step Buccal Cell DNA Purification Kit](#)

Blood DNA Extraction

BcMag™ One-step Blood DNA Purification Kit allows rapid and efficient purification of genomic DNA from whole blood, serum, plasma, or other body fluids. The kit uses our unique proprietary magnetic beads to efficiently lyse cells and remove all impurities simultaneously in an aqueous buffer, leaving the DNA untouched. The procedure employs mild lysis conditions, avoiding harsh conditions such as alkaline lysis and toxic chemicals for lysing cells to maintain DNA integrity and the time-consuming cleanup of organic solvent from the sample. Furthermore, the magnetic beads eliminate PCR inhibitors from samples in a single step without DNA extraction. It increases DNA integrity, boosts nucleic acid yields, and minimizes DNA loss caused by typical DNA purification techniques' time-consuming "bind-wash-elute" procedure. Following sample lysis, the straightforward one-step purification technique enables the simultaneous processing of >96 samples and produces pure DNA in less than 30 minutes. Purified genomic DNA has the highest integrity and can be used in various downstream applications such as qPCR, STR, etc.



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[One-Step Blood DNA Purification Kit](#)

Hair Shaft DNA Purification

BcMag™ Hair Shaft DNA Purification Kit is designed to extract total nucleic acids from single hair shaft samples efficiently and sequentially. The kit uses our unique proprietary lysis buffer to efficiently lyse hair cells and magnetic beads to purify hair shaft DNA.



Workflow of Hair Shaft DNA purification

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[Rootless Hair DNA Purification Kit](#)

Bone and Teeth DNA Isolation

BcMag™ Bone and Teeth DNA Purification Kit are designed to extract total nucleic acids from bone and teeth samples efficiently and sequentially. The kit uses our unique proprietary magnetic beads in combination with an optimized demineralization buffer for higher yield and super-quality DNA. Purified genomic DNA has the highest integrity and can be used in various downstream applications such as qPCR, STR, etc. The procedure employs mild lysis conditions, avoiding harsh conditions such as alkaline lysis and toxic chemicals for lysing cells to maintain DNA integrity and the time-consuming cleanup of organic solvent from the sample.



Workflow of Bone and Teeth DNA Purification Kit

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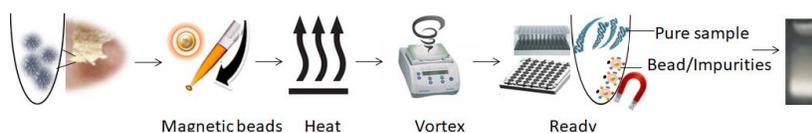
[Bone and Teeth DNA Purification Kit](#)

One-Step Dandruff Cell DNA Purification Kit

BcMag™ One-Step Dandruff Cell DNA Purification Kit allows rapid and efficient purification of genomic DNA from Dandruff. It uses novel negative selection chromatography magnetic beads to quickly capture and remove the impurities, such as PCR inhibitors from cell lysate, leaving the DNA untouched. It reduces the risk of DNA loss and carryover of extraction buffers from the traditional tedious bind-wash-elute procedure. The purification kit provides a fast and straightforward DNA extraction method with only one tube, no liquid transfer, and no requirement for carrier RNA. After preparing the lysates, Hundreds of samples can be processed in less than 30 minutes without using expensive equipment.

Principle and Workflow (Fig.1 “Principle and Workflow”)

The *specially* designed magnetic beads with our *proprietary* surface chemistry function capture the impurity once mixed with the sample. The magnetic beads-impurity complex is then magnetically removed by a magnet while the pure DNA remains in the solution.

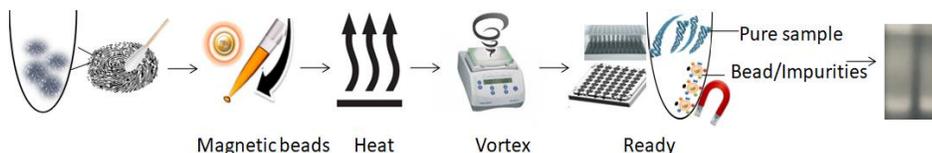


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[One-Step Dandruff DNA Purification Kit](#)

BcMag™ One-Step Fingerprint DNA Purification Kit

The principle of the BcMag™ One-Step Fingerprint DNA Purification Kit is based on negative selection chromatography using magnetic beads. The kit utilizes specially designed magnetic beads with a proprietary surface chemistry that can capture impurities, such as PCR inhibitors, from the sample. Once mixed with the sample, the magnetic beads bind to the impurities and form a magnetic beads-impurity complex. The workflow of the purification process involves three main steps: Sample Preparation: The biological sample is lysed and processed to release the DNA. Purification: The lysate is mixed with the magnetic beads, and the impurities are captured by the beads. The magnetic beads-impurity complex is then magnetically removed from the solution by using a magnet. Elution: The pure DNA remains in the solution and can be easily transferred by simply pipetting the DNA-containing solution to a new tube. Overall, the BcMag™ One-Step Fingerprint DNA Purification Kit provides a fast and straightforward DNA extraction method with only one tube, no liquid transfer, and no requirement for carrier RNA, allowing for rapid processing of hundreds of samples in less than 30 minutes without the need for expensive equipment.



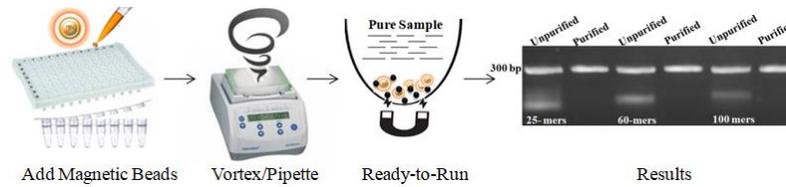
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[One-Step Fingerprint DNA Purification Kit](#)

PCR Cleanup

BcMag™ One-Step PCR Cleanup Kit is a specially designed kit for ultrafast and efficient purification of post PCR or other DNA reactions. The protocol is not only straightforward (one tube and one step, as shown in Fig.1) but also very flexible in removing different size DNA fragments by adjusting processing time, buffer's pH, and detergent concentration (table1). The magnetic Beads are added directly to the finished PCR reactions or other DNA reactions and mixed by a vortex mixer or pipetting to capture and remove the impurities (e.g., excess primer, dimer, adapter, salt, detergent, dNTPs, and enzyme). After mixing, the beads are magnetically removed, while the supernatant contains the purified and ready-to-run

products. In just 1 minute, the purified DNA is ready for downstream applications, such as Sanger Sequencing, Restriction Digestion, Cloning, SNP Detection, or Library Preparation for NGS. The beads enable 96 samples to be processed simultaneously in less than 10 minutes.



Workflow of One-Step PCR Cleanup Kit

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[One-Step PCR Cleanup Kit](#)

BcMag™ One-Minute PCR Inhibitor Removal Kit provides one-step removal of PCR inhibitor from impure DNA samples before PCR, RT, and other downstream applications based on negative chromatography. The magnetic beads are magnetic and modified with our proprietary chemistry. When mixed with inhibitor-containing samples, the beads instantly capture and remove the PCR inhibitors. At the same Time, only the pure DNA remains in the solution and is ready for all downstream applications (Fig.1). The beads can effectively remove many common inhibitors such as polyphenolic compounds, humic/fulvic acids, acidic polysaccharides, tannins, melanin, heparin, detergents, and denim dyes, and divalent cations such as Ca^{2+} , Mg^{2+} , etc.

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[One-Step PCR Inhibitor Removal Kit](#)

General references

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