Research Journal of Recent Sciences ISSN 2277-2502
Vol. 4(**IYSC-2015),** 166-170 **(2015)** *Res. J. Recent. Sci.*

Identification of Headlight and Windshield glass of Car

Theogene Ntakirutimana[1] and Asha Rajiv[2]
[1]Department of Forensics, School of Graduate Studies, Jain University, J.C. Road, Bangalore, Karnataka, INDIA
[2]Department of Physics, School of Graduate Studies, Jain University, J.C. Road, Bangalore, Karnataka, INDIA

Available online at: www.isca.in, www.isca.me
Received 29th July 2015, revised 24th August 2015, accepted 24th September 2015

Abstract

Fragments of glass represent a useful class of evidence for analysis. The work involved identifying the headlight and windshield of the glass obtained during a hit and run case. Experimental analysis like thermal properties, density, refractive index, infrared spectroscopic studies, Laser Ablation Inductively Coupled Plasma –Optical Emission Spectroscopy measurements were conducted on the glass pieces obtained from the site. The observations revealed that the glass pieces collected were from the headlight and the windshield of the glass. This could be concluded because of the overlapping results obtained from almost all the studies conducted. Also both the glasses were found to contain almost same elements. Only the composition was differing and the configuring elements also differed. The variation in the composition gives more strength to the windshield glass as compared to the headlight glass.

Keywords: Glass, fragments, headlight, windshield, Refractive index.

Introduction

Fragments of glass have been of vital importance in criminal investigations. This is especially true in the case of glass from automobile headlight lenses which are broken at the scene of hit and run accidents. In these cases, the laboratory tests are conducted upon to determine whether or not fragments recovered at the accident scene are identical -with particles of glass found in damaged headlights or windscreen of suspected vehicles. The comparisons may be relatively simple, and the results conclusive if a physical match can be made of broken edges of glass from the two sources. Most frequently, however, the fragments from at least one of the two sources are very small or necessary connecting pieces are not recovered from either the accident scene or the suspected vehicle. When this occurs the comparison of the exhibits must depend upon physical or chemical methods, and it becomes the task of the laboratory worker to find the evidence value of the results obtained.

Variation within the physical properties of glass are the primary classical methods used in the trace evidence of forensic glass. In order to compare the unknown glass fragments with the control glass, usually density, color, surface characteristics and optical properties are the primary analysis carried out. In this more stress need to be on surface characteristics and optical properties of the glass fragments. Usually, similarities are observed in surface or patterns between the questioned and reference items during the fracture edge matching but in order to arrive at a final conclusion, it is advisable to have a larger fragment of the unknown glass fragment.

When a glass breaks, there is a tendency for the fragments to get ejected in all directions, including backward toward the direction of the breaking force[1]. This leads to the transference of glass fragments into clothes and the objects nearby[2]. More likely the chances are there for the glass fragments to get pierced into the closer objects and the transference decreases with the distance from the point of breakage[3].

A number of surveys have been made of glass comparison methods. These included general studies, such as those made byand many others[4]. More recently, papers have been published in this Journal on comparative studies of physical properties of glass fragments. The first of these by covered a study of the refractive index and specific gravity of one hundred miscellaneous' glass fragments from a wide variety of sources. In this investigation, it was possible to distinguish each of the samples from all others examined on the basis of refractive index and specific gravity. More recently, Kirk and Roche compared fifty samples of glass by these same methods[5]. This study showed that all but two of the bottle glass samples considered could be distinguished from each other by refractive index and specific gravity. The present work was carried out to determine whether or not the results would be similar when samples of glass which are believed to be subject to more accurate quality control are compared and also to determine if they could have a common source.

Material and Methods

Four automobile headlight and windscreen glasses were collected from a garage. Small pieces were broken from these glasses. Glass fragments obtained from the scene are thoroughly rinsed with distilled water so as to remove dirt and stains. Care should be taken to not to mix the glass pieces as it may be indistinguishable. Each of the glass pieces were rinsed with distilled water and then assigned a number.

Glass transition temperature (T_g) and heat capacity (C_p) of the investigated glasses were recorded using a Differential Scanning Calorimeter with the help of METTLER-TOLEDO DSC-1 (SID, IISc, Bangalore) at a heating rate of 2 degree per minute. Glass transition temperature (T_g) were determined using the point of intersect of the extended linear region in the thermograms[6].

Refractive indices of these glasses have been measured at wavelength 589.3 nm using Digital Abbe Refractometer (DR-A1) with methylene iodide containing sulfur solution as the contact layer between the sample and prism of the refractometer by using sodium vapor lamp as the light source. Refractive index measurement was performed using Digital Abbe Refractometer (DR-A1). Absorbance of glass fragments were measured using USB 4000 Fiber Optic Spectrometer that was connected to a computer and controlled by Spectra Suite software.

The visible light was transmitted to the sample through the optical fiber. The spectrometer measured the amount of light received and transformed it into digital information and passed this information to Spectra Suite which compared the sample measurement relative to the reference measurement and displayed processed spectral information.

The infrared spectroscopic measurements of the suspected glass fragments were recorded with a Perkin-Elmer (PE-580 Double Beam IR Spectrometer) in the range 200-1800 cm^{-1} using KBr pellet at room temperature.

The density of the glasses was determined by the Archimedes principle using toluene ($\rho_{toluene}$ = 0.860 gm/cc) as the immersion liquid. The density of the glasses was obtained using the relation

$$\rho = \left(\frac{W_a}{W_a - W_g} \right) \rho_l \qquad (1)$$

Where Wa is the weight in air, W_b is the weight of the glass sample in buoyant liquid and ρ_l is the density of toluene. All weight measurements were made using a digital balance. The molar volume (M_v) was calculated using the relation $M_v = M/\rho$, where M is the molecular weight[7]. The relative error in the measurement of density was about $\pm$ 0.005g/cm^3.

The ICP-OES measurements were made by placing the samples in a TFM vessel into the HTC safety shield and digesting the samples with 3 ml of nitric acid, 3 ml of Hydro chloric acid and 4 ml of Hydrofluoric acid. The vessel was closed and is introduced into the rotor segment and is placed into the microwave cavity for 20 minutes and 200^{0}C and with a power output of 1000W. The digested glass samples are placed in a laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS), where a laser is used to ionize glass[8]. It is then swept into the ICP torch and the results obtained were analyzed[9].

Results and Discussion

Thermal properties and fragility: DSC thermograms of the glasses under study are shown in figure-1 (a-d) and T_g values are extracted from them and are listed in table-1. The most important feature exhibited by the super-cooled liquids is glass transition (T_g) and it is one of the central issues in material science which has influenced many other fields of science. At T_g, the structural relaxation time of super cooled liquids increases rapidly with decreasing temperature.

The change in the liquidus temperature (T_l) of the melt of the glass is an indication of the glass transition temperature and is given by the relation

$$T_g \approx \frac{2}{3} T_l \qquad (2)$$

The entropy of activation of viscosity flow near T_g rapidly changes. At higher temperatures, the structures arrange themselves rapidly as a quasi-equilibrium state and at temperatures below glass transition; reconstitution among structural units will almost lead to a formation of rigid material referred to as glass. This property classifies glass formers into either fragile or strong[10]. Here it can be observed from table- 1 that the Tg values are quite high which indicates a greater thermal stability and the glasses are quite strong. This is one of the reasons these glasses are used for making Headlight and Windshield glasses.

Table-1
Code and T_G values for the investigated glasses

CODE	T_G ^{0}C
NB1	505.61
NB2	511.87
NB3	505.95
NB4	512.93

Density and Refractive index: The sample code, density and refractive index values are as listed in table- 2. It is evident that NB1 and NB3 are having similar density and refractive index; where as NB2 and NB4 are having identical values. It also shows that the densities of NB1 and NB3 are higher as compared to NB2 and NB4. Same trend is observed in the refractive index values too.

These values are the indication that the glasses of higher density and refractive index are used for windshield glasses and that with lower values are used for headlight glasses. These values were in consistent with the findings of the literature[11]. The standard values are listed in table-3

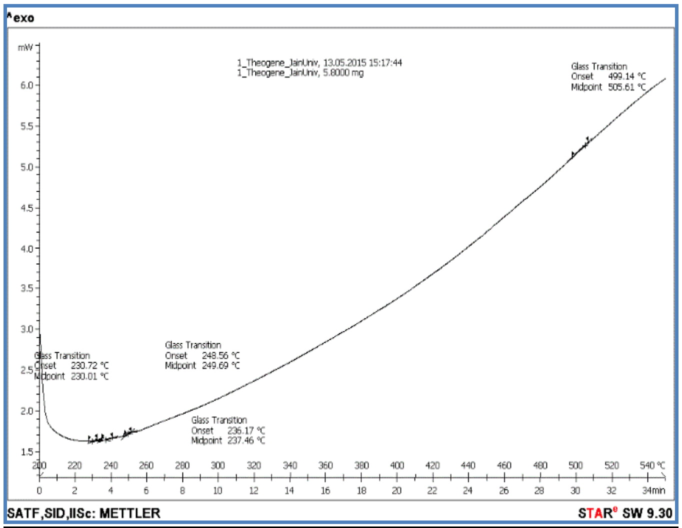

Figure-1(a)
DSC thermograms of NB1 glass system

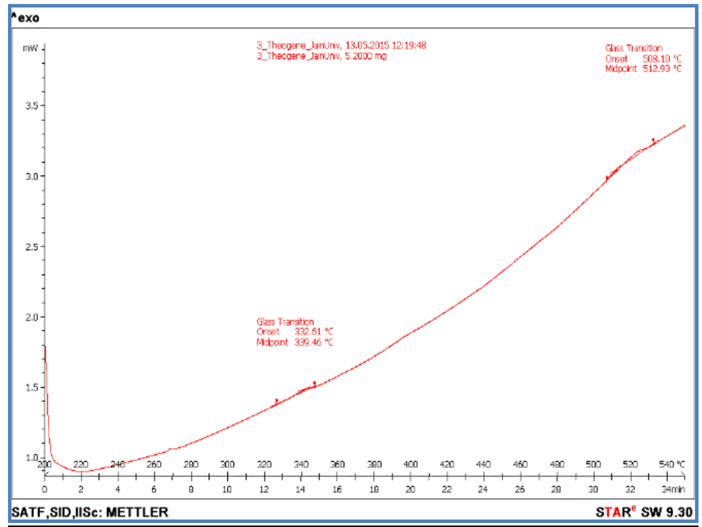

Figure-1(c)
DSC thermograms of NB 3 glass system

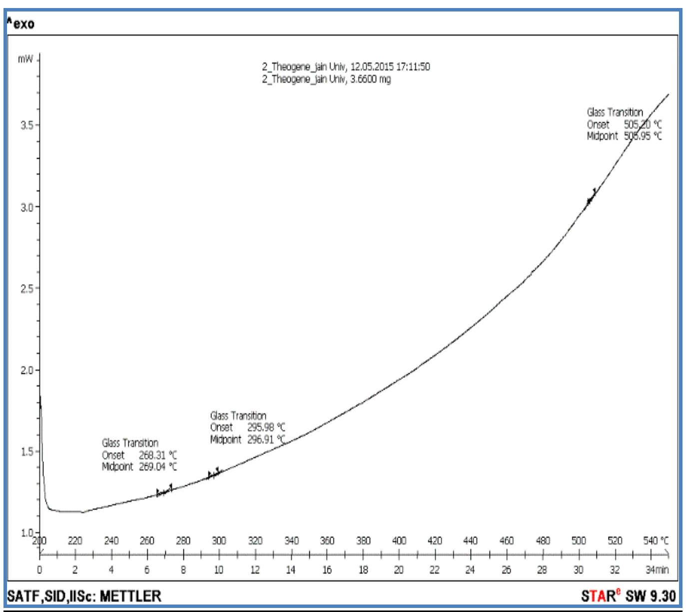

Figure-1(b)
DSC thermograms of NB 2 glass system

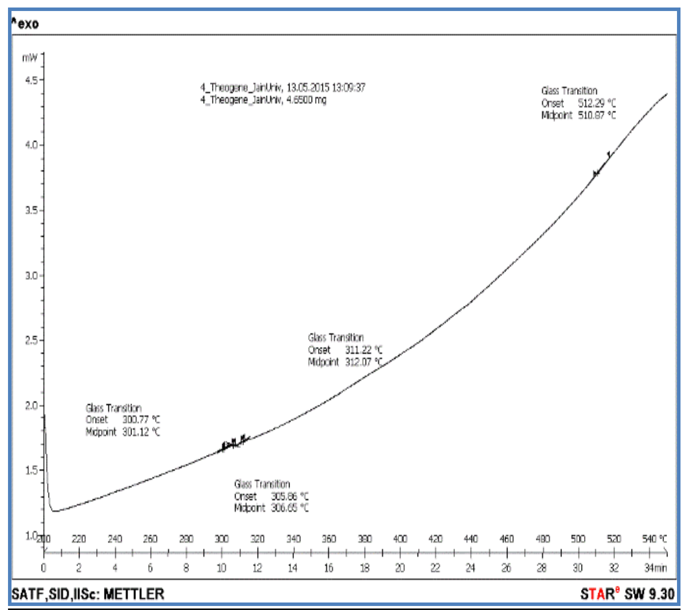

Figure-1(d)
DSC thermograms of NB 4 glass system

Table-2
Measured values of Density and Refractive index for the glasses under study

Sample code	Glass	Refractive index	Density
		RI measured by Abbes' Refractometer	
NB1	Windshield glass	1.518	2.53gm/cc
NB2	Headlight glass	1.468	2.46gm/cc
NB3	Windshield glass	1.520	2.54gm/cc
NB4	Headlight glass	1.472	2.48gm/cc

Table-3
Standard Index of Refraction Ranges for Glass Types

Glass	Refractive index
Headlight glass	1.49 -1.50
Windshield glass	1.51-1.52

Infrared Spectroscopic studies: Studies on Infrared spectra have been carried out on powdered samples dispersed in KBr pellets and are shown in figure-3 for the range 400-4500 cm^{-1}. The band position of the various samples under study is mentioned in tables-4 (a) – (d). The bending and stretching vibrations of calcium, sodium, potassium, manganese and magnesium in the samples were observed. It can be seen from the figure and the tables that the NB1 and NB3 have similar band positions and the intensities also overlap. In other words the ranges of NB1 and NB3 are the same and they are of the same origin. Similarly it can be concluded for the NB2 and NB4 that they are of the same origin. As per the findings of density and refractive index, it can be concluded that NB1 and NB3 are windshield glasses and NB2 and NB4 are headlight glasses. So the results of Infrared spectra are in consistent with the density and refractive index results.

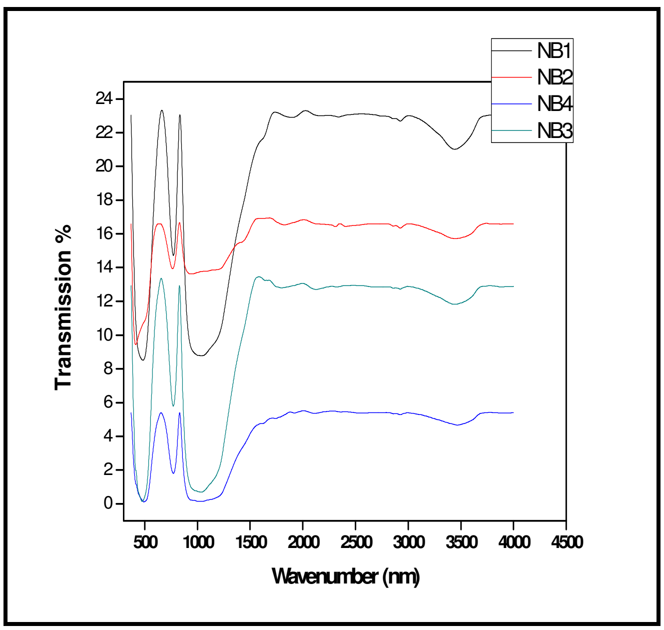

Figure-3
Infrared spectrum of glass system under study

The IR spectra for these glasses arise from sodium and calcium with the addition of potassium, manganese and magnesium glasses which make these glasses relatively strong. When looking at the IR spectra (figure-3), the vibrational modes of the sodium and calcium are seen to be prominent in four IR regions.

Table-4
IR band position in glass samples under study
(a) NB1

Wave number (cm^{-1})	Element
476	Manganese
783	Calcium
1890	Potassium
2146	Magnesium
2927	Sodium

(b) NB 2

Wave number (cm^{-1})	Element
427	Magnesium
763	Calcium
952	Calcium
1813	Potassium
2123	Magnesium
2906	Sodium
3449	Vibrations of sodium

(c) NB 3

Wave number (cm^{-1})	Element
485	Manganese
757	Calcium
1047	Potassium
1618	Magnesium
1741	Magnesium
1917	Calcium
2102	Calcium
2910	Sodium
3463	Vibrations of sodium

(d) NB4

Wave number (cm^{-1})	Element
458	Manganese
748	Calcium
1021	Potassium
1794	Magnesium
2128	Magnesium
2927	Sodium
3437	Vibrations of Sodium

Laser Ablation Inductively Coupled Plasma –Optical Emission Spectroscopy: The analysis of glass evidence has been considered as a competent discrimination tool for forensic analysis. The results obtained were similar to that identified in

IR analysis is seen in these analysis too. The concentration of the elements present in the glass samples is mentioned in ppm. It is evident from the report that the glass samples NB1 and NB3 have more concentration of sodium and magnesium, followed by calcium and potassium. Manganese is present in least concentration. In NB2 and NB4, the concentration of sodium is more followed by magnesium, potassium and calcium. But the concentration of manganese is slightly higher as compared to the earlier samples. These results are all in correlation with our earlier studies and it clearly demarcates the type of glasses under study. So it can be concluded that NB1 and NB3 are from the same origin and these belong to windshield glass and NB2 and NB4 belongs to headlight glass.

Conclusion

Study of thermal, mechanical and spectroscopic properties were carried on the glass samples collected from a car garage. The observations revealed that the glass pieces collected were from the headlight and the windshield of the glass. This could be concluded because of the overlapping results obtained from almost all the studies conducted. Also it can be seen that the both the glasses contain almost same elements. Only the composition is differing and the configuring elements also differed. This composition variation gives more strength to the windshield glass as compared to the headlight glass. This area of study can be further extended by collecting the samples from the manufacturer and to conclude the make and model of the car. Here the work concentrated on identifying the windshield and headlight of the glass by physical, thermal and spectroscopic techniques. This is a fruitful study in the field of forensic sciences especially in the hit and run cases and in burglary. Because it helps in finding which part of the car/ vehicle was damaged and whether the glass pieces are belong to the car or some other glasses were mixed in the crime scene.

References

1. Tryhorn F.G., Examination of Glass, *J. Crimi. L. Crim,* 404 **(1939)**
2. Gamble L, Bard D.Q. and Kirk P.L., Glass Fragments as Evidence*, J. Crini. Law and Crim. (Pol. SaL Sec.),* **33,** 416 **(1943)**
3. Allen T.J. and Scranage J.K, The transfer of glass—Part 1: Transfer of glass to individuals at different distances, *Forensic Science International,* **93,** 167–174 **(1998)**
4. Pounds C.A. and Smalldon K.W, The distribution of glass fragments in front of a broken window and the transfer of fragments to individuals standing nearby, *J Forensic Sci. Soc.,* **18,** 197–203 **(1978)**
5. Kirk P.L., Density and Refractive Index: Their Application in Criminal Identification, *Charles C. Thomas, Springfield, Illinois,* **(1951)**
6. Asha Rajiv, Sudhakara Reddy, Jayagopal Uchil, Narayana Reddy C, Thermal and Optical Properties of Sodium-Phospho - Zinc -Neodymium Oxide Glass System, *J. Adv. Sci. Res.,* **5(2),** 32-39 **(2014)**
7. Asha Rajiv, Sudhakara Reddy M, Jayagopal Uchil, Narayana Reddy C, AC conductivity studies of sodium-boro-vanadate glasses prepared by microwave method, *Int. J. Eng. Res. Tech.,* **2(4),** 1893-1896 **(2013)**
8. Latkoczy C, Duecking M., Becker, *Forensic Sci. Int.,* **50,** 1327 **(2005)**
9. Scientific Working Group for Materials Analysis (SWGMAT). Elemental analysis of glass, *Forensic Science Communications,* (January 2005a) **(2015)**
10. Angell C.A., Spectroscopy, simulation and the medium range order problem in glass, *J. Non-Cryst. Solids.,* **73(1-3),** 1-17, **(1985)**
11. Richard Saferstein, Ed.; Prentice Hall: Engle wood Cliffs, NJ, 139-183 **(1982)**