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TRACE EVIDENCE ANALYSIS USING ELEMENTAL & THERMAL COMPARISON TECHNIQUES IN HIT & RUN CASE

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ABSTRACT Physical evidences play an important role in forensic investigation of any crime. Sometimes analysis of these evidences are challenging because of trace quantity as they need all examinations such as determination of microchemical reaction, chemical composition and their comparison. The physical evidences such as paint and polymer in a hit and run case in similar context were successfully analyzed using Micro XRF and thermal methods. Elemental composition of paint was determined using Micro XRF technique and paint compositions at the site of collision of two vehicles were found matching. Similarly thermal properties of polymer were studied using simultaneous thermal analysis. The results of comparison using thermal analysis and differential scanning calorimetry of the polymer and glass fiber pieces at the crime scene tally with accused car bumper pieces and glass fiber pieces of the victim's vehicle. Thus physical evidences left at the crime scene when properly collected and examined form an important evidence to link the accused with the crime.

KEYWORDS : Polymer comparison, Paint Comparison, STA, XRF.

1. INTRODUCTION:

As per one of the principle of forensic science, "Facts do not lie, men can and do". Hence the importance of circumstantial evidence is as good as oral evidence. Physical evidences such as polymer, paint, blood and earth are important trace evidences in forensic investigations**.** Those trace evidences need careful handling and proper choice of analysis**.** During forensic investigations, instrumental analysis not only provides accurate results but it also has major role to establish the relation between evidence at crime scene and the suspected material. In hit and run cases where there are no eyewitnesses, there these physical evidences are important to solve the cases[1]. The major evidences in hit and run cases are paint or fiber or polymer materials of vehicles. The most common classical method thermogravimetry(TG) and differential scanning Calorimetry (DSC) are special branches that can be successfully useful in forensic investigations of polymeric material[2,3,4]. The term thermal analysis incorporates those techniques in which some physical parameter of the system is determined and recorded as function of temperature[5]. Simultaneous Thermal Analysis (STA) measures both heat flow and weight change in material as a function of temperature or time in a controlled atmosphere. The merit of this technique is that it is very sensitive and accurate, however it also require very small sample (mg) for the analysis and method for sample preparation is also very simple.

For paint analysis, the paint samples are examined by various methods such as of optical microscopy, infrared spectroscopy and X-ray micro spectrometry and scanning electron microscope [6,7]. In the recent years simultaneous multi elemental composition can be determined by a non-destructive instrumental technique Micro XRF and proved to be a useful tool in comparison of the evidences. In serious hit and run case, the physical evidences were collected and forwarded to forensic laboratory for chemical examination.

1.1 Case summary:

In a hit and run case a car hit the motor cycle at back side and ran away from the spot. The collision was so severe that a policeman while patrolling on motor cycle was died on spot and other was seriously injured. The case was registered under section 279, 304 (2), 308 IPC along with 134, 177, 184, 185 motor vehicle Act. Red colored glass fibers pieces of broken indicator light cover and some silver grey colored fiber pieces were found lying on the crime scene spot. Suspected car involved in the collision was observed carefully. In this case front portion of the car bumper was damaged and some pieces of the bumper were found missing. A small red colored piece of glass fiber was also found clung in the bumper of car. Samples collected in incident were as follows and shown in **fig.1, 2 and 3.**

Ex1-Red colored glass fiber piece seized from crime scene.
Ex2- Red colored glass fiber piece clung to bumper of accused car.
Ex3- Silver Grey colored fiber piece seized from crime scene.
Ex4- Silver Grey colored bumper piece seized from crime scene.
Ex5- Silver Grey colored car bumper pieces seized from accuse.
Ex6-fiber piece of suspected car from which traces of white colored paint collected. (hit portion)
Ex7- White colored fiber piece of motor cycle. (control)
Ex8-Silver Grey colored paint scrapings of suspectedcar. (control)

Thus in present study the fiber pieces from the bumper of car, fiber pieces from the crime scene as well as paint scrapings that mutually transferred during collision of the vehicles were collected in order to link the vehicle used in the crime. The STA and XRF study was performed in this case to compare the samples collected from crime scene and seized from accused vehicle.

2.0 Experimental

2.1 Preliminary examination:

Thickness of bumper pieces and glass fibers were determined using digital Mitutoyo absolute digimatic vernier calliper. Surface of the exhibits were observed under Motic stereo microscope. The density of sample was found out using Sartorius density balance, model LA230P.

2.2 Simultaneous thermal analysis:

Silver grey colored fiber pieces-Outer colored coating of the bumper piece was removed in the form of thin layer and inner layer was trimmed to fine particle and used for STA analysis.

Red colored glass fibers pieces-–Pieces of glass fiber of broken indicator light cover were trimmed to fine particles & used for STA analysis.

The STA measurements were performed using NETZCSH STA 449 F3 (Jupiter) instruments using aluminum crucible with pierced lid and nitrogen as purge gas at a flow rate of 40.ml /min. About 4-5 mg samples were used in this study. During study, samples were placed in the center of the aluminum crucible with tweezers and each specimen was encapsuled. The analysis was performed in the range of 50°C to 600° C at the rate of 20K/min. Data was analyzed using NETZCSH protease software.

2.3 Elemental composition:
The elemental composition of the sample was analyzed on Horiba Micro XRF XGT 7200. A piece of paint scrapings collected from fibers was directly mounted on stage. The analysis was performed under partial vacuum for 100 seconds with XGT Dia. 1.2 mm, X-ray tube vol. 50 kV & current 1.000 mA.

3. RESULTS AND DISCUSSION

3.1 Preliminary examination:
On preliminary examination, red colored glass fiber in Ex no. 1 and 2 were tally on basis of hue, design and density. Thickness of red glass fiber piece cover varies at different sides and were found in the range of 2.55-2.85 mm for Ex no. 1 and 2.84-3.54 mm for Ex no 2. Density of red colored glass fiber piece in Ex no. 1 and 2 were found to be 1.18 gm/cm^{3}each with respect to water. Similarly prima facie the silver grey colored fiber pieces in Ex no. 3 and 4 found on the crime scene and the bumper seized from suspected car in Ex no. 5 were tally with each other with respect to hue, thickness, microscopic appearance and density. Thickness and Density of silver grey colored fiber piece in Ex no. 3, 4 and 5 were found to be 3.06 mm and 1.27 gm/cm^{3}each with respect to kerosene oil (density of kerosene oil was 0.792 gm/cm^{3}at room temp. 27 °C)

3.2 Simultaneous Thermal analysis:
Thermogravimetric measurements in polymer degradation study mainly provide information on the thermal stability, composition, thermal decomposition process and its products. STA allows differentiation between endothermic and exothermic events which has no associated weight loss (e.g. melting or crystallization) and those involving a weight loss (e.g. degradation)

Thermal analysis of Ex no. 1 and 2 are shown in **fig 4** respectively, indicated decomposition temperature 372-382°C with mass change of 13%. The results of thermal analysis depicted in **fig 4** and **table 1** clearly show the perfect matching TG and DSC curves of Ex 1 and 2.

Thermal analysis o**f** ex no. 3, 4 and 5 are shown in **fig 5** and **table 2** respectively indicate decomposition temperature in the range of 400-500°C with mass change of 84.16 %, 86.01 % and 89.43% for Ex no 3, 4, 5 respectively. The overlay in **fig 5** of Ex no. 3, 4 and 5 indicate similar thermal properties.

The results of differential scanning calorimetry depicted in **fig 5** and **table 2** clearly shows the perfect matching temperatures of Ex no. 3, 4 and 5. The **fig 5** shows three DSC curves at temperature range of 123-125°C; 162-164°C and 472-476°C.

The results of TG and DSC are presented in Literature states that majority of the modern thermoplastic car bumpers system fascias are made up of polypropylene as major component while small amount of ethylene propylene diene methylene tetra polymer, (EPDM) and of high density polyethylene (HDPE).

The melting temperature of polyethylene and polypropylene used in bumper by DSC was found to be in the range of 124-131°C and 166-168°C respectively[8-11]. The higher temperature of 476°C for Ex no. 3, 4 and 5 are attributed to the thermal decomposition of the polymer used in bumper.

3.3 Elemental composition of Paint by Micro XRF:
Automotive paint are used for both protection and decoration purpose. Paint is made up of color (pigments) generally titanium oxide. This makes up the primary color of the paint and other secondary color pigments additives compose of various components such as calcium, talk and mica. XRF is an efficient technology for spot analysis of metal coating on vehicles. It is a non-destructive technique and capable of analyzing small paint sample. In the present study a small white paint scraping was found on fiber piece of suspected car at collision site. Chemical test such as effect of various solvents on the scrapping was not possible to determine using so small quantity. Hence the paints were compared using Micro XRF technique as major physico-chemical evidence.

Very few white colored paint particles adhered to silver grey colored fiber piece of suspected car in Ex no. 6 (hit portion of car) was removed very carefully and compared with the white colored paint scrapping collected from white colored fiber pieces of motor cycle in Ex no. 7(control). Similarly silver grey colored paint scrapping collected from Ex no. 3 & 4 in crime scene were compared with the silver grey colored paint scrapping collected from fiber piece of bumper in Ex no. 5 siezed from accused and silver grey colored paint scrapping of car in Ex no. 8 (control).

Elemental analysis of very few white colored paint particles adhered to fiber piece in Ex no. 6 and white paint scrapping of Exno. 7 were found to be matching physically and chemically as shown in **table 3** and **fig 6**. Hence it was the paint traced as physical evidence that linked the collision of accused vehicle with victim vehicle. Similarly silver grey color paint scrapping of Ex no. 3, 4, 5 and 8 were found to be matching physically and chemically as shown in **table 4** and **fig 7.**

CONCLUSION:

Modern instrumental methods can now be used as successful tool to establish the similarity or dissimilarity of the physical evidences in hit and run cases in absence of eye witness in any crime. The physical evidences left at the crime scene when properly collected and examined form an important evidence to link the accused with the crime. The present study focused on comparison of polymer using STA that incorporate both TG and DSC. Similarly in spite of too small quantity of paint at site of collision of vehicles, analysis was successfully carried out using Micro XRF. Thus a case of hit and run which took precious life of a policeman especially on duty was solved through comparative analysis of paint and polymer**.**

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FIG .1 Glass Fiber Pieces
(a) Ex-1-red colored glass fiber piece seized from crime scene and
(b) Ex-2-red colored glass fiber piece clung to bumper of accused car

(a) (b)

FIG. 2 Bumper Fiber Pieces
(C) Ex No. 3-Silver Grey colored fiber piece seized from crime scene,
(d) Ex No. 4- Silver Grey colored bumper piece seized from crime scene,
(e) Ex No. 5- Silver Grey colored car bumper pieces seized from accuse for analysis.

(C) (d)

(e)

Fig. 3 Paint comparison
(f) Ex no. 6 fiber piece of suspected car from which traces of white colored paint collected.
(g)Ex no. 7 white colored control piece from motor cycle.

(f)

(g)

Fig. 4: Overlay of DSC & TG profile of Ex no. 1 & Ex no.2

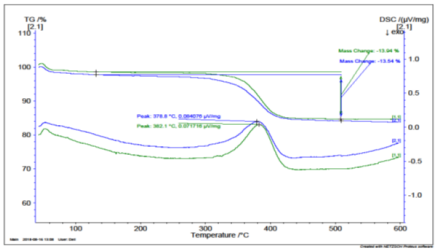

Table-1:DSC and TG results in STA for Red Glass Fiber pieces in Ex no.1&2.

Ex	Weight in mg	Temp°C	µV/mg	Mass Change%
1	5.0	378.8	-0.084076	-13.94
2	4.0	382.1	-0.071716	-13.54

Fig. 5 :Overlay of DSC & TG of Bumper Fiber pieces in Ex no. 3, 4 & 5

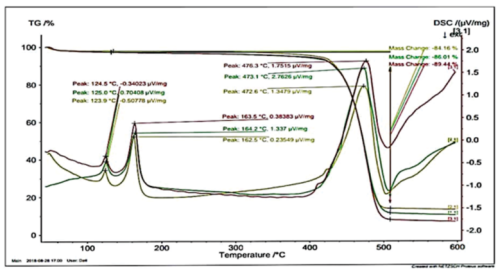

Table-2:DSC and TG results in STA for Bumper Fiber pieces in Ex no.3, 4 and 5.

Ex	weight in mg	Temp °C	µV/mg	Temp °C	µV/mg	Temp °C	µV/mg	% Mass Change
3	4.2	125.2	0.70408	164.2	1.337	473.1	2.7626	-84.16
4	4.5	123.9	-0.50778	162.5	0.23549	472.6	1.3479	-86.01
5	4.2	124.5	-0.34023	163.5	0.38383	476.3	1.7515	-89.43

Fig. 6 :Overlay of White Paint Scrapings of Ex no.6 & 7 by Micro XRF.

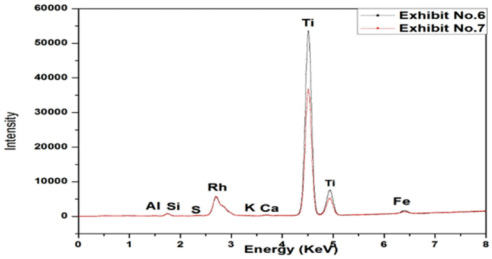

Table-3:Elemental composition of white Paint Scrappings of Ex no.6 & 7 by Micro XRF

Elements	Mass[%]		Atomic[%]	
	Ex6	Ex-7	Ex6	Ex-7
Si	10.81	13.51	16.49	20.09
Ca	0.34	0.41	0.36	0.43
K	-	0.21	-	0.23
Ti	81.51	77.97	72.89	67.98
Fe	1.59	1.18	1.22	0.88
Al	5.40	6.71	8.56	10.39
S	0.35	-	0.47	-

Fig.7:Overlay of Paint Scrapings of Ex no.3, 4, 5 & 8 by Micro XRF

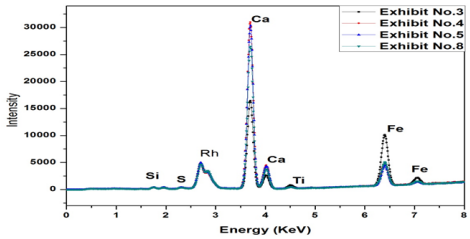

Table - 4 :Elemental composition of Paint by Micro XRF for Bumper pieces in Ex. no. 3, 4, 5 and 8.

Elements	Mass[%]				Atomic %			
	Ex no 3	Ex no 4	Ex no 5	Ex no 8	Ex no3	Ex no4	Ex no 5	Ex no 8
Si	8.30	6.07	7.27	6.31	12.26	8.64	10.32	8.94
S	1.07	0.74	0.92	0.89	1.38	0.92	1.14	1.10
Ca	63.52	83.91	80.83	84.20	65.76	83.63	80.48	83.65
Ti	3.69	1.47	1.75	1.38	3.20	1.23	1.46	1.15
Fe	23.42	7.80	9.23	7.23	17.40	5.58	6.60	5.15

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