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PERSPECTIVE

Clothes and the evidences they carry: A perspective on its forensic examination

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Abstract
Forensic examination of clothes can furbish key evidences which can eventually aid in the overall investigation process. Apart from ascertaining the identity of individuals based on the garment itself, additional evidences of physical, biological, and, chemical nature, interlaced within the fabric can help reconstruct events leading up to the crime. Clothing evidence can also help in determining the manner of death, the location of a crime scene, and, oftentimes even the post-mortem interval. Clothes when encountered at a crime scene must be documented, collected and packaged carefully before subjecting them to characteristic predetermined tests to detect evidences of a specific nature.

Keywords
Clothes; Identification; Forensic examination; Physical, chemical, biological evidence

Anthropologically, the act of draping oneself in garments is an attribute exclusive to the mannerisms of a human society. [1] While such an act has certain obvious anthropological implications, it also has a significant role to play from a forensic viewpoint. Clothes, or lack thereof at any scene of crime can provide key evidences for the investigation process. Not only do they go a long way in establishing the identity of individuals, but also, the hoard of evidences interlaced within the fabric in itself can help in reconstructing events associated with the crime.

Clothes often aid in profiling through indicators of gender, occupation, income and social status, political, religious and/or cultural affiliations and marital status.[2] Such an identification is rendered possible through a careful scrutiny of the type of fabric, colour, make, and possible laundry and tailoring marks. In addition to this, clothing evidence found at a crime scene can provide characteristic clues regarding the manner of death, the location of a crime scene, and in certain cases, even post-mortem interval. Saliva in cases of hanging, vomitus for poisoning cases, mud and other debris in cases of drowning, blood, grease, tyre marks on clothes for road traffic and other accidents, and, the number and directionality of cuts and tears on fabrics, are some common indicators of the manner of death.[2] The presence of seminal stains and other body fluids on garments can oftentimes indicate possible sexual assault. Demarcating the location of a crime scene through the examination of mud stains, grass stains, glass shards and grease stains associated with garments can help speed up the investigation process. Such characteristic marks pave the way forward by providing plausible starting points for investigation. The nature and type of garments are also known to influence the observed post-mortem interval. A fair share of PMI interval targeted research has highlighted the effect different fabrics have on the rate of decomposition. [3-6]

Evidence found on clothes, based on their nature, can be broadly classified as physical, biological and chemical, including prints, impressions and trace evidences. The methodological collection and packaging of clothes post documentation is dependent to a large extent on the number and nature of evidences presenting for examination. Analysis of each evidence is done in a step-wise manner: highly sensitive presumptive tests, followed by a highly specific set of confirmatory tests, with predetermined tests for each evidence.[7-14] Physical evidences include prints and other impressions including tyre, tread and tool marks, paint and glass. A breakdown of the analysis of different physical evidences has been listed under Table 1. The most commonly encountered biological evidences found on clothes include blood and other body fluids. A summary of the documentation/packaging and analysis of different body fluids is shown in Table 2. Table 3 lists out other commonly encountered biological evidences such as hair and fibres, soil, pollen and insect evidences and their examination. Chemical evidences associated with clothes range from drugs, petroleum products, GSR and explosives, to cosmetic evidences. Remnants of petroleum products and accelerants can be visualized and photographed under UV light. Clothes and footwear collected from the scene of crime should be packaged in air-tight nylon bags and subsequently extracted using a sequential combination of filtration, evaporation and steam distillation. Explosive residues should be collected using acetonitrile swabs and visualized using Raman confocal microscopy. Analysis of petroleum and explosive residues is

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Table 1: Forensic examination of physical evidence associated with clothes found at a crime scene

Evidence	Documentation/ Collection	Presumptive tests/ Class characteristics	Confirmatory tests/ Individual characteristics
Fingerprints	For latent prints: photography using ALS, Laser. For visible prints: enhance quality of prints using LMG, Ninhydrin, Amido black, Leuco crystal violet followed by photography.		Iodine fuming; 1,2 Indanedione; Ninhydrin; Cyanoacrylate fuming with IR spectral mapping (destructive); Luminocyan (destructive); VMD
Footwear and footprints	Photography Gelatin lifter Electrostatic dust print lifting Blood prints : enhance using LmG, Ninhydrin, Amido black, Leuco crystal violet followed by photography.	Compared with standard set of prints/impressions using the Gunn method, Optical centre method, and superimposition.	Compared with the standard set of prints/impressions using individual characteristics.
Tyre and tread marks	Photography	Compared with stand ard marks using tyre stance, tread depth, tread width, logo design.	Compared with standard marks using individualising wear and tear marks.
Tool marks	Photography	Identification and comparison using comparison and stereomicroscopes based on type, width, direction, and diameter.	Comparison using individualising wear and tear marks.
Paint	Photography Packaging in plastic or paper bindles after careful drying of fabric. Scraping, lifting, cutting out portion containing paint evidence (destructive).	Physical matching of paint chips; Micro chemical tests (destructive).	Polarizing Light Microscopy ; Vibrational spectroscopy (IR/ RS) ; Pyrolysis GC (destructive) ; MS; SEM-EDX; XRF, XRD ; Fluorescence microscopy ; Low temperature ashing (destructive) ; Solvent extraction (destructive) ; AEM; Cathodoluminescence
Glass	Photography Collected using rubber tipped forceps and packaged in separate cardboard or plastic containers.	Surface, texture and colour analysis to identify possible source. Thickness using a micrometer gauge. Curvature using a spherometer. Density tests Refractive index tests using a refractometer, hot stage microscope, phase contrast microscope.	Examination of glass fractures. Elemental analysis using ICP -AES; XRD; XRF; Vibrational spectroscopy.

Table 2: Forensic examination of body fluids

Evidence	Documentation/ Collection	Presumptive tests/ Class characteristics	Confirmatory tests / Individual characteristics	Additional examination
Blood	Photography Wet stains should be air dried prior to packaging. Dried stains are best collected using acetone/70% ethanol swabs.	Kastle Meyer test TMB test Luminol test LMG test Orthotolidine test	Crystal tests such as Teichmann and Takayama. Spectroscopy and m icroscopic visualisation of RBCs.	Species identification using Precipitin test, Double diffusion and cross-over electrophoresis. Blood grouping tests. DNA extraction and identification. Drug screening using instrumental techniques. Establishing the age of blood stains. Blood spatter analysis
Semen and seminal stains	Detection using UV light followed by photography. Wet stains collected after air drying. Dried stains can be cut out or swabbed with acidulated water.	Acid phosphate test; Zinc paper strip test; TLC of seminal stains can detect both choline and spermine simultaneously through the use of reagents such as Dragendroff, Potassium iodoplatinato.	Cross-over electrophoresis Florence test; Barberio's test. Christmas tress test including the use of two stains - Nuclear fast red (red stain) and picroindigocarmine (green stain) giving a characteristic Christmas tree appearance.	DNA analysis
Saliva	Detection using fluorescence spectroscopy following by photography. Wet stains air dried prior to packaging. Dried stains collected by cutting or swabbing.	Starch-Iodine test Phabedas test	RSID Detection of specific protein components such as histan-3 and statherin	Blood grouping. DNA analysis.
Sweat	Photography using different filters. Swabbing with acetone		Gee's urea nitrate test	Blood grouping. DNA analysis.
Faecal matter	Photography. Wet stains air dried. Dried stains can be scraped, swabbed or cut out for packaging.	Microscopic detection of vegetable residues, pus cells, epithelial cells and specific microorganisms.	Confirmatory tests detect presence of bilirubin using 10% Mercuric chloride solution and Amyl alcohol and 10% alcoholic Zinc chloride.	DNA analysis
Urine	Photography using different filters. Wet stains air dried. Dried stains can be scraped, swabbed or cut out for packaging	Preliminary identification based on colour, odour, pH, and microscopic visualization of characteristic crystals.	Gee's urea nitrate test. Jaffe test. Tests for detecting indican E using resorcinol and cupric bromide.	DNA analysis. Drug screening.
Vaginal secretions and menstrual blood	Photography using different filters when required. Wet stains air dried. Dried stains can be scraped, swabbed or cut out for packaging.		Microscopic detection of s quamous epithelial cells, endometrial cells, and detection of lactate dehydrogenase enzymes are considered specific for vaginal cells; PAS reagent test. Immunochromatography to detect D - dimer present in menstrual blood. Differentiation between menstrual and peripheral blood using MMP14, estrogen receptor alpha, fibrinogen.	DNA analysis
Vomit and gastric fluid	Photography. Wet stains air dried. Dried stains can be scraped, swabbed or cut out for packaging		Fibrin-blue agarose gel analysis. Proteomics.	

Table 3: Forensic examination of biological evidence associated with clothes found at a crime scene

Evidence	Documentation/ Collection	Presumptive tests/ Class characteristics	Confirmatory tests / Individual characteristics	Additional examination
Hair and fibre	Photography. Collected using rubber tipped forceps and adhesive tape lifting. Air drying prior to collection when associated with any stains. Each hair and fibre evidence should be packaged separately using pill box, glass vial or paper bindles.	Colour and texture of hair through microscopic visualization. Hair treatments (if any) Fibre origin evaluated through its cross -sectional appearance, solubility tests and burning tests. Fibre diam eter measured using Airflow, sonic fineness tester, liquid scintillation spectrometer, fibre fineness distribution analyser and projection microscope. Fibre pattern, colour and texture assessed through microscopy.	NAA for detecting different elements present in hair. Dye analysis using chromatography, Mass spectrometry, Raman spectrometry, HPLC - DAD-MS.	Human and non -human hair can be identified based on characteristics of the medulla, cuticle and pigmentation. Cross-sectional appearance of hair provides information regarding site of origin of hair on the body. Sex estimation based on Barr bodies. Differentiation between pulled and shed hair. DNA analysis Drug screening Blood present in thefibre sample may be extracted using saline solutions and subjected to further analysis.
Soil	Photography. Wet soil should be collected after air drying. Dried soil can be scraped or collected using low tack tapes.	Colour examination using Munsell's colour chart. Texture evaluation based on relative proportion of sand, silt and clay. Particle size evaluated using wet sieving for smaller particles and dry sieving for larger ones. Density tests through density gradient method. pH	XRD; PLM; DTA; Organic content can be analysed using HPLC, FTIR. SEM can be employed to analyse plant particles, fossils and diatoms present within the sample. Concrete and dust may also be detected using above mentioned instruments.	Blood present in the sample may be extracted using saline solutions and subjected to further analysis.
Pollen	Pollen can be extracted from clothes using Hydrogen peroxide.		TLM SEM	
Insect evidences	Different life stages are collected for species identification purposes and for estimation of PMI. Some are preserved using ethanol/isopropanol for species identification and toxicological analysis. Dead insects and eggs are preserved using 70% ethanol. Larvae are killed by exposure to (80 degrees)			Insect evidences found on clothes and/or bodies can provide information regarding the location of a crime scene. Entomotoxicological analysis can be undertaken. PMI can be established. Human identification using DNA collected from the gut of insects.

done using HPTLC and NMR. The presence of GSR particles on clothes can be confirmed using SEM/WDX. Oftentimes, cosmetic remnants might be associated with garments which can be analysed using GC-FID, HPLC, GC-MS, FTIR and SEM-EDX. Traces of cosmetic can also be subjected to DNA analysis and at times even scrutinised for lip prints.

Clothes are capable of housing a plethora of evidences which can aid in the overall investigation process. Careful handling of these evidences right from the time it comes in contact with the investigating officer and/or forensic surgeon till the time it reaches the Forensic science laboratory for further scrutiny is of paramount importance. Routinely undertaken thorough examination of clothes and other associated belongings can oftentimes help garner additional information which may prove useful to the investigation.

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