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Analysis of Unusual Trace Evidence-Paint and Glitter

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Abstract

Trace evidence are types evidence evolved when an object comes in contact with a surface (based on Locard's exchange principle). Locard's exchange principle states that: Every contact leaves its trace". Whenever two objects comes in contact there is transfer of substances between them. They are microscopic in nature because it is difficult to detect to our naked eye. These types of evidence are crucial for the investigation and also help in reconstruction of the crime scene. Unusual trace evidence is a unique set of evidence found in the crime scene that will be play an important role in investigation. Trace evidence refers to minimal amount of sample particularly fibres, glass, hair, fingerprints, saliva, paint chips, glitter etc. The trace evidence presence depends on persistence of the evidence. The extent of persistence of evidence depends on size and shape, amount deposited, environmental factors and time.

Paint is a pigmented liquid composed of pigment, binder, liquid and additives. Used for protecting, decoration and for providing texture. Paint chips are mainly encountered in cases of hit and run, burglary, kidnapping, sexual assault and homicide. Paint evidence comes under two main categories class and individual. Class characteristics can be examined through chemical analysis of each layer as the manufacturer uses different combinations.

The paint analysis is performed in three forms they are mechanical, physical, and chemical. The mechanical involves by making a physical matches, chemical involves by determining the chemical composition and finally physical which relates to the color, texture, pattern and appearance. The paint from a vehicle can be traced based on specific modal and make as the manufacturer will mix different constituents with a specific formula which helps in curbing the suspect. Here in this project, we have performed the paint examination based on the following: physical examination, microscopic examination, solubility test and instrumentations.

Glitter as a trace evidence is found in cases of sexual assault, robbery, kidnapping, and accidental cases. It is collected by using a cello tape or post it- notes. The characterization of glitter is performed by using various techniques such as stereomicroscopy, FT-IR and SEM/EDX. Glitter is analysed based on their color, shape, size, thickness and specific gravity etc.

Keywords: Instrumentations • Stereomicroscopy • Evidence-Paint • UV radiation • Pearlescent paints

Introduction

Paint is a pigmented liquid which is used to cover a surface and remain as a decorative coating. It is a dispersion of pigment in a solvent. Properties of paint include: good hiding power, colour, resistance, easy application and economical in cost [1,2].

Composition of paint

Vehicle: When exposed air the oil dries off. Hence it is called as drying oil. The composition of oil is unsaturated but when exposed to air it gets saturated. It has the capability to maintain the pigment and other components of paint in the form of suspension [3].

E.g. Dehydrated castor oil, linseed oil, fish oil and bleached oil.

Dries: Added to drying oil to speed up drying. It acts as a catalyst for the oxidation.

E.g. Naphthalene, resonates, linoleats and metals like lead, magnesium.

Base: A solid substance that forms the body of the paint. It consists of titanium oxide, white lead, red lead and iron oxide which help the paint to become harder, elastic and strong and also provides protection against moisture and crack as well as UV radiation.

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Pigments: It is a colored material used in combination with other components to provide color. Most commonly used in powdered state.

Solvents (Thinner): Helps in decreasing the viscosity of the paint. Usually added to make it smooth, uniform and easy application.

Eg: Petroleum, spirit, turpentine and coal tar.

Extenders (Fillers): Substance added to increase the bulk volume. Eg: chalk, gypsum, barite, silica and magnesium silicate [4].

Classification of Paint

Based on physical state

Solvent-borne paints: Consists of solid components (pigments, additives and binders) dissolved in an organic solvent. It dries fast and consists of binders.

Water-borne paints: Consists of water as the major constituents. They have a long drying time due to very slow evaporation rate.

Water-borne paints based on water-soluble binders: Polymeric binders are dissolved and having a low molecular weight.

Water-borne paints based on polymeric dispersions (emulsions paints): It consists of high molecular weight of polymeric binders dissolved in water just like colloids.

High-solid paints: Consists of solid components dissolved in organic solvent.

Powder coating: Prepared from powdered resin those which are attracted by electrostatic force of attraction.

Radiation curable coating: Combination of prepolymer, monomer and additive which protects against UV radiation.

Based on functions

Paint: Pigmented, non -transparent, protective and thin layered coating.

Varnish: Semi-transparent or transparent coating which is a mixture of binder, solvent and additives that consists of small amount of coloured substances which gives a glossy finish.

Enamel: A hard protective coating.

Primer: Coating applied primarily to increase the binding of paint and give a protection to the substrate.

Forensic importance of paint chips

- Hit and run cases.
- Burglary.
- Sexual assault cases.
- Homicide.
- Kidnapping.

Here in this project we are dealing with automotive paint use dprotection and decoration.

Automotive paint is made of water based acrylic polyurethane enamel paint because of reduced environmental impact [5].

Automotive paint forms

- Liquid polyurethane paints.
- Spray.
- Powder or additives.

Types

- **Removable:** Give appearance to vehicle.
- **Non-removable:** For touch-ups and for painting automobile.

Process: Water spray of high pressure is forced onto the body.

Body is dipped in electro-coat-paint operation (E coat) and applies high voltage. Body acts as the cathode and paint acts as anode, then the paint gets stick onto the body.

Various coatings

Primer: First coat applied it helps in providing a smooth surface by clearing out all the defects. Helps in easy application, to stick onto the surface and prevents corrosion.

Base coat: Helps in providing a visual colour effects and it is applied after the primer. It is divided into three:

Solid: No sparkle effect used in aircraft, equipment for construction and transportation vehicles.

Metallic paints: Provides a metallic look and it consists of aluminium chips which gives sparkling effects.

Pearlescent paints: Also referred to as pearl. To provide finish works to create a depth of colour and spark.

Mottling is the process by which the metallic and pearlescent are applied uniformly that provide a visual and dark spots.

Clear coat: Applied on top of base coat and it should be resistant against abrasion, chemically stable and withstand UV light. It is solvent borne. The coating applied to the metallic body is 1 K formulations (one part) and to the plastic bodies 2 k formulations (two parts) are commonly used.

Collection and preservation

- Hit and run cases.
- Paint chips should be removed using a blade such as scalpel, knife.
- Through the paint layers the blade must be cut down up to the substrate and also run across it with pressure.
- Standard sample should be collected near the area of impact.
- Clothing or shoes found should be dried and packaged in a paper.

Burglary cases

- Tool mark impression should be packaged carefully by not placing the tool onto the impression.
- The whole tool should be submitted by wrapping them in a paper to avoid contamination.

Packaging

- Items which are small should be packed in a paper and then place it in a pill box by labelling the evidence.

- Items which are large can be placed in appropriate size plastic or paper bags.
- Large items with sharp ends can be placed in a cardboard box [6].
- The package must be labelled with appropriate case number, item number and source of sample.

Analysis of paint chips

Physical examination: Colour, size number of layers, texture and state of the evidence.

Microscopic examination

- Used to determine the number of layers, sequence of layers, surface markings and distribution of pigments is noted which is done by using stereomicroscope.
- Microscopic analysis of a paint sample includes its physical examination and its original physical condition that includes its shape, size, color, texture and general condition.
- Microscopic analysis also includes minute details like number of layers in paint chip samples and their arrangement. It also helps us to determine about extra layers coated over original layers [7].
- Microscope that is used for microscopic analysis of paint chip is known as stereomicroscope.

Stereomicroscope

- It is a type of microscope used for observation of sample under low magnification power.
- It utilizes optical light which is reflected back from sample rather than transmitted light.
- Stereomicroscope has 2 separate optical pathways; it contains 2 objective lenses and 1 eye piece.
- The arrangement of 2 objectives lenses and 1 eyepiece produced 3-D visualizations of the samples being examined.
- It is used to study the surface of a sample.
- It has two types of Magnifications one is Primary and the other one is Pancratic.

Chemical tests

Solvent test and micro chemical test

- The samples to be tested are placed on a spot test plate and prepare the sample by cutting a cross section. To the sample add a drop of chloroform and observe the reaction under microscope [8].
- Similarly add a drop of acetone. The same sample can be used if the sample used along with chloroform does not react significantly.
- **Other chemicals used are:** Conc H_2SO_4, conc HNO_3, conc HCL, conc NaOH, Ammonium sulphide, ethyl acetate, Le Rosen reagent (37% formaldehyde 10 drops in 10 ml of sulphuric acid).

Solubility test and TLC

- The solubility of paint is tested using various chemicals and the components which are soluble, examined by thin layer chromatography.
- **Microchemical test:** Test in which various ranges of chemicals are added which is used to determine the composition of paint.
- **Chemicals:** Acetone, ethyl acetate, chloroform, benzene, methanol, methylene chloride, and dimethyl form amide and xylene [9].

Materials and Methods

Instrumentations

Fourier Transform Infrared (Ftir)

Principle: At different frequency the elements absorb light at different wavelength. It creates molecular fingerprints of the sample.

Uses: The unknown material can be identified, quality of the sample and the elemental composition.

The molecular fingerprints give off the peaks of absorption which represents the vibrational frequency in between the bonds. Since the suspected samples have different combination of atoms which gives unique spectrum [9]. Hence it helps in unique identification of the sample and also the peak size determines the amount of material.

Analysis of sample

- **Source:** The source emits infrared radiation from a black body which passes through aperture.
- **Interferometer:** Beam after passing the aperture goes into the interferometer and coding of spectral beam occurs. The resultant beam emerges out as the interoferogram.
- **Sample:** The interoferogram is reflected or transmitted through the sample that is being analysed. Here certain frequency of energy is absorbed by the sample.
- **Detector:** The interferogram signal is detected.
- **Computer:** The Fourier transformed signal which is digitized and the interpretation of results take place. **Measurement of**
- **background spectrum:** It is measured without a sample in between the beam and compared without a sample in between the beam gives the percent of transmittance which helps in overcoming the instrumental defects.

Advantages

- **Speed:** Different frequencies can be measured simultaneously within seconds. Also called as felgett advantage.
- **Sensitivity:** The optical throughput is high (Jacquinot advantage) and low noise levels as well as fast scanning by adding more scans to reduce the noise(signal averaging).
- **Mechanical simplicity:** The breakdown is prevented mechanically with the help of moving mirror in the interferometer.
- **Internally calibrated:** It has HeNe laser which is self-calibrating.
- Helps in positive identification of the sample and assured quality.

Disadvantage

- Single atomic species cannot be detected.
- Two identical atomic which are symmetrical cannot be detected.
- Difficulty in examination of aqueous solutions.
- Samples containing complex mixture give rise to complex spectrum.

Pyrolysis gas chromatography

Principle: Under an inert atmosphere the sample is heated at high temperature which is degraded into smaller molecules which is divided into various components by gas chromatography and confirmed by mass spectroscopy [10,11].

An analytical column is kept in between the pyrolyzer equipped with GC through an injection port. Components get separated when the inert gas such as nitrogen or helium is flowed across the sample. The components are detected using mass spectroscopy.

Types of pyrolyzers

- **Micro furnace:** The sample temperature is raised continuously till the pyrolysis temperature.
- **Curie-point pyrolyzers:** Induction coil is heated in which the sample is loaded at one end of the pyrolysis wire that consists of ferromagnetic alloy placed into the pyrolyzer. Temperature keep on increasing until the Curie point is reached and the magnetic property is lost gradually. Temperature remains constant at this stage till the magnetic coil is switched off.
- **Filament pyrolyzers:** The sample is placed in a direct contact with the wire coil in a tube and it is heated till a particular temperature, conduction of heat takes place which causes the sample to get pyrolyzed [12].

Working

Magnetic fields can deflect atoms and molecules; through which atoms are firstly changed into an ion. Magnetic Field affects electrically charged particle, but not electrically neutral particles.

Ionization: Knocking electrons give rise to a positive ion, hence ions and molecules get ionized.

This is also applicable only for those ions which form negative ions and also for those which never form ions. The mass spectrometer works only with positive ions.

Acceleration: Ions are accelerated from for having the same accelerated energy to ions.

Deflection: The ions are deflected according to their masses. Lighter molecules get deflected more. The ion which gets deflected is based on the negative charge on the ions.

Detection: The passing beams of ions are detected electrically.

Advantage

- It is a very simple process.
- Relatively inexpensive than other techniques.
- Capable of processing a wide variety of samples.

Disadvantage

- It is a destructive technique. Samples used for pyrolysis cannot be used for any other analysis.
- Uneven heating of sample can spoil the results.
- Huge amount of heat is generated.

Applications

- Art forgery
- Evaluation of biological sample.
- Environmental.
- Detection of any adulterants.

Scanning electron microscope

Principle: The topography and the composition of the surface are obtained when the electron beam comes in contact with the sample and produces various kinds of signals [13].

Working components

- Electron source.
- Column through which the electron passes to reach the electromagnetic lens.
- Detector.
- Sample chamber.
- Computer.

The energy is transferred to the sample when an electron beam from the incoming rays is bombarded. The electrons which are bombarded are referred to as primary electrons which eject the electron from the sample. The primary electron goes deep into the sample and release secondary electrons. These electrons are the fed to the detector and translated to signal. Apart from secondary electrons back-scattered electrons are produced from the primary electrons. It is difficult to analyse by the electron detector. SEM is attached with EDX to determine the elemental composition.

Applications

- Identification of firearm.
- Gunshot residue analysis.
- Paint examination.
- Handwriting examination.
- Counterfeit currency notes.

Advantage

- Three dimensional structures in detail.
- Surface imaging.
- Easy operation.
- User friendly.
- Faster working capacity.
- Data is generated in a digital form.
- Easy sample preparation.

Disadvantage

- Size and cost.
- Maintenance is difficult.
- Specialized training is required.
- Sample prepared might contain contaminants.
- It is applicable only for solid samples.
- Radiations those scattered beneath the surface get exposed.

SEM imaging

The electron gun generates a beam of electrons which passes down the column and then to the electromagnetic lens. The lens is folded in a tube of coil called as solenoids. Coil helps in adjusting the voltage that comes in contact with the specimen. The electron beam then falls onto the sample placed on the stage. Samples should be

placed in a low pressure in vacuum. Incident electrons when come in contact with sample the secondary and backscattered electrons are generated which is detected by using various types of detectors [14,15].

Modern automotive coating process

There are five steps involved in the coating process:

Pre-treatment: It helps in forming a surface texture by removing and cleaning excess of metal that enables the bonding of the protection layer against corrosion.

Electro deposition: It helps in preventing the formation of rust.

A Poly Vinyl Chloride (PVC), a sealer: Which that is applied for preventing corrosion, for eliminating leakages caused due to water and also for minimizing chipping property and vibrations caused by noise.

Primer: The application of primer is performed, for enhancing the contact among the basecoat, surface which gives off a smooth surface and also minimize the process of chipping.

The various coatings such as topcoats, basecoat and clear coat are applied which provide color. Glossy finish, resistance to weather and smoothness [16].

Pre-treatment

The metal components are used to make the automobile body by welding them together and forms a structure called as body-in white. Pre-treatment involves cleaning the surface by removing the oils caused due to stamping process and welding residues is done primarily by three process degreasing, conditioning and phosphating.

Phosphating: A layer of phosphate is applied to provide resistance for corrosion.

Degreasing: It is a solution made up of surfactants and alkaline compounds such as caustic soda, sodium carbonate and trisodium phosphate. The surfactants involve various detergents on BIW.

There are two sequence which includes stage of spraying known as Knock-Off Degrease (KOD) and dip sequence which takes place in degreasing zone.

It helps in removing oils and dirt by high pressure spray and also provides fewer loads to the dip sequence.

The surface conditioning also referred to as activation that creates sites of nucleation, which helps in increasing the crystallization nuclei on metal surface for enhancing bonding.

Conditioning: Titanium orthophosphate is used.

Electro-deposition (ED)

For anti-corrosion body parts and frames made of metal are coated. When the coating is not done the metals are primed for applying the coatings-coat which is a combination of resin, binder and paste that consists of pigment and solvent. The anodic electrode position, metal surface is positively charged and paint negatively charged in which, ions migrate and creates a coating. In case of cathodic electrode position the metal surface is negatively charged and paint is positively charged.

The caustic and the acidic components in the ED tank that gives the measurement of pH, particular solvent used. The functional groups present in the resins as well as the neutralizing agents helps in maintaining a balance. A combination of resin, binder, paste and pigments are added into the ED tank where the automobile was dipped into ED tank and electric current is provided. The tank also consists of deionized water and paint solids. For the paint solids the deionized water main role is to remain as a carrier under agitation. Charged nature of the process of coating the ED goes deep into the places where a spray cannot reach.

Resin provides protection against corrosion, makes the paint tough and durable. Pigments function is to provide gloss and color. When an automobile is withdrawn from the tank the surface have paint adhering onto the surface; those which are not bound are rinsed off from the surface by ultrafiltration to enhance the smoothness.

Then the automobile body is being fed to the bake oven where the heating and temperature is around 160°C is maintained for 10 minutes which helps in increasing maximum performance. It helps in providing chip resistance, adhesion resistance and protects against corrosion. In some cases a water spots are present on the body surface from the conveyor belts or some other sources it happens when there is no proper deionization of water and due to higher conductivity. These spots of water on the surface causes problems in coating hence it should be removed by a process called as sanding and also by adding ultra filtrates or surfactants to the rinse zone [17].

A sealer: PVC (Rust proof material)

A sealer such as PVC or urethane is applied on the inner side of doors, front dash board, trunk, hood and exterior and interior metal joints and back wheel. It is either done manually or with helps of robots. Currently PVC or acrylic urethanes are used in areas of under body which is called as dampening coat or DC. It helps in providing noise proof and decreasing the vibration. The sealers reduce the vibrations and noise to the compartment of passengers and also the noise generated from the engines, suspension systems, noise from the tires when moving on the road and the flow of air. The sealers provide protection against corrosion, resistance to chipping which is primarily done by using airless sprayers or robots.

In the next step a soft tip primer is applied to the front hood edge where it is more susceptible to chipping, with the use of high elastic resin that is seen in between the electro-deposition and coats of primer.

The rear areas of body, radiator support and housing of wheels are coated with dull black pigment referred to as blackout coating [18].

Primer

The small imperfections created by sanding and grinding are being filled by primer. The function of primer is to level out all the imperfections and to give a smooth finish, protection from anti-corrosion helps in increasing the contact between primer and the E-coat also the basecoat. The primer layer helps in preventing the process of chipping, when the process of chipping reaches metallic surface or body it may lead to corrosion. It also helps in improving the contact of topcoat onto the primer surface which ensures outer finish when chipping takes place.

Hence the primer should be mixed with various colors in order to mask the damage onto the topcoat due to chipping.

The primer coting is done in three stages exterior coatings, interior coatings and then drying them in an oven. For coating the interior such as doors, compartment of engines and luggage space the manual spray method is used. To impart a uniform coating appearance the basecoat color should match with primer color. The body of the automobile is dried by passing it into an oven at a temperature 140 degree Celsius for 30 minutes.

Topcoat

Top coat consists of two types of layers: Base coat and clear coat.

Base coat consist of paint pigments and the clear coats provide protection against effects of environment, corrosion, resistance against UV light, provides smoothness and a glossy finish. Automobile body is firstly coated with basecoat and then a clear coat is applied before heating an oven at a temperature of about 30 to 40 minutes at 125°C [19].

Basecoat

The color put on the base coat is evaluated is based on certain standards terms, with hue and Chroma. Pigments are particulate solid particles insoluble in paint. The pigments are effective based on the aluminum flakes, mica and other interfering agents. Aluminum flake the lightness or darkness is based on an observation angle and the effect is referred to as lightness flop and mica the observation angle is referred to as color flop. When the concentration level of pigment varies the color intensity applied on the base coat also changes. Hence various finishes can be designed based on the hue and Chroma values.

Clear coat

Function: provide resistance against scratch prevents fading against UV rays and also helps easy repairing and maintenance works.

Environmental etch is a phenomenon in which the automobile coatings such as the clear coat is deformed by forming a water spots which are permanent or marks which not removable caused due to bird dropping, resins from tree or exposure to chemicals.

HALS (hindered amine light stabilizers) chemical in combination with ultraviolet light absorbers blocks the UV radiation by forming a backbone made of polymers and absorbs radiation between 290- 400 nm wavelengths.

Some scratch are seen on the clear coat only when it is exposed to scattering light and some might rise up and break into fragments. The characteristics such as flow depend on 1 K (no need of hardener or a catalyst for thickening) or 2 K (need to be used in combination with hardener or a catalyst for thickening). 1 k coats provide plastic flow resistance and 2 K provides fracture and resistance to impact.

The most commonly used 1 K is acrylic melamine, it is based on combining polyols of acrylic and agents of amino acids cross linking.

The 1 K and 2 K polyurethane provides resistance against environmental etch and scratch, and also 1 K and 2 K epoxy resins provide resistance against etch caused due to acids. Water borne clear coats based on the combination between polyester and acrylic cross linking with melamine and isocyanate. But the powder clear coats are used commonly because the environmental concerns (less emission of VOC). It also have other advantage such as the powder can be reused again, waste water is not produced during application, organic solvent is not used while applying the paint or for cleaning, the total energy supplied is reduced because the supplied air can be recycled, non-toxic and provides thickness which is uniform in appearance.

Spray coating

The spray coating on various coatings is done by using the atomizers. Spray is an immersion of droplets dissolved in gas phase that is condensed. Sparys are formed due to atomization which is generated by the result of propagation of droplets from the liquid by various forces such as electrostatic forces, mechanical and aerodynamics. Spray coating is done with help of various applicators such as air spray guns, rotating disk or bell *i.e.* both which are electrostatic or non-electrostatic [20].

Automatic spray coating is done by using robots hence it is called as robotic coating. Spray booths is required to perform the spray coating. The greatest advantage of spray coating is the efficiency of transfer to the target and also particles of the paint those which do not coat the body of the automobile and particles float in air.

Automotive spray applicators are of two types: Air spray guns and high-speed rotary bell.

Issues with automotive spray

The atomizer atomizes the paint into droplets and coats the surface of the automobile. The issues include: transfer efficiency, deposition of coating, consumption of energy, efficiency of engine, environmental and safety of work place. These can be analysed from the design of atomizers, composition of paint and modifications in the surface. The transfer efficiency is defined as the ratio of amount of paint that coats the surface to those amount ejected from the atomizer.

Transfer efficiency depends on factors such as:

- Characteristics of the target surface.
- The design of spray.
- Parameters of working.
- Conditions of air in the spray booths.
- Coating characteristics-liquid.

The paint which is over sprayed should be incarcerated before it entering the atmosphere, hence the method used to prevent to ptisca ure is the water washing or wet scrubbing. Overspray capturing efficiency referred to as the ratio of captured amount of overspray to the quantity which has entered the capturing system.

Trends in automotive coating process powder coating

The liquid coatings often used have larger emissions of volatile organic compounds; hence the use of particulate solids in the form of powder called as powder coatings reduces the emissions of VOC. It is used in the handles of doors, decorative systems, radiators, engines,

filters, wheels, bumper etc. Powder coatings often provide a glossy finish and protection against corrosion on the any metal when applied.

Powder is mixed with smaller particles of pigments and resin and then the resultant is sprayed electrostatically onto the surface. Powder particles which are charged bind to the surface that is electrically charged, till the powder is heated and gets fused to the smooth surface coating when it is cured in the oven. Then it forms a high quality attractive finish coating.

Advantage of powder coating: Reduce production of VOC, overspray can be recycled, more transfer efficiency, provides thick coatings, low cost, special effects can be achieved when used in combination with powder coatings, shows lesser difference in appearance than liquid coated. Disadvantage of the powder coating is when it is used in combination with the metal particulates.

Wet paint

The waterborne 3 wet paint system in which the application of primer coat firstly then basecoat and at last clear coat then the coatings are cured in the oven. Hence this process is also called as 3 wet process. It is time consuming comparing to the rest and VOC generated is very less, low cost and environmental friendly. Disadvantage of this system is that surface of rough substrate and the primer and then water in basecoat might interfere in the primer layer. These are overcome by using improved steel, ED tank appearance and two stage bake use. Currently, water borne 3-wet paint system with qualities equal to three-coat or two bake was generated by using basic resins with low melamine content in paint helps in reducing the shrinking as well as for promoting the leveling.

Automobile manufacturers

Maruti Suzuki-1981: It is a joint venture of an Indian automobile company and a Japanese car and bike manufacturers formally known as MARUTI UDYOG LTD. 56.21% of the paint is owned by SUZUKI the rest is owned by the public sector of India. Together it has manufactured various popular cars such as Ciaz, Alto 800, Alto K 10, Ertiga, Eeco, Baleno, Ignis, Vitara Brezza, S-cross, Wagon R, Swift.

Mahindra group-1945: Founded by Jagdish chandra mahindra, Kailash Chandra mahindra and Malik Ghulam Mohmmad. Initially emerged as steel manufacturers. The present managing director Anand Mahindra came up with a new logo in 2000 and made Mahindra Scorpio the most successful among other entirely indigenously made four wheeler cars. The company has emerged as a big name with around 100 plants across the globe. Essentially it has shown presence in aerospace, agribusiness, automotive, insurance, farm equipment, and hotels defence and construction equipment.

Tata motors-1945: Founded by JRD Tata. Formally known as TATA Engineering and Locomotive Company Ltd (TELCO). TATA launched Indica in 1998 the first fully indigenous Indian Passenger car.

Tata motors have various working plants across the country at Jamshedpur, Sanand, Pune, Lucknow, and Patnagar and Dharwad. Globally it has plants at Great Britain, South Korea, Thailand, and Spain and South Africa.

The most remarkable event was the acquiring of Jaguar Land Rover, an English premium Car. The most famous cars are Indigo, Indica, Nano (the world's cheapest car), and Sierra.

Honda-1948: Founded by Soichiro Honda and Takeo Fujisawa. It is a Japanese conglomerate and a lead manufacturer in motorcycles, automobiles and power equipment's. In India it is headquartered at Greater Noida, Uttar Pradesh. It has joint venture with Indian automobile company hero motor corps owned by Munjal's but announced split in 2010 selling its 26.78% stakes to Munjal's. Popular models by Honda are: Honda Amaze, Honda City, Honda Civic, Honda Jazz, and Honda Accord.

Royal Enfield-1901: Founded by Albert Eadie and Robert Walker Smith. In 1955 it partnered with Madras motors a Chennai based Motorcycle Company and assembled the 350 cc Royal enfield bullet. The first product manufactured by Royal Enfield was a Quadricycle, a bike with four wheels. The most popular model was 250 cc bullet manufactured during World War II. The most popular models are Royal Enfield Classic 350 cc, Royal Enfield Thunderbird 350 X, and Royal Enfield Interceptor 650.

Toyota-1997: Founded by Kiichiro toyoda. It is a Japanese market leader in producing hybrid electric vehicles and hydrogen fuel vehicles in world. In India it is headquartered at Bidadi, Karnataka. In India it has a joint venture with Kirloskar Brother's Ltd which is an Indian conglomerate India's largest manufacturer of pumps and valves. The subsidiary is known as Toyota Kirloskar Motors headquartered at Bangalore, Karnataka.

89% of the stake held up by the Toyota group and the rest is owned by Kirloskar Brother's Ltd. The most popular models are Fortuner, Camry, Qualis, Etios, Corolla, Innova, and Land Cruiser.

Ford motor company-1903: Founded by Henry Ford. It is an American Multinational Company that manufactures commercial vehicles and luxury cars under name Lincoln Brand. It ows 8% stakes British Luxury Vehicle Brand Aston Martin. Ford (49%) has joint venture with Mahindra and Mahindra Motor corps. The most popular cars nowadays are Figo, Ecosport, Mustang, and Endeavour.

Chevrolet-1911: Founded by Louis Chevrolet and William C Durant, it is an American Car manufacturer headed by General Motors. The only plant in India is at Talegaon which is an export only facility. It is the 5th largest name in car industry in India. The most popular cars in market are Beat, Cruze and Travera.

Joseph Cyril Bamford (JCB) excavator's Ltd-1945: Founded by Joseph Cyril Bramford is a UK based company exclusively working in manufacturing machines for Digging, Tractors, Excavators. It is the lead producer and assures a quality of heavy Weighing Machines. Various Models are present nowadays such as JCB 3DX, JCB 3DX SUPER, JCB 3DXL, JCB 3DX XTRA with an average price range of 20 lakhs to 40 lakhs INR.

Fiat-1899: Founded by Giovanni Agnelli. It is the largest Italian automobile manufacturer and thirds largest In World. In India it is headquartered at Pune, Maharashtra. The most popular models nowadays are Punto, Jeep Compass, Palio, and Siena.

Glitter

Glitter is made up of tiny particle that shows the property of reflection when light is incident on it. Glitter is used in decorative articles, greeting cards, cosmetics, clothes, and ornaments etc.

These are available in different colors, size, and shape. These properties are attributed to the manufacture, how he wants it to be done.

Types of glitter

- **Holographic glitter:** These are the most radiant types of glitter that reflect the incident light into many radiant colors. These are used in nail arts, home decor articles etc.
- **Metallic glitter:** These glitters are not actually made up of metals, but the word metal actually denotes its property to shine like metal. These are the most commonly used for body art.
- **Irridescent glitter:** These are the glitter having soothing appearance and available in various shades these are widely used in cosmetic industries for preparing nail paints, lipsticks, highlighters, and eye shadow etc.

Particle size

- Large size-0.5 mm-0.8 mm.
- Normal size-less than 0.2 mm (most commonly used).

Forensic importance of glitter: Glitter is trace evidence that is entirely man-made. The glitter can be of various shapes, sizes and colors that vary from manufacturer to manufacturer making it easier for the forensic expert to link it with its source.

Glitter can be recovered as evidence from various cases such as:

- "HIT and RUN" cases where glitter particles worn by the suspect can be recovered from alleged vehicle.
- "RAPE and MURDER CASES" glitter obeys Locard's principle of exchange thus it can be mutually exchanged between suspect and victim during the course of the incident.

"Kidnapping cases": What makes Glitter ideal trace evidence?

- Nearly invisible.
- Easily transferable.
- Can tolerate extreme conditions.
- Maximum retention time.
- Variable shape and size.
- Easy sample collection and storage.
- Least degradation.

Forensic analysis of glitter

Collection: Glitter being highly reflective in nature can be located using flashlights.

It can be collected using adhesive tapes or post-it notes. And then can be packaged in zip-lock bags and sent to laboratory for further examination.

After successful separation and collection a forensic investigator would go for:

Physical analysis: Color of particles.

Shape and size of particles: Most commonly the glitter particles are hexagon, Square, Rectangular in shape. However other shapes such star, crescent, round etc. also nowadays manufactured.

Size of the particles is measured in millimetres where normal size range is less than 0.2 mm and size range more than 0.5 mm is considered large.

Thickness: Manufacturers around the world have confirmed the presence of metallic layers used in glitter. Coatings of aluminium, titanium dioxide, bismuth oxychlorides and iron oxides are often used. Thickness varies from 50-175 microns.

Specific gravity: Because glitter is coated with different metallic or plastic layers of different thickness, its specific gravity will vary accordingly.

However the normal specific gravity varies from 1.2-1.25.

Disadvantages of physical analysis

- Provides clue only of the class of the evidence.
- Changes of getting false positive results.

Instrumental analysis

ATR-FTIR micro spectroscopy: Attenuated total reflection-Fourier transform infrared spectroscopy is a sampling technique used for the analysis of reflectance either surface of glitter particle. The major advantage is that no prior sample preparation is required; the only requirement is that, either side of particle is free from dust.

Dispersive Raman microspectroscopy with confocal imaging: It is a non-destructive technique which can easily distinguish between various coatings on the glitter particle without any prior sample preparation. With confocal imaging analysis of even deepest layers can be done.

Scanning Electron Microscopy (SEM): It is a non-destructive technique that focuses a beam of electron on the sample to give information about the topography of the surface and the composition of the particle.

Magnetic levitation: It is used for measuring the density of magnetic substances when suspended in Para magnetic solution. Glitter being coated with metallic substances can be subjected to magnetic leviation method.

Disadvantages of instrumental analysis

- Not feasible.
- Expensive to use.
- Time taking and complex procedure.
- Magnetic leviation causes degradation of sample.

Glitter manufacturers in India

- Advance Syntax Ltd. (Vadodara).
- Global export and import (Jabalpur).
- Lakhotia Polyester India Pvt. Ltd. (Nashik).
- Rohvyo Impex (Mumbai).
- Polyester Marketing (Seccunderabad).
- Astar Foils (New Delhi).

Here we did analyses on three manufactures

- **Middas:** It is an Indian glitter manufacturer having the main office at Vadodara Gujarat. They produce a fine quality of aluminium glitter, polyester films, cosmetic glitter, textile glitter powder, hot stamping foil, epoxy resins and glitter crafts for kids.
- Tenderberry.
- Vozwa.

Terminology

ATR-FTIR (Attenuated Total Reflection-Fourier Transform Infrared): Technique used to identify the composition of the given sample with the help of absorption peaks specific to certain functional groups.

SEM (Scanning Electron Microscope): Non-destructive technique that focuses a beam of electron on the sample to give information about the topography of the surface and the composition of particles.

TLC (Thin Layer Chromatography): Separation technique used to separate the constituents of sample due to interaction of particles of the sample with the mobile phase and stationary phase based upon which the respective R_f values are calculated.

Specific gravity or relative density: It is the measure of density of a material based upon the ratio between the densities of that substance to the ratio of the reference sample in most cases which is water.

UV rays (Ultra-Violet Rays): It is a part of electromagnetic spectra having wavelength of 10 nm-400 nm which lies between X-rays and Infrared rays.

ED (Electro-Deposition): Sometimes called as electroplating refers to the process of coating of a material onto to a conductible surface with the help of electronic charge.

Stereomicroscope: An optical instrument capable of providing a 3-dimensional image of the specimen with the help of reflecting light.

Multi-modal compositional analysis of layered paint chips of automobiles by the combined application of ATR-FTIR imaging Raman microspectrometry and SEM/EDX-MD Abdul Malek

The examination of paint chips are crucial for determining number of layers, painting process, paints used, type of automobile, color, texture and protection agents used for surface that depends on the manufacturers and model year of manufacturing. Optical microscope such as SEM/EDX, ATR-FTIR imaging provides information about the number of layers, sequence of layers, surface markings and thickness

- EDX-elemental analysis.
- ATR-FTIR-profiling or imaging molecular level of paint.
- RMS-inorganic fillers.

To determine physiochemical property and variability in each layer, the cross section of sample produces large amount of spectral data so knowledge on machine techniques is required for classification.

Inter-rater reliability of vehicle color perception for forensic intelligence- Khai lee

Top coat of vehicles provides lots of information in case of accidents. The witness of car accidents helps in curbing the suspect. The research paper mainly deals with color determination by volunteers and by comparing the outcome to prevent the wrongful convictions. The outcomes are of two types, a match or non-match. It follows statistical analysis based on comparison between stationary and moving vehicles.

Frequency of matches and inter–rater reliability depends on basic description of color, disregarding the shades. White and black showed greatest match but intermediate color was confusing. The information from this research paper helps in identifying the top coat color of vehicle based on witness statement which turns out to be more reliable.

Evolution of the automotive body coating process-Nelson K. Akafuah, Sadegh Poozesh, Ahmad Salaimeh, Gabriela Patrick, Kevin Lawler and Kozo Saito

The automotive coating technology has changed over time. The composition of coating and coating process are dependent on each other. The final coat which is applied it is a combination of different composition. The composition of coating, coating process and characteristics of surface will determine the coating film appearance. Automotive coatings face one of the major challenges such as the environmental contamination. The manufacture process coatings based on the customers interest or perception, hence it is unique to each manufactures. This paper clearly discuss about the modern technologies used in automotive coating process, recent trends, potential developments in future and composition each coatings.

Forensic examination of car paints-Jakub M. Milczarek

Paint chips are transferred to the victims clothing in case of an automobile accident and robbery. Two types of investigations are performed: Identification/classification and comparison. The paint basically consists of four types of layers: Primer, surface of primer, basecoat and clear coat. The techniques used for analysis are as follows:

- Microscopic examination.
- FT-IR.
- SEM/EDX all the techniques are explained in this paper in detail. The paper ends by putting forward a suggestive work which includes setting up a database for car paint that will help in narrowing down the area of search more effectively.

Identification of tiny and thin smears of automotive paint following a traffic accident-Yun-Sen Giang

The paint chips are analysed by three techniques

- Stereomicroscopy.
- FT-IR.
- Solubility tests for determining the known and unknown sample.

The three methods used had its own limitations which caused a difficulty in comparison.

Exchange of paints in hit and run collisions (Ajay Kumar)

As we know that there are no eyewitnesses in hit-run cases, so physical evidences provide crucial information in crime cases which depends on the realizing, protecting, selecting, identifying and for evaluating of the transferred material paint. In the hit and run cases usually there is transfer of paint, between the suspect's vehicles with that of the victim in the scene of crime. It is linked to accused vehicles with that of victim's vehicles after collision.

The evidence recovered, helps in proving the suspects innocence. Paint sample are preserved until sample can be forensically examined. The main significance of this review paper will be paint as most important evidence in hit and run cases with the help of relevant case study. From the case study we will discuss about how it collected the paint sample from the crime scene and how it is preserved for the forensic examination. In many hit and run cases there is no eye witness at that time physical examination play an important role for solving the cases.

In this review paper we have mentioned the material physical evidence for example paint chips which can be useful in hit and run cases to identify the origin of the sample.

Glitter the ideal trace evidence, Richard Kam, Ml inda Xiao, Xanthe Spindler, Philip Maynard, Clau de Australia

According to the given research paper it was found out that glitter is entirely man-made has been used since ages for decorative purposes and in cosmetics. Small particles of glitter are cut out of large aluminium sheets into various shapes such as hexagon, square and rectangle. Nowadays the evidential value of glitter has been subsequently increased because of its increasing use in various products and also involved in various criminal cases as evidence.

Instrumental analysis

Raman micro spectroscopy: For the better analysis of inner layers of glitter particles.

Scanning electron microscopy/energy dispersive spectroscopy: For the elemental analysis of each particle.

Results and discussion: It was found out that there were no glitter manufacturer's in Australia. Most of the manufacturers were from United States and China. Results were based upon size, shape and color. Color was the most undermining factor which can be affected by the light conditions, angle of observation and various coatings.

Out of the shapes hexagon was most common thus it had a very low evidential value. Other special shapes such as rectangle, heart and star shape were most uncommon thus it had a very high evidential value.

Conclusion: Glitter particles from different manufacturers were examined by optical, physical and chemical techniques.

FTIR was most differentiating technique due to its depth analysis of various chemical coatings. The results were compared with a computer database.

Scope of study

- Paint is a type of evidence obtained in case of hit and run, robbery, burglary or breaking into house.
- Hence paint chips are examined at the scene of crime.
- The importance of paint chips as an evidence increases when it is obtained from the vehicle of suspect in cases accidents, clothing or footwear of suspect or from the house under suspicion in cases of break-in.
- Paint is commonly obtained as flakes, powders or chips.
- To reveal the possible connection of transfer of paint chips from one surface to another the forensic examination is conducted on the suspected samples.
- Based on the law of comparison, a comparative study is employed on the paint chips using different techniques for identifying the origin of the sample from the same source or not.
- Glitter is made of tiny particles that show the property of reflection when light is incident on it.
- Used in decorative articles, greeting cards, cosmetics, clothes and ornaments etc.
- Usually available in different size, color and shape based on the manufacturers.
- It is recovered in cases of accident, rape and murder and kidnapping cases which helps in linking the suspect to scene of crime.
- Forensic Examination of glitter was performed using various techniques.

Objective

The main objective of the project is analysis of unusual trace evidence found at the scene of crime. Here we have performed analysis on two types of evidences: Paint and glitter. The forensic of examination of paint and glitter was performed. It involves the physical, microscopic, chemical and instrumental analysis. The automobile manufactures imparts different coatings based on the customers satisfaction which makes each manufacturers unique. Hence in this project we were able to find out the various chemicals or characteristics that were imparted by the manufactures and also the number of layers applied onto the automobile if it is modified. In case of glitter the microscopic analysis of various manufactures helped in revealing the shape and also presence of any contaminants present in it. Also the analysis of the FTIR peaks for the determination functional group present in each of the samples.

Aim

- To perform physical and microscopic examination of paint and glitter.
- To determine the number of layers in case of microscopic examination of paint.
- To perform solubility and micro-chemical tests of different automobile manufacturers.
- To separate the various components of paint using TLC.
- To analyse the FTIR peaks for determining the elemental composition of paint.
- To determine the specific gravity of glitter.

Methodology

Our project deals with analysis of unusual trace evidence such as paint and glitter. Paint sample specifically automobile paint sample was obtained from various vehicles of different vehicles of different automobile companies. Physical, microscopic and instrumental examination was done on individual paint chip.

Glitter was obtained from different manufacturer such as Vozwa, Tenderberry and Midas. The physical, microscopic and instrumental analysis of each sample was performed.

Physical examination

Paint chips

The physical characteristics of paint chips were examined, such as color, texture, number of layers etc. manually.

Solubility test: The solubility of individual paint sample was tested with various solvents to check the following reaction and solubility.

Micro-chemical test: Test which is used to determine the composition of the paint

The following solvents were used chloroform, ethyl acetate, methanol, xylene, HCl, H_2SO_4, HNO_3, Methylene Chloride, and Dimethyl Formamide.

Glitter: The physical characteristics of glitter were examined, such as color, texture, shape of particles and edge characteristics etc. were examined manually using hand lens.

Specific density: The specific density of each glitter sample was done using Acetone and a floatation test was conducted to check the specific density.

Microscopic examination

Paint chips and glitter particles: The microscopic examination of paint chips and glitter particles was performed using stereo-microscope. The number of layers and presence of wear and tear marks such as abrasion marks on the surface of the sample were examined.

The number of layers gives idea about the making of each sample and also links it to the manufacturer.

The wear and tear marks gives idea about the age of sample and how it has been used in past.

Instrumental examination

Thin layer chromatography: This technique was used to separate the individual components of paint chips based upon their interaction with the stationary phase and mobile phase. The R_f value of individual samples soluble in appropriate solvent was calculated.

Fourier transforms infrared

It is an instrumental technique based upon the interaction of the molecules of the sample with the electromagnetic waves in the Infrared region.

It usually works by absorption of energy emitted by molecular vibrations, thus giving results in the form of absorption peaks where the intensity of individual peak is studied.

Results

The results show in Tables 1-4. Physical and microscopic examination (Sample no: 1 to 10).

Model	Color		Physical examination		Year of manufacturing	Microscopic examination
	Top coat	Base coat	Shape	Texture		Number of layers
Manu 800	Silver	Yellowish brown	Irregular (flakes)	Smooth	1991	3
Indica	Silver	Dull white	Irregular	Smooth and shiny	2008	3
Swift dzire	Pearl white	Greyish siter	Irregular	Smooth	2008	3
Creta	Pure white	Grey	Irregular	Smooth	2014	3
Etios	Yellowish	Creamy white	Flakes	Smooth	2014	2
Tata Mahindra	Shiny green	Rusted brown	Regular	Rough due to rust	1998	2
Maruti 800	Shiny white	Grey	Irregular	Smooth and shiny	1983	3
Tata Safari	White	Brown	Irregular	Smooth	2012	3

Lancer	White	Red	Irregular	Smooth	2007	2
Maruti Suzuki 800	White	Brown	Irregular (rusted)	Rough	1983	3

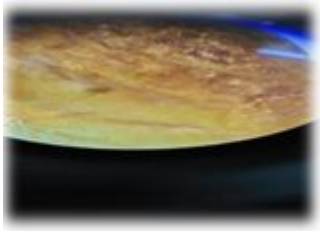
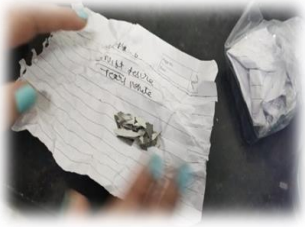
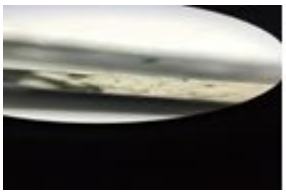
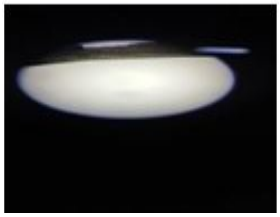
Table 1. Physical and microscopic examination (sample no: 1 to 10).

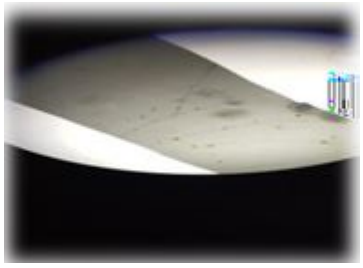
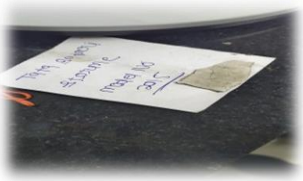
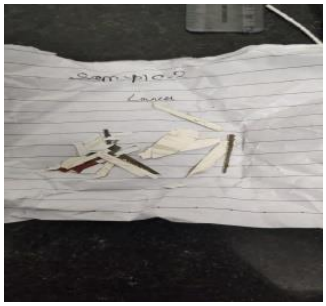
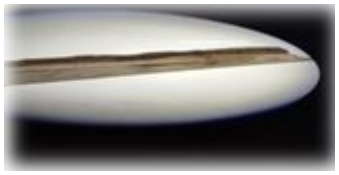
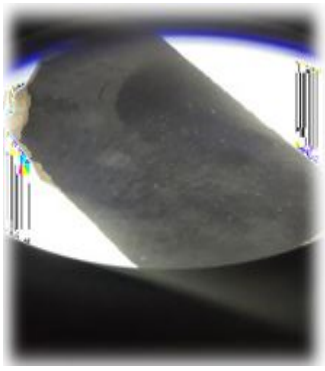
Model	Color		Shape	Texture	Year of manufacturing	Number of layers
	Top coat	Base coat				
pulsar 180	Black	Dull black	Irregular (flakes)	Smooth	2001	2
Maruti 800	Shiny white	Grey	Irregular	Smooth and shiny	1983	2
Mahindra LX	White	Sliver	Regular	Rough	2003	2
Bullet 350cc	Shiny black	Yellowish brown	Irregular	Smooth	1974	2
Mahindra scorpio	Facelift creamy white	Grey	Irregular	Smooth	2017	2
Mahindra scorpio	Black	Brown	Irregular	Smooth	2002	2
Bullet 250cc	Red	Creamy brown	Irregular	Matte	1960	3
Indigo Pal	White	Grey	Irregular (rusted)	Rough		3
Maruti 800-1985	Red	Creamy	Regular sharp edges	Smooth	1985	3
Force tempo travellar	White	Brown brown	Irregular (rusted)	Smooth	1999	3

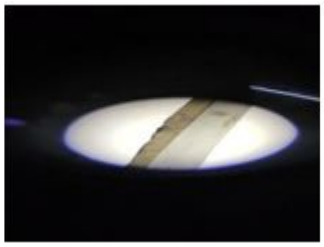
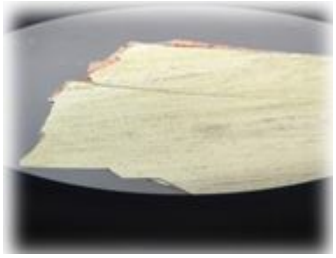
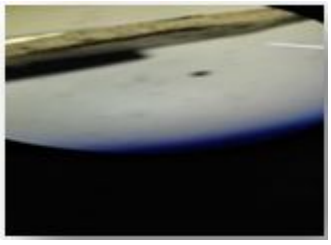
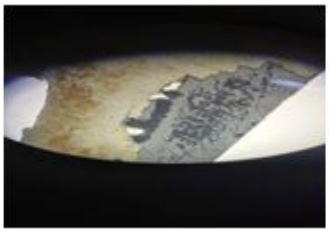
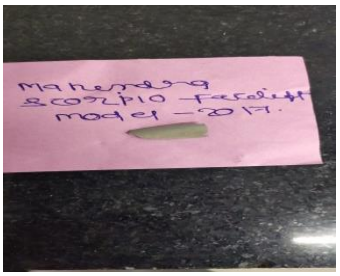
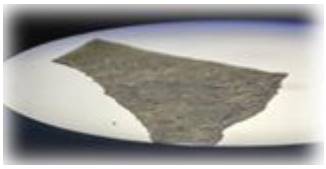
Table 2. Physical and microscopic examination sample no: 10 to 20.

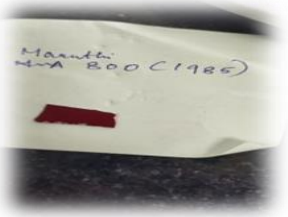
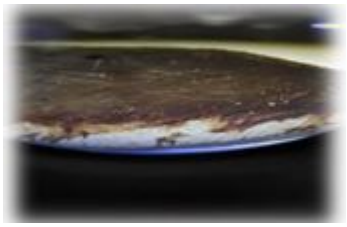
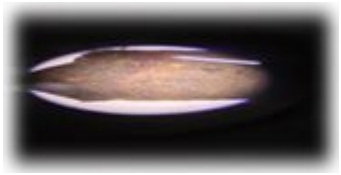
Model	Color		Shape	Texture	Year of manufacturing	Number of layers
	Top coat	Base coat				
GLS Pajero	Maroon Shiny	Brown rusted	Regular and sharp	Rough	2000	2
Toyota qualis	White	Grey	Irregular (rusted)	Smooth	2001	3
Chevrolet FA	Shiny green	Shiny green	Irregular flakes	Smooth	1941	2
Bolero	Creamy white	Black	Irregular flakes	Rough	2011	2
Innova	White	Grey	Irregular	Rough	2008	3
Indigo marina	Shiny silver and black	Dull black	Powdered lustrous	Smooth	2008	2
Mahindra Bolero	Crystal white	Yellowish grey	Irregular	Smooth	2000	3
Fiad	White	Grey	Irregular (rusted)	Rough	1957	3
Scorpio turbo 2.6	Silver		Powdered	Smooth	2002	2
Toyota Qualis	Black	Brown	Regular (flakes)	Rough	2001	3

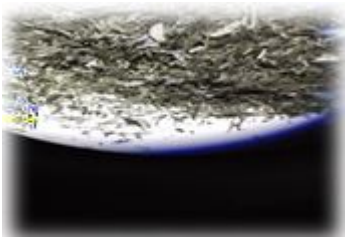
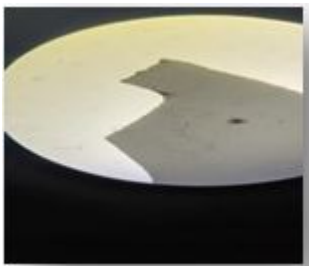
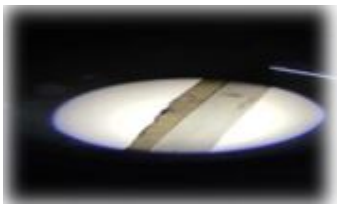
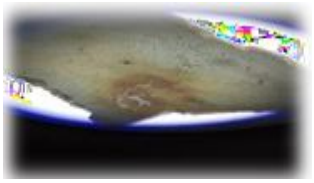
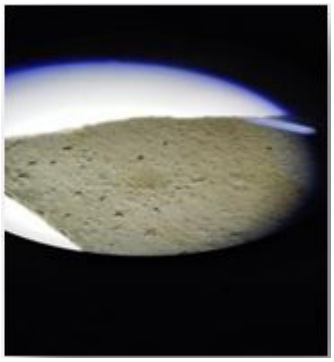
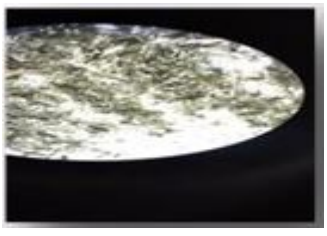
Table 3. Physical and microscopic examination sample no: 20 to 30.

S. no.	Model	Physical examination	Microscopic examination
1	Maruti 800 DX		
2	Indica		
3	Swift dzire		
4	Creta		
5	Etios		
6	Tata Mahindra		

7	Maruti 800		
8	Tata safari strome		
9	lancer		
10	Maruti suzuki 800		
11	Maruti suzuki 800		

12	Maruti 800		
13	Mahindra LX		
14	Bullet 350cc		
15	Mahindra scorpio facelift		
16	Mahindra scorpio		
17	Bullet 250cc		

18	Indigo pal		
19	Maruti 800 (1985)		
20	Force tempo traveller		
21	GLS Pajero		
22	Toyota gualis		
23	Chevrolet FA		
24	Bolreo		

25	Innova		
26	Indigo marina		
27	Mahindra bolero		
28	FIAD		
29	Scorpio turbo 2.6		

30	Toyota qualis		

Table 4. Detail explanation about physical examination and microscopic examination.

Discussion

Physical examination: The physical feature of the paint was observed which includes the color, size, texture and shape and year of manufacturing. It helps in documentation, for describing the general condition as well as the easy evalution of the sample.

Microscopic examination:

- It is done by using stereomicroscope for determining the number of layers, surface markings, formation of rust, modification applied onto the coating by applying more number of coatings to change the topcoat color
- **Physical matching:** The matching of the sample from the broken pieces obtained along their edges with the control samples.
- **Layers matching:** It consists of several layers such as topcoat, basecoat and clearcoat. Whether it matches with the suspected sample obtained from the crime scene to those of the control sample based on the Law of comparison.
- Sequences of layer determination
- Repainted vehicles have difference in layers when the matching of layers is performed.
- **Surface markings:** Scratch marks, texture, any material adhered onto the surface.
- Different automobile manufactures have incorporated different color combination or coating process depending upon the cutomers satisfaction or needs in the market which makes them unique. Hence the layers observed are different for different manufacturers (Tables 5-8).

S. no	Model	Acetone	Chloroform	Characteristics observed	
				Acetone	Chloroform
1	Marruti 800DX	Not soluble	Soluble	No change	Curling along the edges
2	Indica	Not soluble	Soluble	No change	Curling along the Softening
3	Swift desire (pearl white)	Not soluble	Soluble	No change	Curling
4	Creta (pure white)	Not soluble	Soluble	No change	Curling along the edges, softening with cracks
5	Etios	Not soluble	Soluble	No change	colour fading and softening
6	Tata mahindra	Soluble	Soluble	Colour fading	colour fading
7	Maruti 800	Not soluble	Soluble completely	No change	Forms cracks and effervescence
8	Tata safari strom	Soluble completely	Not soluble	Formation of cracks	
9	Lancer	Not soluble	Not soluble	No change	No change
10	Maruti suzuki 800	Soluble	Soluble	Colour fading	No change
11	Pulsar 180	Soluble	Soluble	Softening	Colour fading
12	Maruti 800	Soluble	Soluble	Curling along the edges, Colour faded to grey	No change
13	Mahindra LX	Soluble completely	Soluble	Separated into two layers	
14	Bulet 350CC	Soluble	Not soluble	No change	Curling along the edges and softening
15	Mahindra scorpio facelift	Soluble	Not soluble	No change	Separated into two layers

16	Mahindra scorpio	Soluble	Not soluble	Softening	No change
17	Bulet 250	Soluble	Soluble	No change	Efferevescence, colour fading
18	Indigo pal	Soluble	Soluble	No change	Colour fading
19	Maruti 800 (1985)	Soluble	Soluble	No change	Colour fading and formation of cracks
20	Fce tempo traveller	Soluble	Not soluble	No change	No change

Table 5. Solubility tests acetone and chloroform sample no: 1 to 20.

S. no	Model	Acetone	Choloroform	Characteristics observed	
				Acetone	Chloroform
21	GLS Pajero	Not soluble	Soluble	No change	Color fading
22	Toyota Quals	Not soluble	Sobble	No change	Softening
23	Chevrolet FA	Not soluble	Soluble	No change	Curing
24	Bolereo	Not soluble	Soluble	No change	Curing softening
25	Innova	Not soluble	Soluble	No change	Curling softening
26	Indigo marina	Not soluble	Not soluble	No change	No change
27	Mahindra Bolero	Not sobble	Soluble	No change	Curling
28	FLAD	Soluble	Not soluble	Separate layers	No change
29	Scorpio turbo 2.6	Not solibble	Soluble	No change	Curing
30	Toyota Quals	Not soluble	Not soluble	No change	No change

Table 6. Solubility test acetone and chloroform sample no: 21 to 30.

S. no	Model	Cone HCl	Conc H_2SO_4	Conc HNO_3
1	Maruti 800	Color change-yellow	Color change-light red	No change
2	Indica	No change	Color change and hissing	No change
3	Swift dire	Effervescence hissing sound	Slight color change	Color change-pale yellow
4	Creata	No change	Color change-light brown	Color change-pale yellow
5	Etios	No change	Slight color change	No change
6	Tata mahindra	Color change-deep yellow	Color faded	Color change-pale brown
7	Maruti 800	No change	Color change-pale brown	No change
8	Tata safari storm	Color change-pale yellow	Color change-light brown	No change
9	Lancer	Color change-grey	Color change-light brown	Color change-pale yellow
10	Maruti suzuki 800	Color change-pale yellow	No change	No change softening
11	Pulsar 180	No change	No change	No change
12	Maruti 800	No change	Color change-pale yellow	No change
13	Mahindra LX	Color change-pale yellow	Color change-pale Brown	No change
14	Bullet 350cc	No change	Color change-pale brown	No change
15	Mahindra scorpio facelift	No change	Color change-pale yellow	No change

16	Mahindra scorpio	Color change-deep yellow	Color change-pale brown	Color change-pale brown
17	Bullet 250cc	Color change-deep yellow	Color change-pale red	Color change-pale red
18	Indigo pal	Color change-yellow	No change	No change
19	Maruti 800 (1985)	Color change-pale yellow	Color change-deep red	No change
20	Force Tempo traveller	Color change-deep yellow	Color change-pale yellow	No change

Table 7. Microchemical test conc HCl, conc H_2SO_4, conc HNO_3 sample No: 1 to 20.

S. no	Model	Conc HCl	Conc H_2SO_4	Conc HNO_3
21	Gls pajero	Color change-deep yellow	Color change-purple	Color change-red
22	Toyota qualis	Color change-pale yellow	Color change-pale brown	No change
23	Chevrolet FA	Color change-yellow	Color change-pale brown	No change
24	Bolereo	No change	Color change-pale brown	No change
25	Immova (2008)	No change	No change	Color change-pale yellow
26	Indigo menina	No change	Color change-deep brown	Color change-pale yellow
27	Mahindra bolereo	Color change-deep yellow	Color change-pale brown	No change
28	FIAD	No change	Color change-pale brown	No change
29	Scorpio turbo 2.6	No change	No change	No change
30	Toyota quals	Color change-pale yellow	Color change-dark green	No change

Table 8. Microchemical and solubility test conc HCl, conc H_2SO_4, conc HNO_3 sample No: 21 to 30.

Micro chemical tests

- **Diphenyl amine reagent:** 0.3 gm of diphenylamine in 20 ml H_2SO_4 and glacial acetic acid (Table 9).
- **Le Rosen reagent:** 10 drops of 37% formaldehyde added drops by drop to 10 ml of Sulphuric acid (Figures 1-8)

Reagents	Results
Conc NaOH	No change
Le Rosen reagent	No change
Diphenylamine	No change
Benzene	No change
Methanol	No change
Xylene	No change
Ethyl acetate	No change
Ammonium sulphide	No change

Table 9. Reagents and results.

Observation

The observations of acetone and chloroform show in Figures 1-4.

Figure 1. Curling, softening.

Figure 2. Separation two layers.

Figure 3. Effervescence.

Figure 4. Color change.

Observation

The observations of Conc HCL, conc H_2SO_4, conc HNO_3 show in Figures 5 and 6.

Figure 5. Color change, effervescence.

Figure 6. Benzene, xylene, methanol no change.

Observation

The observations of Conc. NaOH and ammonium sulphide show in Figures 7 and 8.

Figure 7. Conc NaOH, diphenylamine reagent, Le Rosen reagent, no change.

Figure 8. Ammonium sulphide, ethyl acetate, no change.

Solubility test:

- **Acrylic lacquers:** Soluble (Chloroform, acetone).
- **Nitrocellulose lacquers:** Soluble (acetone).
- **Nitrocellulose lacquers:** Insoluble (Chloroform).
- **Enamels:** Insoluble(acetone, chloroform).

Microchemical tests

- Paint chips are tested using the chemicals which lead to various chemical reactions that help in identifying the components in the paint such as pigment, binder, additives etc.
- Almost all the samples show reaction such as effervescence, cracks formation, color change, softening etc. with conc H_2SO_4 and conc HCL.
- Paint chips having carbonates gives off bubbles or hissing sound with strong acids.
- Conc HNO_3 showed very less compared to the conc H_2SO_4 and conc HCL among different manufacturers.
- Ethyl acetate, Ammonium sulphide, conc NaOH, Le Rosen reagent, Diphenyl amine reagent, Benzene, Methanol and xylene gave negative results with all the paint chips (Figure 9).

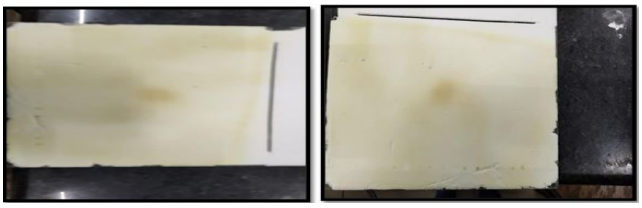


Figure 9. Thin layer chromatography.

Retardation factor

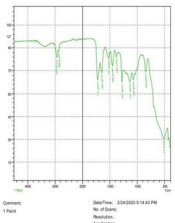
R_f=Distance travelled by solute/distance travelled by solvent.

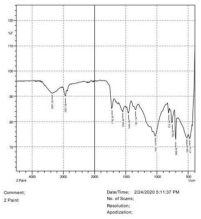
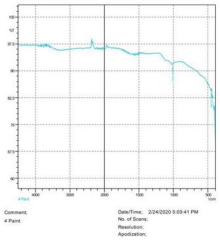
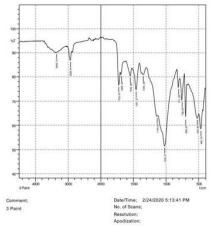
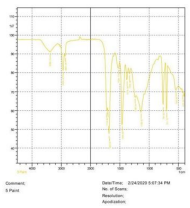
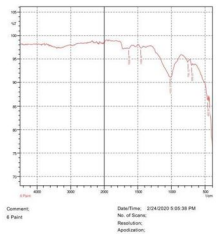
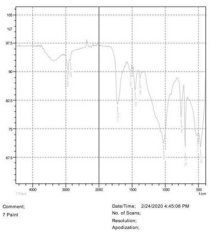
R_f value: 7.8, 8.9, 9.5, 10, 6.5

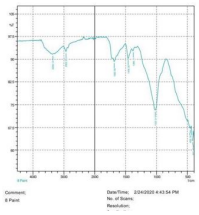
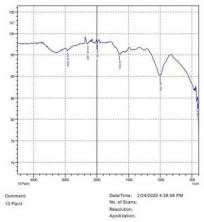
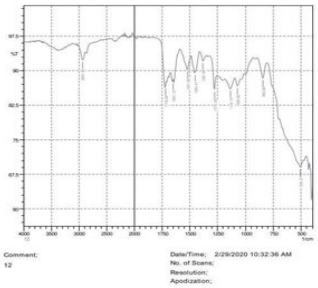
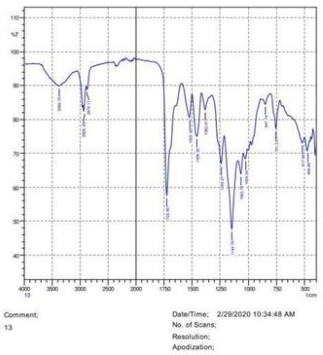
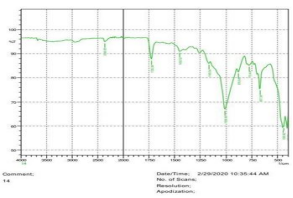
The paint chips which are soluble in acetone and chloroform were separated using TLC. The components get separated based on the affinity towards stationary phase.

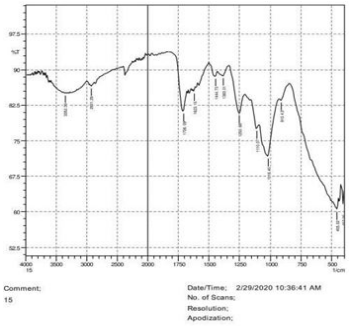
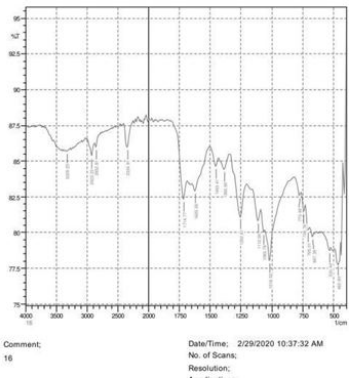
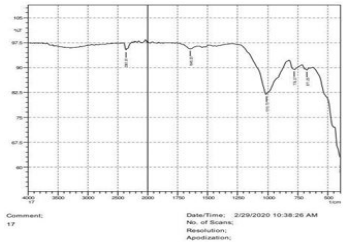
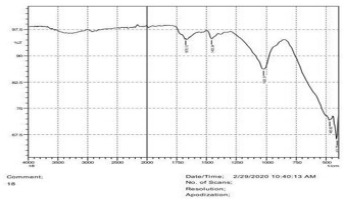
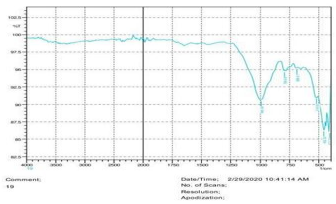
Instrumentation fourier transform infrared

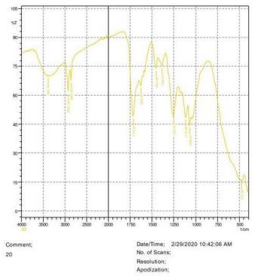
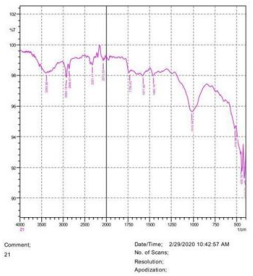
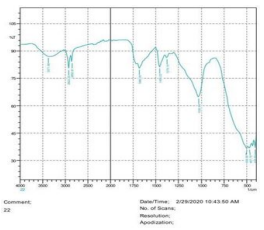
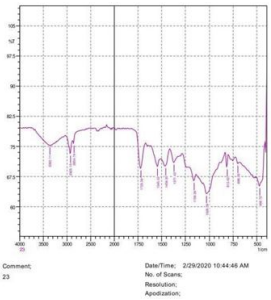
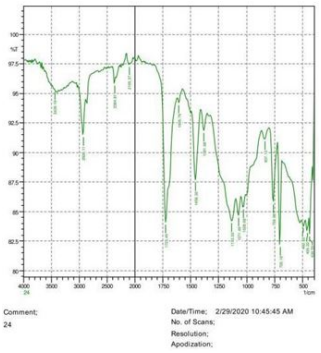
- The FTIR peak examination gives idea about the composition of the given sample such as the functional group present and the molecular vibration associated. A graphical representation of absorption peak v\s intensity gives the exact idea about the composition. The automobile paint samples were submitted for FTIR peak examination and the following information was derived:
- Almost 28 samples were given for examination and the absorption peak of every individual sample was obtained.
- Functional groups and their molecular vibration were observed. Alcohol derivatives, ketone, Aldehyde, Esters, Ether, Halogen, Nitro Groups, Amine, Sulfur compounds *i.e.* sulfoxide; sulfone and sulfonate etc. were found to be present in the automobile paint samples. The composition varies according to the model and the pigment used (Table 10).

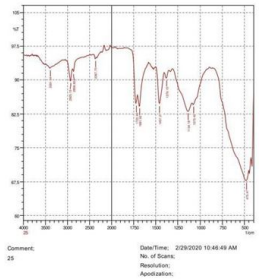
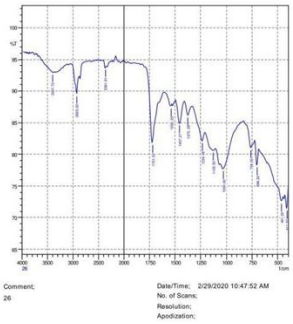
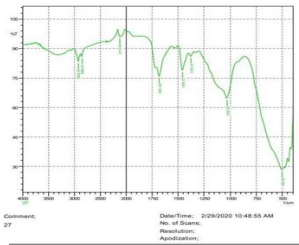
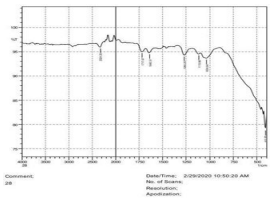
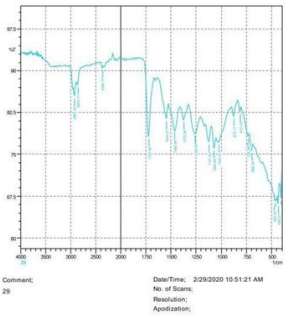
FTIR peak	Absorption (cm^{-1})	Group	Interpretation
	1134.18	C-O stretching	Tertiary alcohol
	1452.45	C-H bending	Alkane
	1645.33	C=C stretching	Vinylidene
	1721.53	C=O stretching	Cyclohexane
	2856.67	C-H stretching	Cyclopentanone
	2928.04	O-H stretching	Aldehyde
			Alcohol

	759.05	C-H bending	1,2 disubstituted
	812.06	C-H bending	1,4 disubstituted
	1027.13	S=O stretching	Sulfoxide
	1341.54	C-N stretching	Aromatic amine
	1454.38	C-H bonding	Methyl group
	1550.82	N-O stretching	Nitro compound
	1720.56	C=O stretching	Dimer, Conjugated acid
	2927.08	C-H stretching	Alkane
	3357.22	N-H stretching	Aliphatic primary amine
	1015.56	S=O stretching	Sulfoxide
	811.09	C-H bonding	1,4 disubstituted
	1023.27	N-O stretching	Hydrate
	1140.93	N-O stretching	Hydrate
	1348.29	O-H bending	Intramolecular bond
	1457.27	N-O stretching	Carboxylic acid
	1549.86	C=N stretching	Nitro group
	1685.84	C=O stretching	Imine/oxime
	1723.45	C=O stretching	Conjugated acid
	2928.04	N-H stretching	Amine salt
	3359.14	C-H stretching	Alkyne
	761.91	C-H bending	1,2,3-trisubstituted
	1139.97	C-O stretching	Secondary alcohol
	1333.82	S=O stretching	Sulfonamide
	1378.18	S=O bending	Sulfate
	1459.2	C-H bending	Alkane
	1526.71	N-O stretching	Nitro group conjugated
	1683.91	C=O stretching	ketone carboxylic acid
	1719.6	C=O stretching	Alkane
	2961.49	C-H stretching	Alkane
	2929.97	C-H stretching	Aliphatic primary amine
	3339.15	N-H stretching	
	699.22	C=C stretching	Alkene
	756.12	C-H bending S=O stretching	Mono substitute
	1023.27		Sulfoxide
	1456.3	O-H bending C=C stretching	Dimer
	1636.65		alkene
	700.18	C-H bending	1,2,3,4,5,6 substituted
	759.98	C-H bending	1,2-disubstitude
	1028.09	C-O stretching	Vinyl ether
	1381.00	O-H bending	Phenol
	1452.45	C-H bending	Alkane
	1526.71	N-O stretching	Nitro group
	1719.63	C-O stretching	Carboxylic acid

	2854.74	C-H stretching	Alkane
	29324.18	C-H stretching	Alkane
	1022.31	C-O stretching	Alkyl aryl ether
	1380.11	O-H bending	Phenol
	1456.3	C-H bending	Alkane
	1682.95	C=O stretching	Conjugated ketone
	2922.25	C-H stretching	Alkane
	3359.14	N-H stretching	Secondary amine
	1003.98	C=C bending	Alkene
	1642.44	C=C stretching	Alkene
	1990.6	C-H bending	Aromatic compound
	2287.65	N=C=O stretching	Nitrile
	2920.32	C-H stretching	Alkane
	840.99	C-H bending	1,2 disubstituted
	1069.56	S=O stretching	Sulfoxide
	1135.15	C-O stretching	Secondary alcohol
	1276.92	C-O stretching	Aromatic ester
	1381.08	O-H bending	Phenol
	1453.41	C-H bending	Methyl group
	1521.89	N-O bending	Nitro compound
	1651.12	O-C=N stretching	Oxime
	1719.6	P-C=O stretching	Dimer
	2931.9	Q-H stretching	Carboxylic acid
	751.3	C-H bending	1,2 dsiubstituted
	847.74	C-H bending	1,4 disubstituted
	1024.24	S=O stretching	Sulfoxide
	1063.78	C-O stretching	Alkyl aryl ether
	1144.79	S=O stretching	Sulfone
	1240.27	C-O stretching	Alkyl aryl ether
	1383.01	O-H bending	Phenol
	1456.3	C-H bending	Alkane
	1522.85	N-O stretching	Nitro compound
	1723.45	C=O stretching	αβ-unsaturated ester
	2870.17	C-H stretching	Alkane
	2929	C-H stretching	Alkane
	3369.75	N-H stretching	Aliphatic primary amine
	773.48	C-H bending	1,2-disubstituted
	876.68	C-H bending	1,2,3-trisubstituted
	1008.8	C=C stretching	Alkene
	1165.04	N-O stretching	Nitro compound
	1450.52	O-H bending	Phenol
	1725.38	P-C=O stretching	Carboxylic acid
	2380.95	C≡C stretching	Alkyne

	910.43	N-O stretching	Nitro compound
	1018.45	O-O stretching	Nitro compound
	1110.07	C-O stretching	Tertiary alcohol
	1250.88	C-F stretching	Fluoro compound
	1383.01	C-N stretching	Aromatic amine
	1444.73	O-H stretching	Carboxylic acid
	1623.15	C=C stretching	Conjugated alkene
	1706.09	C=O stretching	Carboxylic acid
	2921.29	O-H stretching	Carboxylic acid
	3352.39	O-H stretching	Carboxylic acid
	705.01	C-H bending	Benzene derivative
	739.76	C-H bending	1,2-disubstituted
	773.48	C-H bending	1,2-disubstituted
	1016.52	C=C bending	Alkene
	1063.78	S=O stretching	Sulfoxide
	1112	C-O stretching	Secondary alcohol
	1252.81	C-O stretching	Alkyl aryl ether
	1385.9	O-H bending	Phenol
	1453.41	C-H bending	Alkane
	1620.26	C=C stretching	αβ-unsaturated ketone
	1714.77	C=O stretching	Carboxylic acid
	2334.91	O=C=O stretching	Carboxylic acid
	2852.81	C-H stretching	Alkane
	2923.22	C-H stretching	Alkane
	3329.25	N-H stretching	Aliphatic primary amine
	671.25	C-Br stretching	Halo compound
	776.37	C-Cl stretching	Halo compound
	1010.73	C-F stretching	Fluoro compound
	1645.33	C=N stretching	Imine
	2361.91	C≡N stretching	Nitrile
	1022.31	N-O stretching	Nitro group
	1455.34	C-F stretching	Fluoro compound
	1678.13	C=O stretching	Carboxylic acid
	688.61	C-Br stretching	Halo compound
	789.88	C-Cl stretching	Halo compound
	990.48	C-F stretching	Halo compound

	1066.67	S=O stretching	Sulfoxide
	1112.96	C-O stretching	Secondary alcohol
	1252.81	C-N stretching	Amine
	1383.01	O-H bending	Phenol
	1451.48	C-H bending	Alkane
	1625.08	C=C stretching	αβ unsaturated ketone
	1713.81	C=O stretching	Carboxylic acid
	2853.78	C-H stretching	Alkane
	2923.22	C=H stretching	Alkene
	3391.94	C≡C stretching	Alkyne
	1015.56	C-O stretching	Vinyl ether
	1460.16	C-H bending	Alkane
	1577.82	C=C stretching	Cyclic alkane
	1735.03	C=O stretching	Aldehyde
	2073.55	N=C=S stretching	Isothiocynate
	2321.41	O=C=O stretching	Carbondioxide
	2856.67	C-H stretching	Alkane
	2924.18	C-H stretching	Alkane
	3393.86	N-H stretching	Aliphatic primary amine
	1030.99	S=O stretching	Sulfoxide
	1379.15	O-H bending	Phenol
	1458.23	C-H bending	Alkane
	1680.05	C=O stretching	Secondary amide
	2852.81	N-H stretching	Amine salt
	2922.25	N-H stretching	Amine salt
	3371.68	N-H stretching	Aliphatic primary amine
	813.02	C-H bending	1,4-disubstituted
	1028.09	S=O stretching	Sulfoxide
	1159.26	S=O stretching	Sulfone
	1371.43	S=O stretching	Sulfonamide
	1459.2	C-H bending	Alkane
	1545.03	N-O stretching	Nitro compound
	1720.56	C=O stretching	αβ unsaturated ester
	2854.74	C-H stretching	Alkane
	2925.15	C-H stretching	Alkane
	3360.11	N-H stretching	Aliphatic primary amine
	759.98	C-H bending	Monosubstitute
	837.13	C-H bending	1,4-disubstituted
	1028.09	S=O stretching	Sulfoxide
	1071.49	C-O stretching	Secondary alcohol
	1133.22	C-O stretching	Aliphatic ether
	1381.08	C-N stretching	Aromatic amine
	1451.3	C-H bending	Alkane
	1605.79	N-O stretching	Nitro compound
	1723.45	C=O stretching	Aliphatic ketone
	2105.37	C≡C stretching	Alkyne
	2364.81	O=C=O stretching	Carbondioxide
	2926.11	N-H stretching	Amine salt

	1073.42	C-O stretching	Primary alcohol
	1134.18	C-O stretching	Aliphatic ether
	1379.15	O-H bending	Phenol
	1457.27	C-H bending	Alkane
	1681.02	C=O stretching	Primary amide
	1722.49	C=O stretching	Aliphatic ketone
	2367.7	N=C=O stretching	Isocyanate
	2858.6	C-H stretching	Alkane
	2925.15	C-H stretching	Alkane
	3391.94	N-H stretching	Aliphatic primary amine
	1030.02	S=O stretching	Sulfoxide
	1125.5	C-O stretching	Aliphatic ether
	1234.48	C-N stretching	Amine
	1375.29	C-H bending	Alkane
	1457.27	O-H bending	Carboxylic acid
	1539.25	N-O stretching	Nitro compound
	1721.53	C=O stretching	Aliphatic ketone
	2361.91	O=C=O stretching	CO_2
	2923.22	C-H stretching	Alkane
	3397.72	N-H stretching	Aliphatic primary amine
	1030.99	S=O stretching	Sulfoxide
	1379.15	O-H bending	Alcohol
	1458.23	C-H bending	Alkane
	1681.02	C=N stretching	Imine
	2119.84	N=C=S stretching	Isothiocynate
	2852.81	C-H stretching	Alkane
	2922.25	C-H stretching	Alkane
	1034.84	S=O stretching	Sulfoxide
	1115.86	C-O stretching	Aliphatic ether
	1269.2	C-O stretching	Alkyl aryl ether
	1640.51	C=C stretching	Conjugated alkene
	1717.67	C=O stretching	Aliphatic ketone
	2324.3	O=C=O streching	Carbondioxide
	812.06	C-H bending	1,2,4-trisubstituted
	875.71	C-H bending	1,2,4-trisubstituted
	1022.31	C=C bending	Alkene
	1069.56	S=O stretching	Sulfoxide
	1121.64	C-O stretching	Secondary alcohol
	1258.59	C-O stretching	Alkyl aryl ether
	1373.36	S=O stretching	Sulfonate
	1462.09	C-H bending	Alkane
	1544.07	N-O stretching	Nitro compound
	1720.56	C=O stretching	Carboxylic acid
	2365.77	N=C=O stretching	Isocynate
	2855.71	C-H stretching	Alkane
	2923.22	N-H stretching	Amine salt

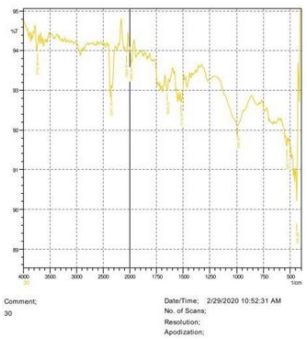
	988.55	C=C bending	Alkene
	1518.03	N-O stretching	Nitro compound
	1648.23	C=C stretching	Alkene
	1989.64	C-H bending	Aromatic compound
	2064.87	N=C=S stretching	Isothiocyante
	2347.45	O=C=O stretching	CO_2
	3743.96	O-H stretching	Alcohol

Table 10. The FTIR peak examination gives idea about the composition of the given sample.

Glitter

Types of glitter

- **Holographic glitter:** It is a type of glitter that reflects the incident light into different colors.
- **Metallic glitter:** It is not made of glitter but it denotes the property to shine like a metal.
- **Irridescent glitter:** It is a type which is available in different shades.
- Particle size
- **Large size:** 0.5 mm-0.8 mm
- **Normal size:** Less than 0.2 mm (most commonly used).
- **Physical analysis:** Different manufactures have different colors.

Shape and size

- **Tenderberry and Vozwa:** Hexagonal, circular, polygonal, pentagonal
- **Middas:** polygonal

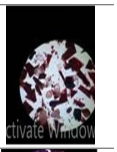
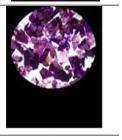
Specific gravity: The glitter particles sink in acetone which states that the specific gravity of glitter is more than that of the acetone.

During the microscopic examination of Middas manufacutrer there was contaminants such as sand was present in the samples. The adulterants were added to enhance the shinning property of the glitter or to increase the quantity of glitter particles (Tables 11 and 12).

Manufacturer			Color	Texture	Shape	Specific gravity
VOZWA	1)	V1	Red shimmer	Smooth	Hexagonal	Sink
	2)	V2	Red matte	smooth	Circular/Spherical	Sink
	3)	V3	Blue matte	smooth	Spherical	Sink
	4)	V4	Silver	smooth	Hexagonal	Sink
	5)	V5	Orange matte	Smooth	Polygonal	Sink
	6)	V6	Golden shimmer	Smooth	Hexagonal	Sink
	7)	V7	Golden matte	Smooth	Pentagonal	Sink
	8)	V8	Dark green	Smooth	Hexagonal	Sink
	9)	V9	Orange	Smooth	Hexagonal	Sink
	10)	V10	Silver matte	Smooth	Polygonal	Sink
	11)	V11	Pink	Smooth	Hexagonal	Sink
	12)	V12	Pink matte	Smooth	Spherical	Sink
TENDERBERY	13)	T1	Baby pink	Rough	Spherical	Sink
	14)	T2	Magenta pink	Rough	Polygonal	Sink

	15)	T3	Blue matte	Rough	Polygonal	Sink
	16)	T4	Dark brown	Rough	Polygonal	Sink
	17)	T5	Multi-color	Rough	Polygonal	Sink
	18)	T6	Green	Rough	Hexagonal	Sink
	19)	T7	Golden	Rough	Polygonal	Sink
	20)	T8	Purple	Rough	Polygonal	Sink
	21)	T9	Black	Rough	Polygonal	Sink
	22)	T10	Brown	Rough	Hexagonal	Sink
	23)	T11	Red shimmer	Rough	Polygonal	Sink
	24)	T12	Rose orange	Rough	Polygonal	Sink
MIDDAS	25)	MI	Golden	Smooth	Polygonal	Sink
	26)	M2	Green	Smooth	Polygonal	Sink
	27)	M3	Red	Smooth	Polygonal	Sink
	28)	M4	Pink	Smooth	Polygonal	Sink
	29)	MS	Silver	Smooth	Polygonal	Sink

Table 11. Graphical representation of gliter.

Tenderbery	Shape	Colour	Texture	Image	Vozwa	Shape	Colour	Texture	Image	Middas	Shape	Colour	Texture	Image
T1	Spherical	Baby pink	Rough		V1	Hexagonal	Red shimmer	Smooth		M1	Polygonal	Golden	Smooth	
T2	Polygonal	Magnet A pink	Rough		V2	Circular/ Spherical	Red matte	Smooth		M2	Polygonal	Green	Smooth	
T3	Polygonal	Blue matte	Rough		V3	Spherical	Blue matte	Smooth		M3	Polygonal	Red	Smooth	
T4	Polygonal	Dark brown	Rough		V4	Hexagonal	Silver	Smooth		M4	Polygonal	Pink	Smooth	
T5	Hexagonal	Multi-colour	Rough		V5	Polygonal	Orange matte	Smooth		M5	Polygonal	Silver	Smooth	
T6	Hexagonal	Green	Rough		V6	Hexagonal	Golden shimmer	Smooth		M6				
T7	Hexagonal	Golden	Rough		V7	Pentagonal	Golden matte	Smooth		M7				

T8	Hexagonal	Purple	Rough		V8	Hexagonal	Dark green	Smooth		M8
T9	Hexagonal	Black	Rough		V9	Hexagonal	Orange	Smooth		M9
T10	Hexagonal	Brown	Rough		V10	Polygonal	Silver matte	Smooth		M10
T11	Polygonal	Red shimmer	Rough		V11	Hexagonal	Pink	Smooth		M11
T12	Polygonal	Rose orange	Rough		V12	Spherical	Pink matte	Smooth		M12

Table 12. Explanation about glitters.

Conclusion

Paint is the coating substance that is implemented on metallic and non-metallic surfaces for decorative or protection purposes. It is composed of four components pigment, binder, liquid and additives. Application method can depend on the types of paint it can include spray, brush, and electrostatic spraying. Paint is mainly of two types, based on physical state and based on function. Primer, first coat applied directly on a steel surface and also provides surface protection from corrosion. Base coat is applied after the primer and helps in providing a visual color effects. Clear coat is placed on the top of the base coat. It does not contain any color and provide protection to the paint and to make it look shiny. It consists of UV inhibitor's as paint gets damaged because of the sun's UV rays. Paint chips are found very useful in the forensic field. Paint chips are used in cases involving hit and run cases, burglary case, sexual assault cases, homicide and kidnapping. These evidences are collected, preserved and packaged. In hit and run cases, it is removed using sharp object such as knife, blade and layers of paint is scrapped from the vehicle. These collected paint chips are analyzed. Firstly, physical examination is done on the evidence, which involves color, size, texture of evidence and then state of evidence. After physical examination, the evidence is analyzed under the stereomicroscope for determining the number of layers, surface marking and distribution of pigments using stereomicroscope. Various chemical test are also performed on these evidences; microchemical test, solubility test and TLC.

Inorganic solvent which includes conc. HCl, conc. H_2SO_4, and conc. HNO_3 was used for microchemical tests. Various types of reactions was observed such as color change, bubbling, effervescence, softening, curling and formation of cracks was observed after the addition of reagents. Thin layer chromatography was performed and calculated the R_f factors based on the chromatogram which was obtained after visualization. The elemental analysis of various paint chips was done using Fourier Transform Infrared (FTIR). It helps in determine the molecular functional groups in the paint chips based on the peaks obtained.

Glitters are sparkling material which shines by reflecting bright and shimmery light at different angles. It is entirely man-made. It is made up of many of tiny pieces of different material such as aluminum foil, titanium dioxide, copolymer plastic and iron oxides. In prehistoric time glitter was made from stones such as malachite and mica and also from some insects and glass. Glitter is used to make cosmetic products, craft, projects, clothes, decorative items etc. Glitter is of main three types; holographic glitter, metallic glitter and iridescent glitter. It is classified on the basis of shape, size and transparency. Glitter can also be important in the forensic as trace evidence eg. Sexual assault case, kidnapping, hit and run cases, homicide etc. Currently glitter is used in many products, cosmetic, designer clothes or bags etc. It is hardly visible, easily transferable, can tolerate extreme condition, maximum retention time, least degradation. We can locate glitter by using flashlights and can be collected using post-it note. In zip-lock bags packaging is done. Physical examination, microscopic examination and instrumental analysis are conducted. Color of glitter, shape, size, thickness, specific gravity is examined. Techniques used for instrumental analysis ATR-FTIR, dispersive Raman micro spectroscopy with confocal imaging, scanning electron microscopy.

Color is physically examined. Using stereomicroscope shape and size of glitter was examined. Glitters are manufactured in different shapes such as hexagonal, square, rectangle, diamond etc. Specific gravity can be measured using ethanol, suspend the glitter in acetone and then observe whether it sinks or floats. Here most of the glitter particles sink which states that the specific gravity of glitter is more than that of the solvent used.

Acknowledgement

It gives us great pleasure to complete and submit this thesis entitled. Analysis of unusual trace evidence-paint and glitter within a stipulated time. We hope that this work will be of immense value.

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Declaration

I hereby declare that the project report entitled analysis of Unusal Trace Evidence-Paint and Glitter" submitted to the School Bioengineering and Biosciences, Lovely Professional University for the award of degree of Bachelor of science (B. Sc.) is a record of original and independent research work done by us under the supervision and guidance of Kiran Yadav, Assistant professor (Forensic Science), School of Bioengineering and Bio-Sciences, Lovely Professional University. This work has not been submitted for any other degree or professional qualification except as specified.

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