Forensic Classification of Glass Employing Refractive Index Measurement

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ABSTRACT: Burglary and accident cases may involve glass fragments as physical evidence found at the crime scene. In forensic investigation, the major physical examination to determine the origin of glass is refractive index (RI) measurement. It was therefore of interest to determine RI measurements of several types of glasses commonly found in Malaysia with a view of classifying glass as building and automobile glasses. Twenty samples of glass from each classification were collected from car workshops and glass pane shops. Determination of RI value was affected using Glass Refractive Index Measurement 3 (GRIM3) instrument. From this study, the RI values of automobile glass can be classified into 3 types according to their RI values and thickness. Windscreen glass was found to be in the RI range of 1.5152 – 1.5225, rear screen glass with RI of 1.5147- 1.5217 and side window glass with RI range of 1.5188-1.5190, all samples with thickness of between 2 – 6 mm. Building glass can be classified into heat absorbing float (1.5197 – 1. 5211), clear float (1.5189 – 1.5213), figured float (1.5164 – 1.5234) and reflective float (1.5167 - 1.5188) with sample thicknesses of 2 – 6 mm. The results show that each glass type has different range of RI value which is related to thickness, manufacturer and colour due to its end-use. Thus, the origin of glass according to its end-use types could be determined by the relationship between RI and thickness to assist forensic scientists in their investigation.

Keywords: Refractive Index (RI), Glass fragment, glass type, GRIM3

Introduction

Glass fragments constitute as contact trace evidence that are often sent to forensic laboratory for examination especially in cases involving accidents or house breaking [1]. The fragment size is often equal to or less than 1 mm [2].

One of the problems in forensic glass analysis is comparison between known and unknown glass to establish their origin or to aid in sample matching purposes [3]. In addition, determination of glass classification regarding end-use type categories is a difficult task in forensic glass analysis. It is important especially when there is no control sample found at the crime scene for the comparison process [4]. Therefore knowledge on the type of glass may help forensic scientist in forensic glass investigation.

Refractive index (RI) measurement is the most common method employed for glass analysis [5-7]. Refractive index (RI) value was reported to be dependent upon on the nature of raw materials used and manufacturing process especially during annealing process [8, 9]. Distribution of RI was slightly affected by types of glass according to its color, manufacturer and thickness [10].

Safety window glass is one of the items found as safety features in an automobile. There are two main types of safety glass used in automobile today which are laminated glass and tempered glass [11]. Laminated glass that consists of a layer of plastic between two glass panes is commonly used as windscreen. Tempered glass is used as side and rear windows. Building glass comprised of various types of float glass that are used as window, door and partition. Examples of common types of float glass are clear glass, tinted (heat-absorbing) glass, reflective glass and low-emissivity glass [11].

In this study, glass fragments are classified according to end-user type using RI measurements and glass thickness.

Experimental

i. Sampling

Freshly broken glass pieces collected from car workshops in Kajang, Selangor, Malaysia with 14 samples of windscreen, three samples of rear screen and three samples of side window glasses were obtained.

Four samples of clear float glass, four samples of heat absorbing float glass, four samples of reflective float glass and eight samples of figured float glass as building glass were taken from glass pane shops in Bandar Baru Bangi, Selangor, Malaysia. These glasses were from several manufacturers, colors and thicknesses.

ii. Refractive Index Measurement

RI of glass was determined by oil immersion method using GRIM3 system (Foster & Freeman). Selected glass fragments were mounted onto glass slides and immersed in silicon oil B. Each prepared slide was inserted into a hot stage (Mettler Toledo FP82HT) and illuminated using monochromatic sodium light at 589 nm. Temperature of the hot stage was controlled by the GRIM3 unit equipped with an attached video camera and a phase contrast microscope (LEICA DM 2500).

The observation in measuring RI was noted by the disappearance of the Becke line and minimum contrast between the glass and liquid medium. The temperature at which the Becke line disappeared was taken as the match point, at which the RI of the glass fragment equals to the RI of oil at that temperature.

Results and Discussion

Automobile glass is commonly used as windscreen, rear screen and side window of a vehicle. The relationship of RI values with glass thickness for automobile glass is shown in Figure 1. Three clusters were obtained corresponding to the types of vehicle glass. RI values for windscreen glass was in the range of 1.5152 – 1.5225 for glass thickness of between 2-3 mm. Most laminated windscreen glass consisted of 2 glass colors, with green as the outer glass layer and a transparent inner glass layer.

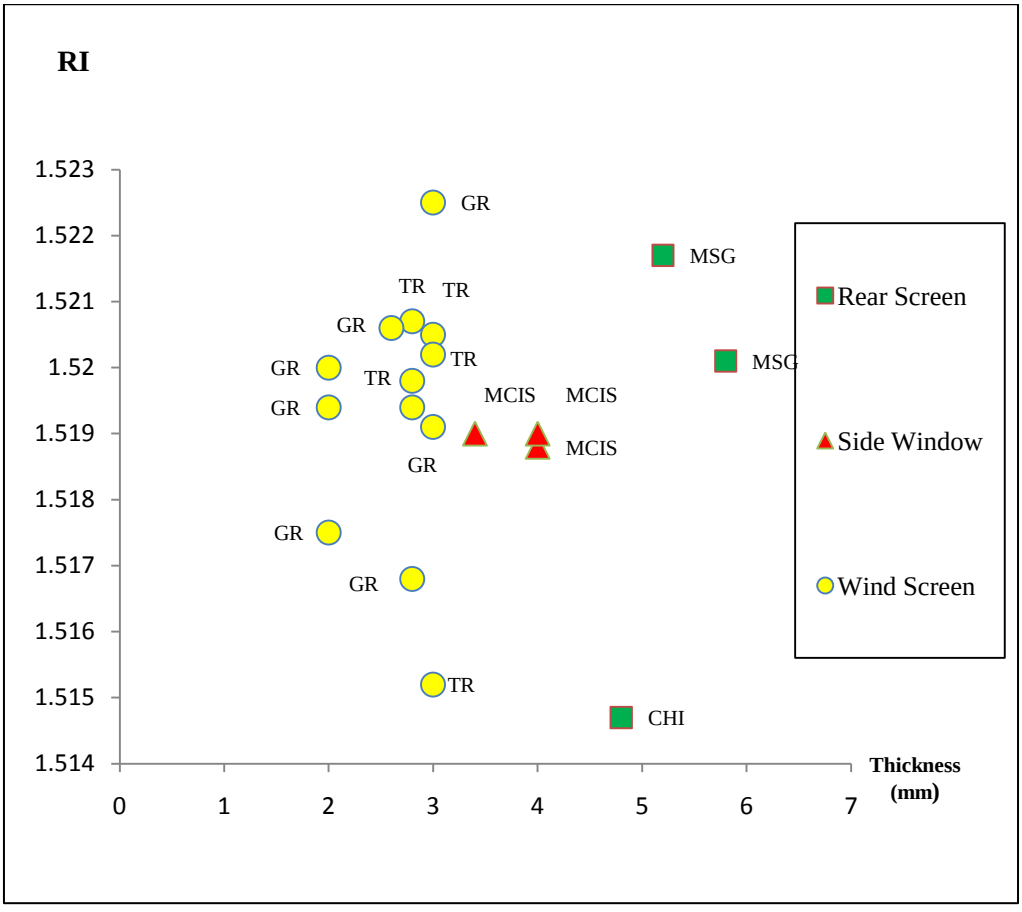

Fig. 1: Graph of RI value verse thickness for automobile glass, where MSG denotes Malaysian Sheet Glass, CHI denotes China, MCIS denotes Malaysia Cooperative Insurance Society Safety Glass, TR as Transparent and GR as Green.

Three side window samples (manufactured by MCIS) with thickness of 3.0 – 4.0 mm show close RI values of 1.5190 and 1.5188. Two fragments that display the same RI of 1.5190 were found to originate from the domestic manufactured car (Proton Persona and Proton Exora). Rear window glass with thickness of more than 4 mm showed the RI values in a wide range from 1.5147 to 1.5217. This is mainly attributed to the different glass manufacturer (from China and Malaysian Sheet Glass, MSG).

Graph of RI versus thickness for building glass, shows four clusters corresponding to the four types of building glass (Figure 2). Heat absorbing float glass with thickness between five and six mm, had the RI values of 1.5197 – 1.5211. Note that the colour of glass has a profound effect on the RI value measured. For instance, green glass was found to have higher RI (1.5210 and 1.5211) compared to grey glass (1.5197 and 1.5205) for this type of building glass.

RI for figured float glass was found to be distributed between 1.5164 and 1.5234 with thickness between 2.8 and 4.2 mm. The large RI variation is mainly attributed to its colour. The highest RI value measured (1.5234) was from the green colour glass. This was followed by the grey glass (1.5220), the transparent glass (1.5196 – 1.5205) while the lowest RI was displayed by blue r glass (1.5164).
Clear float glass has two ranges of thickness which are two mm and 5-6 mm, respectively. Both thickness shared the same range of RI (1.5189 – 1.5213). Since all samples were colourless, variation of RI was mainly due to different manufacturer of glass samples. Samples with thicknesses of 5-6 mm were from Malaysian Sheet Glass (MSG) and Kein Safety Glass (KSG). A coloured float glass manufactured by Hesin Glass gave a lower RI value.

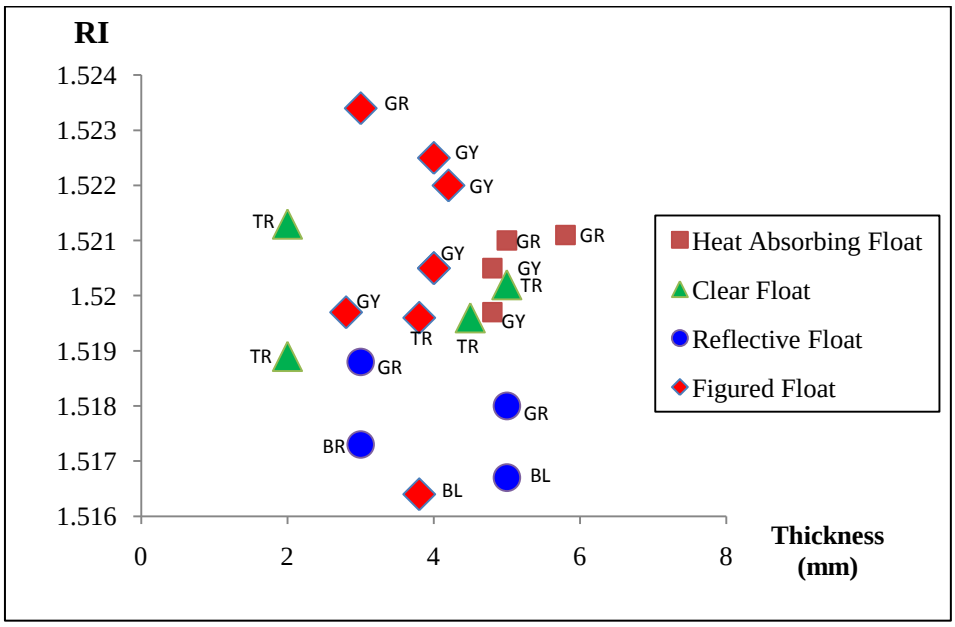

Fig. 3: Graph of RI value verse thickness for building glass where GR denotes green, GY denotes gray, TR denotes transparent, BR denotes bronze and BL denotes blue color.

The results show that reflective float glass has lower RI value than other types of glass (1.5167 - 1.5188) with thickness between 3 – 5 mm. Since all the samples came from same manufacturer (MSG), the variation of RI values are attributed to the different colors of glass (green, bronze and blue).

RI of building glass is highly affected by the colour of the glass. Nevertheless, the type of glass due to its intended end-use can be classified via its relationship between refractive indices and thicknesses. The study revealed that each type of building glass has high RI for green colored float glass and lowest RI for blue colored glass from the same manufacturer.

Conclusion

Classification of automobile and building glasses by their end-use type has been performed using refractive index measurements. Automobile glass can be classified into 3 types according to their RI values and thickness. Windscreen glass was found to be in the RI range of 1.5152 – 1.5225, rear screen glass with RI of 1.5147- 1.5217 and side window glass with RI range of 1.5188-1.5190, for all samples with thicknesses of between 2 – 6 mm. On the other hand, building glass can be classified into 4 end-user types; namely heat absorbing float (1.5197 – 1. 5211), clear float (1.5189 – 1.5213), figured float (1.5164 – 1.5234) and reflective float (1.5167 - 1.5188) with sample thicknesses of 2 – 6 mm.

Each glass type has different range of RI value which is related to thickness, manufacturer and color according to the end-use of glass. Thus, the origin of glass according to its end-use types could be determined by the relationship between RI and thickness to assist forensic scientists in their glass examination.

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