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FORENSIC TESTING PROGRAM

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Glass Analysis
Test No. 25-5481 Summary Report

Each participant received a sample pack containing two sets of known glass samplings and two sets of questioned glass fragments, which they were asked to examine the questioned fragments using their existing protocols. Data were returned from 63 participants and compiled into the following tables:

This report contains the data received from the participants in this test. Since these participants are located in many countries around the world, and it is their option how the samples are to be used (e.g., training exercise, known or blind proficiency testing, research and development of new techniques, etc.), the results compiled in the Summary Report are not intended to be an overview of the quality of work performed in the profession and cannot be interpreted as such. The Summary Comments are included for the benefit of participants to assist with maintaining or enhancing the quality of their results. These comments are not intended to reflect the general state of the art within the profession.

Participant results are reported using a randomly assigned "WebCode". This code maintains participant's anonymity, provides linking of the various report sections, and will change with every report.

Manufacturer's Information

Each sample pack contained two sets of known glass samplings and two sets of questioned glass fragments. Participants were asked to examine the questioned fragments and determine if either could have originated from the same source as the recovered known glass samplings.

SAMPLE PREPARATION: The glass was examined for defects and then broken, utilizing glass tools to remove edges and unwanted areas. Elimination items were processed and packaged separately from other items to prevent cross-contamination. Association items were selected at the same time and within close spatial proximity to one another prior to item packaging and maintained together as association batches during sample pack assembly.

KNOWN ITEMS: Two glass fragments, approximately 1/8" x 1/8" in size, were selected and deposited into a glassine bag and then placed into a pre-labeled item envelope and sealed.

QUESTIONED ITEMS: Two glass fragments, approximately 1/16" x 1/16" in size, were selected and deposited into a glassine bag and then placed into a pre-labeled item envelope and sealed.

SAMPLE PACK ASSEMBLY: All items were placed into a pre-labeled sample pack envelope and sealed. This process was repeated until all of the sample packs were prepared.

VERIFICATION: Predistribution results were consistent with each other and the manufacturer's preparation information. The following procedures were used to examine the items: Color, Thickness, nD Refractive Index, Short and Long UV Fluorescence, and SEM/EDS. The average refractive indices for the glass as reported by predistribution laboratories are as follows: Item 1 RI =1.51816, Item 2 RI =1.51878, Item 3 RI =1.51737, and Item 4 RI =1.51815.

Item	Known/ Questioned	Association/ Elimination	Source
1	Known	Association	Coffee Table Glass
2	Known	Elimination	Fish Tank Glass
3	Questioned	Elimination	Glass Shelf
4	Questioned	Association	Coffee Table Glass

Summary Comments

This test was designed to allow participants to assess their proficiency in the examination, comparison, and interpretation of glass samples. Participants were supplied with two sets of known glass samplings (Item 1 and Item 2) and two sets of questioned glass fragments (Item 3 and Item 4). Item 1 and Item 4 were prepared from the same source of glass. Item 2 and Item 3 were each separately prepared from different sources of glass. Refer to the Manufacturer's Information for preparation details.

All 63 responding participants (100%) associated Item 4 and eliminated Item 3 as having originated from the same source as the Item 1 known glass and eliminated both Item 3 and Item 4 as having originated from the Item 2 known glass.

The most commonly reported examination procedures include: Thickness, Color, nD Refractive Index, and Short UV Fluorescence.

Examination Results

Could the questioned glass fragments recovered from the suspect (Item 3 and Item 4) have originated from either the broken coffee table and/or fish tank as represented by Item 1 and Item 2?

TABLE 1

	Item 1		Item 2			Item 1		Item 2	
WebCode	Item 3	Item 4	Item 3	Item 4	WebCode	Item 3	Item 4	Item 3	Item 4
289KC4	No	Yes	No	No	E87CPD	No	Yes	No	No
2T8GWW	No	Yes	No	No	F2BCWF	No	Yes	No	No
32G7AV	No	Yes	No	No	FKNWTJ	No	Yes	No	No
38HH7R	No	Yes	No	No	FVAZ2J	No	Yes	No	No
3CDC4T	No	Yes	No	No	GCQRTB	No	Yes	No	No
3UX33T	No	Yes	No	No	GEY4BC	No	Yes	No	No
4BHT2R	No	Yes	No	No	GQ9CXG	No	Yes	No	No
4P23GP	No	Yes	No	No	H4TJLP	No	Yes	No	No
63L6A2	No	Yes	No	No	H946HF	No	Yes	No	No
6FBAQQ	No	Yes	No	No	J7DHZC	No	Yes	No	No
6K4EKV	No	Yes	No	No	KH3AE8	No	Yes	No	No
6TGXU2	No	Yes	No	No	L8FZCC	No	Yes	No	No
6YNTMU	No	Yes	No	No	LQV9DD	No	Yes	No	No
7HC64L	No	Yes	No	No	LWGUB7	No	Yes	No	No
7YFYAL	No	Yes	No	No	LWKUHE	No	Yes	No	No
8DXJER	No	Yes	No	No	MBYEFD	No	Yes	No	No
9KAXWN	No	Yes	No	No	MH2V4K	No	Yes	No	No
AN9ZCW	No	Yes	No	No	ML28ZK	No	Yes	No	No
AXXNAK	No	Yes	No	No	N2Q2YA	No	Yes	No	No
B7HAEL	No	Yes	No	No	NGVV69	No	Yes	No	No
BCNBTG	No	Yes	No	No	QL6Z8F	No	Yes	No	No
BV3RXV	No	Yes	No	No	RFDL68	No	Yes	No	No
C6MQDK	No	Yes	No	No	RH4C4D	No	Yes	No	No
D3CVZE	No	Yes	No	No	TFMAJ4	No	Yes	No	No
DLR6ZE	No	Yes	No	No	TN4DJX	No	Yes	No	No
E2ZF4R	No	Yes	No	No	TV38N6	No	Yes	No	No

TABLE 1

	Item 1		Item 2	
WebCode	Item 3	Item 4	Item 3	Item 4
V472V3	No	Yes	No	No
VQH36Z	No	Yes	No	No
W8LWCY	No	Yes	No	No
WGR9JA	No	Yes	No	No
WHNEM3	No	Yes	No	No
WYCYJA	No	Yes	No	No
Y9UF2U	No	Yes	No	No
YLVL3X	No	Yes	No	No
YWDZ7Z	No	Yes	No	No
ZQP9MR	No	Yes	No	No
ZYJDGT	No	Yes	No	No

WebCode	Item 1		Item 2	
	Item 3	Item 4	Item 3	Item 4

Response Summary **Total Participants: 63**

Could the questioned glass fragments recovered from the suspect (Item 3 and Item 4) have originated from either the broken coffee table and/or fish tank as represented by Item 1 and Item 2?

	Item 1		Item 2	
	Item 3	Item 4	Item 3	Item 4
Yes:	0 *(0.0%)*	63 *(100.0%)*	0 *(0.0%)*	0 *(0.0%)*
No:	63 *(100.0%)*	0 *(0.0%)*	63 *(100.0%)*	63 *(100.0%)*
Inconclusive:	0 *(0.0%)*	0 *(0.0%)*	0 *(0.0%)*	0 *(0.0%)*

Examination Procedures

TABLE 2

	Refractive Index							Elemental		UV		
	nD	nF	nC	ΔRI	Color	Density	Thickness	SEM/ EDS	XRS/ XRF	Long	Short	Other
289KC4	✓				✓		✓			✓	✓	LA-ICP-MS
2T8GWW	✓						✓		✓		✓	
32G7AV	✓	✓	✓	✓	✓		✓			✓	✓	ICP-MS
38HH7R	✓						✓	✓			✓	
3CDC4T	✓				✓		✓		✓	✓	✓	Stereoscopic (Morphology)
3UX33T	✓				✓		✓			✓	✓	
4BHT2R	✓			✓	✓		✓				✓	
4P23GP	✓				✓		✓				✓	LA-ICP-MS
63L6A2				✓	✓		✓					
6FBAQQ	✓				✓		✓	✓			✓	
6K4EKV							✓	✓				
6TGXU2	✓				✓		✓	✓			✓	
6YNTMU				✓	✓	✓	✓	✓		✓	✓	
7HC64L				✓	✓		✓		✓	✓	✓	
7YFYAL								✓				FTIR
8DXJER	✓				✓		✓		✓		✓	
9KAXWN	✓				✓		✓				✓	LA-ICP-MS and LIBS
AN9ZCW				✓	✓		✓	✓	✓	✓	✓	
AXXNAK	✓				✓		✓			✓	✓	
B7HAEL	✓				✓		✓		✓	✓	✓	
BCNBTG	✓				✓		✓	✓				
BV3RXV	✓				✓		✓		✓	✓	✓	
C6MQDK	✓				✓		✓	✓			✓	
D3CVZE							✓	✓				
DLR6ZE					✓		✓		✓	✓	✓	GRIM
E2ZF4R												ICP-MS
E87CPD						✓						LIBS, μXRF

TABLE 2

	Refractive Index							Elemental		UV		
	nD	nF	nC	ΔRI	Color	Density	Thickness	SEM/ EDS	XRS/ XRF	Long	Short	Other
F2BCWF	✓				✓		✓		✓	✓	✓	
FKNWTJ	✓				✓		✓			✓	✓	
FVAZ2J	✓				✓		✓		✓	✓	✓	SM, HPM, PLM
GCQRTB	✓				✓		✓	✓		✓	✓	Raman
GEY4BC	✓				✓		✓				✓	LA-ICP-MS
GQ9CXG	✓				✓		✓				✓	Stereomicroscopy, Polarized Light Microscopy
H4TJLP	✓			✓	✓		✓				✓	
H946HF	✓				✓		✓		✓	✓	✓	
J7DHZC	✓				✓		✓	✓				
KH3AE8	✓						✓		✓		✓	
L8FZCC	✓			✓	✓		✓					surface analysis
LQV9DD	✓				✓		✓		✓		✓	
LWGUB7							✓		✓	✓	✓	
LWKUHE	✓				✓		✓		✓	✓	✓	LA-ICP-TOFMS
MBYEFD	✓				✓		✓		✓	✓	✓	
MH2V4K					✓		✓		✓			LA-ICPMS
ML28ZK	✓				✓		✓	✓			✓	
N2Q2YA	✓				✓		✓		✓	✓	✓	
NGVV69	✓				✓		✓	✓		✓	✓	
QL6Z8F	✓				✓		✓	✓		✓	✓	
RFDL68	✓				✓		✓			✓	✓	
RH4C4D	✓			✓	✓		✓				✓	Surface features
TFMAJ4	✓				✓		✓		✓	✓	✓	
TN4DJX	✓						✓	✓				
TV38N6	✓				✓		✓		✓		✓	
V472V3					✓		✓		✓	✓	✓	
VQH36Z	✓						✓	✓			✓	
W8LWCY	✓				✓		✓				✓	LAICPMS

TABLE 2

	Refractive Index							Elemental		UV		
	nD	nF	nC	ΔRI	Color	Density	Thickness	SEM/ EDS	XRS/ XRF	Long	Short	Other
WGR9JA	✓			✓	✓		✓		✓			
WHNEM3	✓				✓		✓		✓	✓	✓	
WYCYJA	✓				✓		✓		✓	✓	✓	LA-ICP-MS
Y9UF2U	✓			✓	✓		✓	✓			✓	
YLVL3X	✓				✓		✓		✓	✓	✓	
YWDZ7Z	✓	✓	✓		✓		✓	✓				
ZQP9MR	✓				✓		✓		✓			
ZYJDGT	✓				✓		✓		✓		✓	

Response Summary

	Refractive Index							Elemental		UV	
Participants	nD	nF	nC	ΔRI	Color	Density	Thickness	SEM/ EDS	XRS/ XRF	Long	Short
63	50	2	2	11	52	2	60	19	27	28	49
Percent	*79%*	*3%*	*3%*	*17%*	*83%*	*3%*	*95%*	*30%*	*43%*	*44%*	*78%*

Conclusions

TABLE 3

WebCode	Conclusions
289KC4	The questioned glass fragments marked "Item 3", recovered from the suspect, were found to be different from the known glass fragments marked "Item 1" and "Item 2", recovered from the broken coffee table and fish tank, respectively, in terms of trace elemental composition. Hence, the questioned glass fragments marked "Item 3" did not originate from the same sources as the known glass fragments marked "Item 1" and "Item 2". The questioned glass fragments marked "Item 4", recovered from the suspect, were found: a) To have no exclusionary difference with the known glass fragments marked "Item 1", recovered from the broken coffee table, in terms of colour, fluorescence, thickness, refractive index and trace elemental composition. Hence, the questioned glass fragments marked "Item 4" were very likely to have originated from the same source as the known glass fragments marked "Item 1"; other sources of glass with similar characteristics are limited. b) To be different from the known glass fragments marked "Item 2", recovered from the fish tank, in terms of trace elemental composition. Hence, the questioned glass fragments marked "Item 4" did not originate from the same source as the known glass fragments marked "Item 2".
2T8GWW	Item 2 is excluded as a possible source of items 3 and 4. Item 1 is excluded as a possible source of item 3. Item 4 could have come from the same source as item 1, or from another source of broken glass with similar manufactured characteristics.
32G7AV	Visual and microscopic examination of exhibits item 1, item 2, item 3, and item 4 revealed the presence of multiple fragments confirmed as glass. Physical, microscopic, and instrumental analysis and comparison of the glass from item 4 to the glass from item 1 revealed them to be the same with respect to physical properties, optical properties, and elemental composition. This is an association with highly discriminating characteristics. Therefore, the glass recovered from the subject (item 4) came from the broken coffee table at the victim's home or another source of broken glass with identical physical properties, optical properties, and elemental composition. Physical and microscopic analysis and comparison of the glass from item 1 to the glass from item 3 revealed them to be inconsistent with respect to optical properties. Therefore the glass recovered from the subject (item 3) could not have come from the broken coffee table at the victim 's home. Physical and microscopic analysis and comparison of the glass from item 2 to the glass from item 3 and item 4 revealed them to be inconsistent with respect to optical properties. Therefore the glass recovered from the subject (item 3, item 4) could not have come from the broken fish tank at the victim's home. Results were confirmed using the following instrumentation: polarized light microscope, digital calipers, glass refractive index measurement system, and inductively coupled plasma mass spectrometer.
38HH7R	In my opinion: i. the known glass fragments from the broken coffee table, Item 1, were different in terms of their physical properties to the known glass fragments from the fish tank, Item 2. ii. the findings provide moderate support for the proposition that the glass fragments recovered from the suspect, Item 4, came from the broken coffee table, Item 1. iii. the glass fragments recovered from the suspect, Item 3, did not originate from the broken coffee table (Item 1) nor from the fish tank (Item 2) but originated from an unrelated source. The evaluation is based on my understanding of the relevant circumstances provided. If this assumption or any of the information is incomplete or incorrect, I will have to re-evaluate my findings.
3CDC4T	The questioned glass fragments recovered from the suspect (Items 3 and 4) were examined and compared to known glass standards from the broken coffee table (Item 1) and the fish tank (Item 2) to determine if they could have originated from either of those sources. 1 – Known glass fragments recovered from the broken coffee table Item 1 was opened and found to contain two (2) colorless glass fragments with characteristics consistent with non-tempered float sheet glass. Both fragments have their complete thickness. These fragments were used as

TABLE 3

WebCode	Conclusions
	standards for comparison purposes. 2 – Known glass fragments recovered from the fish tank Item 2 was opened and found to contain two (2) colorless glass fragments with characteristics consistent with non-tempered float sheet glass. Both fragments have their complete thickness. These fragments were used as standards for comparison purposes. 3 – Questioned glass fragments Item 3 was opened and found to contain two (2) colorless glass fragment. These fragments had characteristics consistent with tempered float sheet glass. Macroscopic and microscopic examinations and comparisons revealed exclusionary differences between the questioned glass in Item 3 and the glass from the broken coffee table (Item 1) and fish tank (Item 2), with respect to their glass type. It is therefore concluded that the glass fragments recovered from the suspect in Item 3 could not have originated from the broken coffee table (Item 1) or the fish tank (Item 2) as represented by the standards. 4 – Questioned glass fragments Item 4 was opened and found to contain two (2) colorless glass fragment. These fragments had characteristics consistent with non-tempered float sheet glass. Macroscopic and microscopic examinations and comparisons revealed that they are like the glass standard from the broken coffee table (Item 1) with respect to their color, thickness, refractive index values and chemical composition. It is therefore be concluded that the glass fragments recovered from the suspect in Item 4 originated either from the broken coffee table (Item 1) or another source of broken colorless non-tempered float sheet glass having the same characteristics. Macroscopic and microscopic examinations and comparisons of the glass fragments in Item 4 also revealed that they are different from the glass standard from the fish tank (Item 2) with respect to their thickness. It is therefore be concluded that the glass fragments recovered from the suspect in Item 4 could not have originated from the glass recovered from the fish tank (Item 2) as represented by the standard.
3UX33T	I formed the opinion based on the techniques used, that the glass fragments recovered from the suspect (item 4) had the same appearance, thickness and refractive index as the control glass collected from the broken coffee table (item 1) and could have originated from it. I also formed the opinion based on the techniques used, that the glass fragments recovered from the suspect (item 3) had a different thickness and refractive index as the control glass collected from the broken coffee table (item 1) and could not have originated from it. I further formed the opinion based on the technique used, that the glass fragments recovered from the suspect (items 3 and 4) had a different thickness as the control glass collected from the fish tank (item 2) and could not have originated from it.
4BHT2R	Item 3, described as coming from the suspect, contained two fragments of flat, float glass with a thickness of 4.8 millimetres. Item 4, described as coming from the suspect, contained three fragments of flat, float glass with a thickness of 4.9 millimetres. Item 1, described as coming from the broken coffee table, contained two fragments of flat, float glass with a thickness of 4.90 millimetres. Item 2, described as coming from the broken fish tank contained two fragments of flat float glass with a thickness of 4.60 millimetres. The thickness of this glass is different to the two samples of glass from the suspect (items 3 and 4) and therefore could not be a source of the glass found on the suspect. The refractive indices of the two samples of glass from the suspect and the sample of glass from the broken coffee table were measured. The refractive index of one fragment from each sample was measured after it was annealed. Annealing can be used to determine whether or not a fragment of glass is toughened or non-toughed. The glass from item 1 and item 4 were both non-toughened and had the same thickness and refractive index. Therefore the glass from item 4 could have come from the broken coffee table (item 1) or from another source of non-toughed flat, float glass with the same thickness and refractive index. Laboratory surveys show that less than 0.006 % of vehicle glass and less than 0.02% of building glass would be flat, non-toughened glass with the same refractive index and thickness as the glass from the suspect (item 4). The glass from item 3 was toughened and had a different refractive index to the glass from Item 1. Therefore item 1 was

TABLE 3

WebCode	Conclusions
	not a source of the glass from item 3. In interpreting these glass findings I have considered the probability of obtaining this glass evidence given the suspect was close to the breaking coffee table and fish tank. Conversely I have also considered the probability of obtaining this glass evidence given the suspect was not close to these breaking glass objects. In my opinion this glass evidence provides moderate support for the proposition that the suspect was close to the breaking coffee table and fish tank, as opposed to not being close to these breaking objects. I have chosen the term "moderate support" from the following scale; neutral, slight support, moderate support, strong support, very strong support and extremely strong support. This scale can be used to indicate the level of support for either proposition.
4P23GP	Glass recovered from the suspect (Item 4) is indistinguishable from glass from the coffee table (Item 1). Consequently, the glass from the suspect (Item 4) either originated from the coffee table (Item 1) or from another source of broken glass indistinguishable in all of the measured or observed physical properties, refractive index, and elemental composition. Glass recovered from the suspect (Item 3) is different from the glass from the coffee table (Item 1). Consequently, the glass from the suspect (Item 3) did not originate from the same source as the glass from the coffee table (Item 1). Glass recovered from the suspect (Items 3 and 4) is different from the glass from the fish tank (Item 2). Consequently, the glass from the suspect (Items 3 and 4) did not originate from the same source as the glass from the fish tank (Item 2).
63L6A2	The results strongly support the proposition that the glass in item 4 and item 1 are of the same type (level +2). The glass in item 3 is not of the same type as the glass in item 1 and 2 (level -4).
6FBAQQ	The glass samples Items 1-4 were each found to comprise two colourless glass fragments with identical thickness. The known glass samples Items 1-2 were found to differ in thickness and refractive index from each other. The questioned glass fragments in Item 3 were found to differ in thickness and refractive index from the known glass fragments in Items 1-2, indicating that the questioned glass fragments in Item 3 did not originate from the same source as the known glass fragments in Items 1-2. The questioned glass fragments in Item 4 were found to agree in colour, thickness, UV fluorescence, elemental composition and refractive index with the known glass fragments in Item 1, but differ in thickness and refractive index from the known glass fragments in Item 2, indicating that the questioned glass fragments in Item 4 could have originated from the same source as the known glass fragments in Item 1, but did not originate from the same source as the known glass fragments in Item 2.
6K4EKV	Based on applied methods, the evidence (elemental composition of glass samples as well as the thickness measurements) provides support for the proposition that questioned glass fragments recovered from the suspect described as Item 4 could have originated from the broken coffee table (Item 1) wile questioned glass fragments recovered from the suspect described as Item 3 could not have originated from both the broken bedroom coffee table (Item 1) and the broken fish tank (Item 2).
6TGXU2	The known samples of the coffee table glass (item #1) and the fish tank glass (item #2) were similar in thickness and exhibited similar fluorescence under short-wave UV illumination, however these samples were distinguishable by the relative abundance of Al and K as shown by SEM-EDS. The unknown samples (Items #3 and #4) were similar thickness and showed similar fluorescence as both known samples but again differed in their elemental compositions. SEM-EDS showed that item #3 did not contain a detectable amount of either Al or K, while Item #4 contained a similar relative abundance of both Al and K as was observed in Item #1. Further supporting this conclusion is the finding that both Item #1 and Item #4 had refractive index close to 1.515. Overall Items #1 and #2 are distinguishable, Item #3 is not similar to either of the known glass samples, and Item #4 is similar to Item #1.

TABLE 3

WebCode	Conclusions
6YNTMU	Unknown Item #3 could be differentiated from Known Items #1 and #2 by the observed and measured physical and chemical properties. The glass from Unknown Item #3 could not have originated from the same source as Item #1 or the same source as Item #2. Unknown Item #4 could be differentiated from Known Item #2; however, Unknown Item #4 and Known Item #1 could not be differentiated by the observed and measured physical and chemical properties. The glass from Unknown Item #4 could not have originated from the same source as Item #2 but could have originated from the same source as Item #1.
7HC64L	The questioned glass fragment recoverd (item4) could be originated from the known glass fragment (item1) recovered from the broken coffee table. The questioned glass fragment recoverd (item3) could not be originated from the known glass fragment (item1) recovered from thr broken coffee table or the known glass fragment (item 2) recovered from the fish tank.
7YFYAL	Based on the SEM/EDS analysis, it is concluded that Item 3 can be excluded as having originated from either of items 1 or 2, as Sn and Al are lower on the Sn side and Al and K are lower on the non-Sn side. However, Item 4 cannot be excluded as having originated from Item 1, but can be excluded from having originated from item 2, due to containing lower proportions of Sn on the Sn side and higher K and Al on the opposite side when compared to item 2. FTIR analysis was inconclusive and could not draw a conclusion based on the results.
8DXJER	The questioned glass fragments from Item 3 are float glasses and have a thickness of around 4.86 mm. The glass differs in its refractive index and in its elemental composition from both Items 1 and 2. The questioned glass fragments Item 4 and the known glass fragments from Item 1 are both float glasses, have both a thickness of around 4.92 mm and cannot be differentiated by their refractive indices and their elemental composition. The questioned glass fragments from Item 4 could have originated from the broken coffee table, but not from the fish tank.
9KAXWN	The glass fragments (Item 001-4) recovered from the suspect were indistinguishable in physical appearance, refractive index, and elemental composition from the glass fragments (Item 001-1) taken from the broken coffee table. Therefore, the glass fragments (Item 001-4) recovered from the suspect could have originated from the broken coffee table or from another source of glass produced by the same glass manufacturer exhibiting the same physical and chemical properties. The other glass fragments (Item 001-3) recovered from the suspect were distinguishable in refractive index from the glass fragments (Item 001-1) taken from the broken coffee table. Therefore, these glass fragments (Item 001-3) did not originate from the same source as the fragments from the broken coffee table (Item 001-1). The glass fragments recovered from the suspect (Items 001-3 and 001-4) were distinguishable by thickness from the glass fragments (Item 001-2) from the fish tank. Therefore, the glass fragments (Items 001-3 and 001-4) from the suspect did not originate from the same source as the fragments from the fish tank.
AN9ZCW	On analysis, I found: i) The refractive index of the questioned glass fragments recovered from the suspect (Item 4) to be similar to the refractive index of the known glass fragments recovered from the broken coffee table (Item 1) and to be dissimilar to the refractive index of the known glass fragments recovered from the fish tank (Item 2). ii) The refractive index of the questioned glass fragments recovered from the suspect (Item 3) to be dissimilar to the refractive index of the known glass fragments recovered from the broken coffee table (Item 1) and the refractive index of the known glass fragments recovered from the fish tank (Item 2). Therefore, I am of the opinion that: (i) The questioned glass fragments recovered from the suspect (Item 4) could have originated from the known glass recovered from the broken coffee table (Item 1) and did not originate from the the known glass fragments recovered from the fish tank (Item 2). (ii) The questioned glass fragments recovered from the suspect (Item 3) did not originate from the

TABLE 3

WebCode	Conclusions
	known glass fragments recovered from the broken coffee table (Item 1) and the known glass fragments recovered from the fish tank (Item 2).
AXXNAK	The two (02) fragments of questioned glass recovered from the suspect (item3) have not the same physical properties to the two (02) fragments of known glass recovered from the broken coffee table (item1), therefore, the two (02) fragments of questioned glass recovered from the suspect (item3) have not originated from the glass of the broken coffee table. The two (02) fragments of questioned glass recovered from the suspect (item3) have not the same physical properties to the two (02) fragments of known glass recovered from the fish tank (item2), therefore, the two (02) fragments of questioned glass recovered from the suspect (item3) have not originated from the glass of the fish tank. The two (02) fragments of questioned glass recovered from the suspect (item4) have the same physical properties to the two (02) fragments of known glass recovered from the broken coffee table (item1), therefore, the two (02) fragments of questioned glass recovered from the suspect (item4) could have originated from the glass of the broken coffee table or from another source exhibiting the same physical properties. The two (02) fragments of questioned glass recovered from the suspect (item4) have not the same physical properties to the two (02) fragments of known glass recovered from the fish tank (item2), therefore, the two (02) fragments of questioned glass recovered from the suspect (item4) have not originated from the glass of the fish tank.
B7HAEL	The glass fragments recovered from the suspect (Item 3) did not originate from the glass standard recovered from the broken coffee table (Item 1) or from the glass standard recovered from the fish tank (Item 2) (Elimination). The glass fragments recovered from the suspect (Item 4) are associated to the glass standard recovered from the broken coffee table (Item 1) upon comparison of optical, physical, and elemental properties and either originated from this item or from another broken glass sources with the same characteristics (Level III Association). The glass fragments recovered from the suspect (Item 4) did not originate from the glass standard recovered from the fish tank (Item 2) (Elimination).
BCNBTG	1.There are no noticeable differences in color, thickness,elemental composition , and refractive index between Item 4 and Item 1. Item 4 could have originated from Item 1. 2.There is no noticeable difference in color between Item 3 and Item 1, however, noticeable differences in thickness, elemental composition and refractive index were detected between them.Item 3 could not have originated from Item 1. 3.There is no noticeable difference in color between Item 4 and Item 2, however, noticeable differences in thickness, elemental composition and refractive index were detected between them.Item 4 could not have originated from Item 2. 4.There is no noticeable difference in color between Item 3 and Item 2, however, noticeable differences in thickness, elemental composition and refractive index were detected between them.Item 3 could not have originated from Item 2.
BV3RXV	Comparison: 1. Examination of Laboratory item #3, Q1A and Q1B and comparison to Laboratory item #1, K1A and K1B as well as Laboratory item #2, K2A and K2B disclosed that they are different with respect to thickness and elemental composition. 2. Examination of Laboratory item #4, Q2A and Q2B and comparison to Laboratory item #2, K2A and K2B disclosed that they are different with respect to thickness and elemental composition. 3. Examination of Laboratory item #4, Q2A and Q2B and comparison to Laboratory item #1, K1A and K1B disclosed that they are consistent and no exclusionary differences were observed with respect to color, appearance, thickness, response to UV light, elemental composition, and refractive index. Interpretation: 1. It is the opinion of the undersigned that Laboratory item #3 (questioned fragments Q1A and Q1B) could not have originated from the sources represented by Laboratory item #1 (known fragments K1A and K1B) or Laboratory item #2 (known fragments K2A and K2B). 2. It is the opinion of the undersigned that Laboratory item #4 (questioned fragments Q2A and Q2B) could not have originated from the source represented

TABLE 3

WebCode	Conclusions
	by Laboratory item #2 (known fragments K2A and K2B). 3. It is the opinion of the undersigned that Laboratory item #4 (questioned fragments Q2A and Q2B) could have originated from the source represented by Laboratory item #1 (known fragments K1A and K1B) or from another source exhibiting all of the same analyzed characteristics.
C6MQDK	The glass samples items 1-4 were each found to comprise two colourless glass fragments of identical thickness. The known glass samples items 1-2 were found to differ in thickness and refractive index from each other. The questioned glass fragments in item 3 were both found to differ in thickness and refractive index from the known glass samples items 1-2, suggested that the questioned glass fragments in item 3 did not originate from the same source as any of the known glass samples items 1-2. The questioned glass fragments in item 4 were both found to agree in colour, thickness, UV fluorescence, elemental composition and refractive index with the known glass sample item 1; but differ in thickness and refractive index from the known glass sample item 2; suggested that the questioned glass fragments in item 4 could have originated from the same source as the known glass sample item 1, but not from the same source as the known glass sample item 2.
D3CVZE	On the basis of the analysis carried out and the results obtained, Item 3 and Item 4 were both identified as soda lime float glass. Item 3 was considered to be toughened glass, whereas Item 4 was considered to be non-toughened. Item 1 and Item 2 were also considered to be non-toughened soda-lime float glass. Item 1 was consistent in thickness and elemental composition to Item 4 and, therefore, was considered to be a possible source of Item 4. Item 2 was consistent in elemental composition to Item 4 but was significantly different in thickness. Therefore, it was not considered to be a source of Item 4. Item 3 was not considered to originate from the same item as either Item 1 or Item 2. This is due to it being toughened glass, having a different thickness, and having a different elemental composition.
DLR6ZE	Item 3 could not have originated from Item 1 or Item 2 Item 4 could have originated from Item 1
E2ZF4R	The concentrations of 8 elements in Item 3 were distinguishable from the concentrations of those same elements in Item 1 by using a ± 4 standard deviation criteria. The concentrations of 9 elements in Item 3 were distinguishable from the concentrations of those same elements in Item 2 by using the same criteria. The concentration of 38 elements in Item 4 were not distinguishable form the concentrations of those same elements in Item 1 by using a ± 4 standard deviation criteria. The concentrations of 7 elements in Item 4 were distinguishable from the concentrations of those same elements in Item 2 by using the same criteria. Opinions/Interpretations: Based on the results, Item 3 could not have originated from the same source as either Item 1 or Item 2. Item 4 could have originated from the same source as Item 1 but could not have originated from the same source as Item 2.
E87CPD	Item 1 is only identical with Item 4. Item 2 is not identical to any other Item.
F2BCWF	CONCLUSIONS: Two glass fragments identified as from the suspect (item 4) either originated from the coffee table (item 1) or another source of broken glass possessing the same distinct physical, optical, and chemical characteristics. These two glass fragments did not originate from the fish tank (item 2). Two glass fragments identified as recovered from the suspect (item 3) did not originate from the coffee table (item 1) or the fish tank (item 2). RESULTS: Questioned glass fragments identified as from the suspect (items 3 and 4) were examined for the purpose of determining whether or not they are like the known glass standards identified as from the broken coffee table (item 1) or the fish tank (item 2). The known glass standards from the broken coffee table (item 1) and the fish tank (item 2) are both colorless non-tempered float sheet glass. Examination of the questioned glass identified as from the suspect (item 3) revealed two full thickness glass fragments. Examination and comparison of these two

TABLE 3

WebCode	Conclusions
	questioned glass fragments with the known glass standards from the broken coffee table (item 1) and the fish tank (item 2) revealed they are dissimilar with respect to physical characteristics. It is therefore concluded these two questioned glass fragments did not originate from the coffee table (item 1) or the fish tank (item 2). Examination of the questioned glass identified as from the suspect (item 4) revealed two full thickness glass fragments. Examination and comparison of these two questioned glass fragments with the known glass standard from the fish tank (item 2) revealed they are dissimilar with respect to physical characteristics. It is therefore concluded these two questioned glass fragments did not originate from the fish tank (item 2). Further examination and comparison of these two questioned glass fragments (item 4) with the known glass standard from the broken coffee table (item 1) revealed they are alike with respect to physical, optical, and chemical characteristics. It is therefore concluded these two questioned glass fragments either originated from the coffee table (item 1) or another source of broken glass possessing the same distinct physical, optical, and chemical characteristics. METHODS OF ANALYSIS: Examinations were performed visually, by stereo microscopy, polarized light microscopy, ultraviolet fluorescence, micrometry, refractive index determination, and x-ray fluorescence spectroscopy.
FKNWTJ	The glass fragments from item 3 (questioned glass fragments recovered from the suspect) and the item 1 (know glass fragments recovered from the broken coffee table) and the item 2 (know glass fragments recovered from the fish tank) were inconsistent (refractive index, color and thickness) and could not have originated from the same source. The glass fragments from item 4 (questioned glass fragments recovered from the suspect) and the item 2 (know glass fragments recovered from the fish tank) were inconsistent (refractive index and thickness) and could not have originated from the same source. The glass fragments from item 4 (questioned glass fragments recovered from the suspect) and the item 1 (know glass fragments recovered from the broken coffee table) were consistent (refractive index, color and thickness) and could have originated from the same source.
FVAZ2J	Item 3 is different in thickness, glass type, and elemental composition from Items 1 and 2. Therefore, Item 3 did not originate from the broken coffee table or the broken fish tank as represented by Items 1 and 2, respectively. Items 4 and 1 are consistent with respect to their physical characteristics, optical properties, and elemental composition. Therefore, Item 4 originated from the broken coffee table as represented by Item 1, or from another source of broken glass exhibiting all of the same analyzed characteristics. Item 4 is different in thickness and elemental composition from Item 2, and therefore did not originate from the broken fish tank as represented by Item 2.
GCQRTB	Two particles of questioned glass fragments recovered from the suspect (Item 3) are different from two known glass fragments recovered from the broken coffee table (Item 1) and two known glass fragments recovered from the fish tank (Item 2) in refractive index. Two particles of questioned glass fragments recovered from the suspect (Item 4) are different from two known glass fragments recovered from the fish tank (Item 2) in refractive index. Two particles of questioned glass fragments recovered from the suspect (Item 4) are consistent with two known glass fragments recovered from the broken coffee table (Item 1) in color, thickness, UV fluorescence, refractive index, elemental composition and Raman spectrum. Item 4 could have originated from the broken coffee table. Item 3 could not have originated from the the broken coffee table and the fish tank.
GEY4BC	Glass recovered from the debris from the suspect (Item 4) is indistinguishable from the glass recovered from the broken coffee table (Item 1). Accordingly, the Item 4 glass fragments either originated from the broken coffee table as represented by Item 1, or from another source of broken glass indistinguishable in all of assessed physical characteristics, refractive index, and elemental composition. Glass recovered from the debris from the suspect (Item 4) is different

TABLE 3

WebCode	Conclusions
	from the glass recovered from the fish tank (Item 2). Therefore, the Item 4 glass fragments are eliminated as originating from the fish tank as represented by Item 2. Glass recovered from the debris from the suspect (Item 3) is different from the glass recovered from the broken coffee table (Item 1) and the glass recovered from the fish tank (Item 2). Therefore, the Item 3 glass fragments are eliminated as originating from the broken coffee table as represented by Item 1 and the fish tank as represented by Item 2.
GQ9CXG	Exhibit 197 (CTS Item 1) consists of two small fragments of transparent, colorless material that is consistent with float glass, described as known glass fragments recovered from a broken coffee table. Exhibit 198 (CTS Item 2) consists of two small fragments of transparent, colorless material that is consistent with float glass, described as known glass fragments recovered from a broken fish tank. Exhibit 199 (CTS Item 3) consists of two small fragments of transparent, colorless material that is consistent with tempered float glass, described as questioned glass fragments recovered from a suspect. Exhibit 200 (CTS Item 4) consists of two small fragments of transparent, colorless material that is consistent with float glass, described as questioned glass fragments recovered from a suspect. Exhibits 200 (CTS Item 4) and 197 (CTS Item 1) each include glass fragments which are similar in physical and optical properties. The Exhibit 200 glass fragments either originated from the known glass source represented by Exhibit 197 or from another broken glass source with similar properties. The questioned glass fragments in Exhibit 200 (CTS Item 4) could not have originated from the known glass source represented by Exhibit 198 (CTS Item 2) due to differences in physical and optical properties. The questioned glass fragments in Exhibit 199 (CTS Item 3) could not have originated from the known glass sources represented by Exhibit 197 (CTS Item 1) or Exhibit 198 (CTS Item 2) due to differences in physical and optical properties. Exhibits 197 through 200 were analyzed using an alternate light source, a micrometer, stereomicroscopy, polarized light microscopy, and an automated glass refractive index measurement system (GRIM3). Elemental composition analysis was not performed on the glass in Exhibits 197 and 200. The chance of finding coincidentally indistinguishable glass is higher when elemental composition analysis is not performed.
H4TJLP	Item 3 These questioned glass fragments did not originate from either the broken coffee table or fish tank (Items 1 and 2) Item 4 In my opinion, these questioned glass fragments could have originated from the broken coffee table (Item 1). These questioned glass fragments did not originate from the broken fish tank (Item 2).
H946HF	Items 1, 2, 3, and 4 were examined by stereomicroscopy and micrometry. Items 1, 3, and 4 were examined by ultraviolet-light fluorescence and X-ray fluorescence microscopy. Items 1 and 4 were further examined by refractometry. The glass in Item 4 was indistinguishable from the glass in Item 1 in optical, physical, and elemental properties (Type 3 Association: Association with Conventional Characteristics). This means the glass fragments recovered from the suspect in Item 4 could have come from the broken coffee table. The glass in Item 3 was different from the glass in Item 1 (Elimination). This means the glass fragments recovered from the suspect in Item 3 did not come from the broken coffee table. The glass in Items 3 and 4 was different from the glass in Item 2 (Elimination). This means the glass fragments recovered from the suspect did not come from the fish tank.
J7DHZC	Item 1 - Known glass fragments recovered from the broken coffee table - Contained two fragments of full thickness, clear, colourless glass. Item 2 - Known glass fragments recovered from the fish tank- Contained two fragments of full thickness, clear, colourless glass. Item 3 - Questioned glass fragments recovered from the suspect - Contained two fragments of full thickness, clear, colourless glass. Item 4 - Questioned glass fragments recovered from the suspect - Contained two fragments of full thickness, clear, colourless glass. The glass fragments recovered from the suspect (items 3 and 4) were found to have a different thickness

TABLE 3

WebCode	Conclusions
	to the glass from the fish tank (item 2) and therefore could not have originated from that source. In relation to colour, thickness, refractive index and elemental composition the glass recovered from the suspect (item 4) was found to be indistinguishable to the glass from the coffee table (item 1). Therefore these two glass samples may share a common origin. The glass recovered from the suspect (item 3) was found to have a different refractive index and elemental composition to the glass from the coffee table (item 1) and therefore could not have originated from that source.
KH3AE8	The questioned glass from Item #4 was consistent in thickness, optical properties and chemical composition with the known glass from Item #1; therefore, Items #1 and #4 could have originated from the same source (Level III association). The questioned glass from Item #3 was dissimilar in thickness from the known glass from Items #1 and #2; therefore, Item #3 and Items #1 and #2 did not originate from the same source (elimination). Terminology Key for Associative Evidence: The following descriptions are meant to provide context to the levels of opinions reached in this report. Every level of conclusion may not be applicable in every case nor for every material type. Level I Association: A physical match; items physically fit back to one another, indicating that the items were once from the same source. Level II Association: An association in which items are consistent in observed and measured physical properties and/or chemical composition and share atypical characteristic(s) that would not be expected to be readily available in the population of this evidence type. Level III Association: An association in which items are consistent in observed and measured physical properties and/or chemical composition and, therefore, could have originated from the same source. Because other items have been manufactured that would also be indistinguishable from the submitted evidence, an individual source cannot be determined. Level IV Association: An association in which items are consistent in observed and measured physical properties and/or chemical composition and, therefore, could have originated from the same source. As compared to a Level III association, items categorized within a Level IV share characteristics that are more common amongst these kinds of manufactured products. Alternatively, an association between items would be categorized as a Level IV if a limited analysis was performed due to the characteristics or size of the specimen(s). Level V Association: An association in which items are consistent in some, but not all, physical properties and/or chemical composition. Some minor variation(s) exists between the known and questioned items and could be due to factors such as sample heterogeneity, contamination of the sample(s), or having a sample of insufficient size to adequately assess the homogeneity of the entity from which it was derived. Inconclusive: No conclusion could be reached regarding an association/elimination between the items. Elimination: The items were dissimilar in physical properties and/or chemical composition, indicating that they did not originate from the same source.
L8FZCC	The above glass findings provide moderately strong support for the view that the matching glass (item 4) recovered from the suspect, originated from the same source as the broken coffee table (item 1), rather than from another source. Note: no inference on the activity that led to the presence of the glass can be made. The remaining questioned glass fragments (item 3) did not originate from the broken coffee table or fish tank, they originated from another source.
LQV9DD	The tested questioned glass fragment (Item 3) differed in elemental composition from both sources of known glass (Items 1 and 2). In addition, Item 3 differed in thickness from Item 2. In the opinion of the examiner, the questioned glass (Item 3) did not originate from the broken coffee table (Item 1) or the fish tank (Item 2). (Elimination) The tested questioned glass fragment (Item 4) differed in thickness and elemental composition from the known glass (Item 2). In the opinion of the examiner, the questioned glass (Item 4) did not originate from the fish

TABLE 3

WebCode	Conclusions
	tank (Item 2). (Elimination) The tested questioned glass fragment (Item 4) was similar in color, thickness, refractive index, and elemental composition to the known glass (Item 1). In the opinion of the examiner, this questioned glass fragment recovered from the suspect (Item 4) originated either from the coffee table represented by Item 1 or from another broken object with indistinguishable properties. (Level 3 - Association)
LWGUB7	Two known and two questioned glass samples were submitted for comparison. Each sample consisted of two fragments. All eight fragments were compared on the basis of original surfaces, fluorescence, thickness, and trace elemental composition. Each pair of fragments associated within a sample was consistent by all properties studied. The analytical results show that sample Q1 (Item 3) could not have originated from any of the known samples submitted (K1, K2, which are also known as Items 1 and 2). Sample Q2 (Item 4) was consistent in all properties studied with Sample K1 (Item 1) but different from the other samples (K2 and Q1, which are also known as Items 2 and 3, respectively). Therefore, sample Q2 could have originated from sample K1, or another source of glass with the properties described in this report. The number of potential sources with these properties is not known.
LWKUHE	Based on our analysis the questioned fragments from the suspect (Item 4) could not be differentiated from the reference material form the coffee table (Item 1). The questioned fragments from the suspect (Item 3) could be clearly distiguished form both reference materials (Item 1 & 2). Those fragments originate from another unknown source.
MBYEFD	There is a very high probability that the glas fragment recovered from the suspect (item 4) originated from the broken coffee table (item 1).
MH2V4K	Item 1: 4.91 cm Item 2: 4.62 cm Item 3: 4.85 cm Item 4: 4.91 cm According to the XRF analysis, Items 1 and 4 exhibit similar elemental ratios of key components such as calcium (Ca), sodium (Na), magnesium (Mg), aluminum (Al), and iron (Fe). This trend is consistently observed in the LA-ICP-MS results as well, suggesting that the two samples may share a common raw material composition or manufacturing process.
ML28ZK	The Interpretations & Opinions stated below are based solely on the representative samples analyzed. Examination and comparison of representative glass from Item 3 compared to representative glass from Items 1 and 2 were found to be dissimilar in all measured physical and optical properties. They could not have come from the same source. Examination and comparison of representative glass from Items 4 and 1 were found to be similar in all measured physical and optical properties and elemental compositions. They could have come from the same source or any other source with the same properties and compositions. Examination and comparison of representative glass from Items 4 and 2 were found to be dissimilar in all measured physical and optical properties. They could not have come from the same source.
N2Q2YA	The following methodologies were used in the examination of this case: visual examination, physical examination, microscopy, solubility, digital calipers, UV fluorescence, XRF and GRIM3. Analysis showed the known glass fragments recovered from the broken coffee table (item #1) and the questioned glass fragments recovered from the suspect (item #3) were not consistent in elemental composition. These fragments could not have shared a common origin. Analysis showed the known glass fragments recovered from the broken coffee table (item #1) and the questioned glass fragments recovered from the suspect (item #4) were consistent in physical properties, refractive index, and elemental composition. These fragments could have shared a common origin. Analysis showed the known glass fragments recovered from the fish tank (item #2) and the questioned glass fragments recovered from the suspect (items #3 and 4) were not consistent in elemental composition. These fragments could not have shared a common origin.

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WebCode	Conclusions
NGVV69	Item 1: Clear and colorless glass standard was analyzed for comparison to Item 3 and Item 4. Item 2: Clear and colorless glass standard was analyzed for comparison to Item 3 and Item 4. Item 3: Two pieces of clear and colorless glass were found. The unknown glass from the suspect and the standard glass (Item 1) from the "coffee table" and the standard glass (Item 2) from the "fish tank" are not the same in physical and chemical characteristics. The unknown glass from the suspect could not have originated from the standards. Item 4: Two pieces of clear and colorless glass were found. The unknown glass from the suspect either originated from the standard glass (Item 1) from the "coffee table" or another source of glass possessing the same distinct physical and chemical characteristics. The unknown glass from the suspect and the standard glass (Item 2) from the "fish tank" are not the same in physical and chemical characteristics. The unknown glass from the suspect could not have originated from the standard (Item 2).
QL6Z8F	The glass fragments recovered from the suspect (Item #4) compare by physical, elemental, and optical properties to the glass fragments recovered from the broken coffee table (Item #1), indicating that they could have come from the same piece of glass or another glass source with indistinguishable properties. The glass fragments recovered from the suspect (Item #3) do not compare to the glass fragments recovered from the broken coffee table (Item #1) and the fish tank (Item #2). The glass fragments recovered from the suspect (Item #4) do not compare to the glass fragments recovered from the fish tank (Item #2).
RFDL68	Results Item 1 compared to Item 4: Type 3 - Association Item 1 compared to Item 3: Elimination Item 2 compared to Item 3: Elimination Item 2 compared to Item 4: Elimination
RH4C4D	The two particles of glass recovered from the suspect, item 4 could have originated from glass from the broken coffee table as represented by the submitted control item 1. The two particles of glass recovered from the suspect, item 3 did not originate from the broken coffee table or the fish tank as represented by items 1 and 2. Item 4 could not have originated from item 2.
TFMAJ4	1. Comparative examinations of Exhibit 4 (questioned glass fragments recovered from the suspect) with Exhibit 1 (known glass standard from broken coffee table) disclosed them to be consistent in their physical characteristics, elemental compositions, and refractive indices. As a result of these findings, the questioned glass in Exhibit 4 could have originated from the coffee table or another source of broken glass with the same characteristics. A glass association is not a means of positive identification and the number of possible sources for a specific glass is unknown. 2. Comparative examinations of Exhibit 4 (questioned glass fragments recovered from the suspect) with Exhibit 2 (known glass standard from the fish tank) disclosed them to be inconsistent in their elemental compositions. As a result of these findings, the questioned glass in Exhibit 4 could not have originated from the fish tank as represented by Exhibit 2. 3. Comparative examinations of Exhibit 3 (questioned glass fragments recovered from the suspect) with Exhibit 1 (known glass standard from broken coffee table) and Exhibit 2 (known glass standard from the fish tank) disclosed them to be inconsistent in their elemental compositions. As a result of these findings, the questioned glass in Exhibit 3 could not have originated from the coffee table or the fish tank as represented by Exhibits 1 and 2 respectively.
TN4DJX	Item 3 fragments have not originated from either the fish tank or the coffee table. In my opinion, the findings provide strong support for the view that Item 4 has originated from the coffee table.
TV38N6	Exhibit 3 was differentiated from Exhibit 1 and from Exhibit 2 via physical properties. Therefore, the glass fragments recovered from the suspect in Exhibit 3 could not have come from the broken coffee table as represented by Exhibit 1 or the broken fish tank as represented by Exhibit 2. Exhibit 4 was differentiated from Exhibit 2 via elemental composition. Therefore, the glass fragments recovered from the suspect in Exhibit 4 could not have come from the broken

TABLE 3

WebCode	Conclusions
	fish tank as represented by Exhibit 2. Exhibit 4 could not be differentiated from Exhibit 1 via physical properties, elemental composition, or refractive index. Therefore, the glass fragments recovered from the suspect in Exhibit 4 originated from the broken coffee table as represented by Exhibit 1 or from another broken glass item with the same, physical, elemental, and optical properties. These combined methods of comparison have been shown to be highly discriminating between glass sources. This type of association provides very strong to extremely strong support for the proposition that the items originated from the same source as opposed to different sources. Coincidental associations of glass originating from different sources could occur but are expected to be highly unusual.
V472V3	Item 1 This item was used as a comparison standard. Item 2 This item was used as a comparison standard. Item 3 The glass (Item 3) was determined to be dissimilar in thickness to the glass from the broken coffee table (Item 1) and the glass from the fish tank (Item 2). It is our opinion that this glass did not originate from the same source as the known glass from the broken coffee table or the fish tank. Item 4 The glass (Item 4) was determined to be similar in color, thickness, fluorescence, and elemental composition to the known glass from the broken coffee table (Item 1). It is our opinion that this glass could share a common origin to the known glass from the broken coffee table. Please note that refractive index comparison between this glass and the known glass from the broken coffee table cannot be performed by our laboratory at this time. In addition, the glass (Item 4) was determined to be dissimilar in thickness to the glass from the fish tank (Item 2). It is our opinion that this glass did not originate from the same source as the known glass from the fish tank.
VQH36Z	Item1 (control glass from the broken coffee table) comprised two fragments of pale-green float glass, with original surfaces and an average thickness of 4.93 mm. Item2 (control glass from the fish tank) comprised two fragments of pale-green float glass, with original surfaces and an average thickness of 4.64 mm. Item3 (recovered from the suspect) comprised two fragments of toughened, pale-green float glass, with original surfaces and an average thickness of 4.87 mm. The fragments differed in thickness to those of Item 1 and Item 2 and therefore could not have originated from either of the control glass sources as represented by Item1 and Item2. Item4 (recovered from the suspect) comprised two fragments of pale-green float glass, with original surfaces and an average thickness of 4.93 mm. The fragments corresponded in apparent colour, thickness, average refractive index and bulk elemental composition to Item1 and therefore could have originated from the control glass source as represented by Item1. The glass fragments in Item4 differed in thickness to those of Item2 and therefore could not have originated from the control glass source as represented by Item2.
W8LWCY	In my opinion, the fragments item 4 recovered from the suspect were statistically indistinguishable from the glass from the coffee table Item 1, based on appearance, type, thickness, refractive index and elemental analysis. In my opinion the fragments Item 3 recovered from the suspect were different to the glass from the coffee table Item 1 and the fish tank Item 2. The LR(s) for this examination was calculated using the following propositions: H1 Suspect was close to glass (within 1 - 2m) at the scene when it was broken. H2 Suspect was not close to the glass at the scene when it was broken Therefore, in my opinion the findings provide very strong support, or the evidence is approximately 13000 times more likely, for the proposition that the clothing believed to belong to suspect was close to the glass items at the scene when they broke, rather than the proposition that it was not close to the glass items at the scene when they were broken. My conclusions are based on the results of my laboratory examination and the information made available to me at this time. If any aspects of the case should change (in particular the propositions) then I am prepared to review my conclusion in light of such changes.
WGR9JA	The fragments of the known samples Item 1 and Item 2 differ from each other based on their

TABLE 3

WebCode	Conclusions
	elemental composition measured by micro-XRF and on the RI values measured before and after annealing, as well. The questioned fragments of Item 3 – based on type, elemental composition measured by micro-XRF, and based on the RI values measured before and after annealing, as well – cannot originate from either the glass represented by known sample Item 1, or the glass represented by known sample Item 2. The questioned fragments of Item 4 – based on type, color, thickness, elemental composition measured by micro-XRF, and based on the RI values measured before and after annealing, as well – can most likely originate from the glass represented by known sample Item 1. The questioned fragments of Item 4 – based on elemental composition measured by micro-XRF, and based on the RI values measured before and after annealing, as well – cannot originate from the glass represented by known sample Item 2.
WHNEM3	Items #01.01 and #01.04-Microscope and Instrumental analysis (GRIM3 & XRF) of the questioned glass from the suspect, Item#01.04, and the known glass from the coffee table, Item# 01.01, revealed that they are consistent with respect to their physical properties (COLOR & THICKNESS), optical properties (ISOTROPISM & REFRACTIVE INDEX) and elemental composition. Therefore, the questioned glass from Item# 01.04 could have originated from the source represented by the known glass, Item# 01.01, or another glass source that exhibits the same physical and optical properties, elemental composition and is damaged. Items #01.01 and #01.03- Microscopic examination of the questioned glass from the suspect, Item# 01.03, and the known glass sample from the coffee table, Item# 01.01, revealed that they are not consistent with respect to their physical properties (THICKNESS). Therefore, the questioned glass, Item#01.03, could NOT have come from the source represented by the known glass Item# 01.01. Items #01.02, #01.03 and #01.04-Microscopic examination of the questioned glass from the suspect, Items #01.03 and #01.04, and the known glass sample from the fish tank, Item #01.02, revealed that they are not consistent with respect to their physical properties (THICKNESS). Therefore, the questioned glass, Items #01.03 and #01.04, could NOT have come from the source represented by the known glass Item #01.02.
WYCYJA	The questioned glass fragments recovered from the suspect (Item 4) can come from the broken coffee table (Item 1) or from another glass material with the same characteristics. The questioned glass fragments recovered from the suspect (Item 4) don't come from the fish tank (Item 2). The questioned glass fragments recovered from the suspect (Item 3) don't come from the broken coffee table (Item 1) or fish tank (Item 2).
Y9UF2U	The two examined pieces of glass in Item 3, from the suspect, do not originate from the broken coffee table represented by Item 1 or the broken fish tank represented by Item 2. The results give support for the hypothesis that the examined pieces of glass in Item 4, from the suspect, originate from the broken coffee table represented by Item 1 (Level +2).
YLVL3X	1. Comparative examinations of Exhibit 1 (glass from broken coffee table at the scene) with Exhibit 4 (glass from the subject) disclosed them to be consistent in their physical characteristics, elemental compositions, and refractive indices. As a result of these findings, Exhibit 4 could have originated from Exhibit 1, or another source with the same characteristics. 2. A glass association is not a means of positive identification and the number of possible sources for a specific glass is unknown. 3. Comparative examinations of Exhibit 1 with Exhibit 3 (glass from the subject) and comparative examinations of Exhibit 2 (glass from fish tank at the scene) with Exhibits 3 and 4 disclosed them to be inconsistent in their elemental compositions. As a result of these findings, Exhibit 3 could not have originated from Exhibits 1 or 2 and Exhibit 4 could not have originated from Exhibit 2.
YWDZ7Z	1. Class-characteristic associations were found upon comparing thickness and RI values (nD,

TABLE 3

WebCode	Conclusions
	nC, and nF) of Item 4 fragments to those of Item 1 fragments. Therefore, it is concluded that Item 4 either shares a common source or originates from another source that is class-characteristic-associated to Item 1. 2. No class-characteristic associations were found upon comparing thickness values of Item 3 and Item 4 fragments to those of Item 2 fragments. Therefore, Item 3 and Item 4 do not share a common source with Item 2. 3. No class-characteristic associations were found upon comparing thickness and RI (nD only) values of Item 3 fragments to those of Item 1 and Item 4 fragments. Therefore, Item 3 do not share a common source with Item 1 and Item 4.
ZQP9MR	The glass fragment from the suspect (item 4) cannot be distinguished from the glass from the broken coffee table (item 1) either by refractive index or by elemental analysis. Therefore, item 4 could have originated from the broken coffee table (item 1). The other glass fragment from the suspect (item 3) can be clearly distinguished from the glass of the broken coffee table (item 1) and from the fish tank (item 2) on the basis of the examination procedures carried out.
ZYJDGT	Glass fragments labeled as Item 1 match the tested physico-chemical properties (color, thickness, elemental composition and RI) with the glass labeled as Item 4. Considering all the common characteristics, the glass samples from Item 1 and 4 most likely originate from the same source. Glass fragments labeled as Item 1 differ in elemental composition and RI from the glass fragment labeled as Item 3. The glass fragments labeled as Item 2 differ in thickness as well as RI from the glass fragments labeled as Item 3 and 4.

Additional Comments

TABLE 4

WebCode	Additional Comments
3UX33T	This laboratory does not conducted elemental analysis.
63L6A2	The results give moderate support to the hypothesis that item 4 originates from the source item 1. The hypothesis is held against the alternative, claiming that item 4 has another origin/source, different from item 1.
6K4EKV	The thickness of glass fragments from item 1 and item 4 looks similar (measured to the second decimal place) and differed from glass fragments from item 2 and item 3. Thickness of glass fragments from item 2 and item 3 was also different. Although accordingly internal procedure, LR calculation was introduced into quantitative element composition delivered by SEM/EDX. LR value obtained for comparison between item 1 and item 4 suggests a support for the hypothesis that they originated from the same object than for the hypothesis that they originated from different objects. LR values obtained for comparison between item 1 and item 3; item 2 and item 3; item 2 and item 4 suggest a support for the hypothesis that they originated from different objects than for the hypothesis that they originated from the same object.
6TGXU2	Elemental compositions for the known and unknown glass samples were collected from two (or four in the case of Item #2) larger chunks and then from two areas of two separate pulverized fragments by SEM/EDS using an oxide model. The elemental compositions were then averaged, and the standard deviation of the samples set calculated from repeated measurements. The concentrations of Al and K in Items #1 and #2 differ by>3 standard deviations, whereas the difference in the concentrations of Al and K in Items #1 and #4 differ by <1 standard deviation.
D3CVZE	Assignment of glass toughening was determined by the appearance of the fractured surfaces of the fragments and the birefringence observed in the fragments when viewed between crossed polarising filters.
FVAZ2J	Note(s): Methods of analysis: Glass was analyzed using a combination of stereomicroscopy, high power and polarized light microscopy, and ultraviolet light examination. X-ray Fluorescence Spectrometry (XRF) was used to analyze elemental composition. Glass Refractive Index Measurement system (GRIM) was used to analyze optical properties (refractive index). XRF and GRIM are standard glass analysis techniques. XRF data was compared using spectral overlay comparisons. Elemental ratio comparisons were also performed on Items 1 and 4.
GEY4BC	Methods, Interpretation and Limitations included in actual report of examination but your test box is too limited to include these sections here.
H946HF	Type 3 Association: Association with Conventional characteristics--Items are consistent in all measured and observed physical properties, chemical composition, and/or microscopic characteristics, and therefore could have originated from the same source. Because other items have been manufactured or are naturally occurring that would also be indistinguishable from the submitted evidence, an individual source cannot be determined. Elimination--Items exhibit differences in one or more of the following: physical properties, chemical composition, or microscopic characteristics and therefore did not originate from the same source.
L8FZCC	As no timeline is available for the incident or recovery of clothing from the suspect, it is not possible to evaluate at activity level. A higher support level would likely be reported if the results could be evaluated at activity level vs source level.
RFDL68	From Association Scale (did not include entire scale): Type 3 - Association: Items are consistent with observed characteristics (physical and/or chemical) and could have originated from the same source. Because other items have been manufactured that could also be consistent with observed characteristics, an individual source cannot be determined.

TABLE 4

WebCode	Additional Comments
	Elimination - Items are dissimilar in observed characteristics (physical and/or chemical) and did not originate from the same source.
TN4DJX	If this case had been submitted and the fragments had originated from damage or were embedded in the bat then we would have addressed this at activity level. As the fragments 3 and 4 are simply listed as being recovered without additional information, we have addressed the findings at source level.
TV38N6	When possible, agencies should submit at least 10 fragments (20-50 fragments are preferred) from the known broken glass object so minor variations within the glass object can be assessed.
YWDZ7Z	Average thickness results [mm]: Item 1: 4.939 Item 2: 4.643 Item 3: 4.870 Item 4: 4.942 Average RI nD results [RIU]: Item 1: 1.51825 Item 3: 1.51735 Item 4: 1.51824 Average RI nC results [RIU]: Item 1: 1.52014 Item 4: 1.52008 Average RI nF results [RIU]: Item 1: 1.51337 Item 4: 1.51329 *Qualitative SEM/EDS analysis has found no differences in either major, or minor elemental composition within the different items.

-End of Report-
(Appendix may follow)

Collaborative Testing Services ~ Forensic Testing Program

Test No. 25-5481: Glass Analysis

DATA MUST BE SUBMITTED BY **Aug. 04, 2025, 11:59 p.m. EDT** TO BE INCLUDED IN THE REPORT

Participant Code: U1234A WebCode: 8ZAGXL

The Accreditation Release section can be accessed by using the "Continue to Final Submission" button above. This information can be entered at any time prior to submitting to CTS.

Scenario:
Police are investigating a violent assault at a home. The home owner claims a man attacked him with a bat, breaking a coffee table and fish tank. That same night, police apprehended a suspect and recovered glass fragments similar to those collected at the crime scene. Investigators are asking you to compare the glass fragments recovered from the suspect to the fragments recovered from the coffee table and fish tank and report your findings.

Please Note:

-Samples contained within each individual item are from a single source.

-CTS will not reproduce Interpretation Scales, Scale of Conclusions or Terminology Keys in the final report. Please do not submit with the participant's data sheet.

Items Submitted (Sample Pack GL):
Item 1: Known glass fragments recovered from the broken coffee table.
Item 2: Known glass fragments recovered from the fish tank.
Item 3: Questioned glass fragments recovered from the suspect.
Item 4: Questioned glass fragments recovered from the suspect.

1.) Could the questioned glass fragments recovered from the suspect (Item 3 and Item 4) have originated from either the broken coffee table and/or fish tank as represented by Item 1 and Item 2?

	Item 1		
	Yes	No	Inconclusive
Item 3:	○	○	○
Item 4:	○	○	○

	Item 2		
	Yes	No	Inconclusive
Item 3:	○	○	○
Item 4:	○	○	○

2.) Indicate the procedure used to examine the submitted items:

Refractive Index:		UV Fluorescence:		
☐ nD	☐ nC	☐ Long	☐ Color	☐ Thickness
☐ nF	☐ Δ RI	☐ Short	☐ Density	
		Elemental Analysis:		
☐ SEM/EDS	☐ XRS/XRF			

Other:

3.) What would be the wording of the Conclusions in your report?

Note: *Please use appropriate punctuation to indicate the end of sentences, sections, and statements in the free-form space below. Extra spacing and returns used for separation within your text will not transfer and may cause your information to be illegible in the Summary Report. The use of lists and tabular formats to deliver information is also cautioned against, as these do not transfer.*

4.) Additional Comments

Note: *Please use appropriate punctuation to indicate the end of sentences, sections, and statements in the free-form space below. Extra spacing and returns used for separation within your text will not transfer and may cause your information to be illegible in the Summary Report. The use of lists and tabular formats to deliver information is also cautioned against, as these do not transfer.*

RELEASE OF DATA TO ACCREDITATION BODIES

The Accreditation Release is accessed by pressing the "Continue to Final Submission" button online and can be completed at any time prior to submission to CTS.

CTS submits external proficiency test data directly to ANAB and/or A2LA. Please select one of the following statements to ensure your data is handled appropriately.

- ○ This participant's data is intended for submission to ANAB and/or A2LA. (Accreditation Release section below must be completed.)
- ○ This participant's data is **not** intended for submission to ANAB and/or A2LA.

Have the laboratory's designated individual complete the following steps
only if your laboratory is accredited in this testing/calibration discipline
by one or more of the following Accreditation Bodies.

Step 1: Provide the applicable Accreditation Certificate Number(s) for your laboratory

ANAB Certificate No.

A2LA Certificate No.

Step 2: Complete the Laboratory Identifying Information in its entirety

Authorized Contact Person and Title

Laboratory Name

Location (City/State)