Electronic Supplementary Information

Chemical characterization of automobile windshield glass samples by nuclear and radio-analytical techniques namely SEM-EDX, ED-XRF, PIXE, PIGE and INAA and potentials of external (in air) PIGE and INAA in conjunction with chemometrics for glass forensics

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Figure S1. Ternary plot of five automobile glass samples utilizing REEs sum, transition sum and major elemental concentration sum (Sample A3(G1), A30 (G2), A33 (G3), A45 (G4), A46 (G5))

Table S1. Details of automobile (car) windshield glass samples analyzed for forensic studies

Glass ID	Manufacture of Car	Model	Year	Remark
A1	Mazda	Lantis	1997	Left/Front
A2	Mazda	Lantis	1997	Left/Back
A3	Mazda	Lantis	1997	Right/Back
A4	Peugeot	206	2001	Right/Front
A5	Peugeot	206	2001	Left/front
A6	Mazda	Lantis	1997	Right/Front
A7	Hyundai	Accent	1999	Right/Back

A8	Honda	Civic	1993	Right/Front
A9	Honda	Civic	1993	Left/Back
A10	Ford	Focus	2002	Left/Front
A11	Honda	Civic	1993	Right/Back
A12	Daewoo	Lanos	2000	Right/Back
A13	Hyundai	Accent	1999	Left/Back
A14	Peugeot	206	2001	Right/back
A15	Ford	Focus	2002	Left/Back
A16	Hyundai	Elantra	1998	Right/Back
A17	Hyundai	Elantra	1998	Left/Back
A18	Honda	Civic	1993	Left/Front
A19	Hyundai	Elantra	1998	Right/Front
A20	Fiat	Punto	2000	Left/Back
A21	Hyundai	Accent	1997	Left/Back
A22	Daewoo	Lanos	2000	Right/Front
A23	Daewoo	Lanos	2000	Left/Back
A24	Mitsubishi	Pajero	1998	left/front
A25	Subaru	Impreza	1994	right/front
A26	Mitsubishi	Pajero	1998	left/back
A27	Fiat	Punto	2001	left/front
A28	Subaru	Impreza	1994	left/front
A29	Renault	Clio	1995	right/back
A30	Ford	Focus	2002	right/back
A31	Hyundai	Accent	2001	right/back
A32	Hyundai	Accent	2001	right/back
A33	Hyundai	Accent	2001	right/back
A34	Hyundai	Accent	2001	left/back
A35	Hyundai	Accent	1997	right/front
A36	Hyundai	Accent	1997	left/back
A37	Ford	Focus	2002	rifht/front
A38	Hyundai	Accent	1997	right/back
A39	Renault	Clio	1995	left/back
A40	Subaru	Impreza	1994	left/back
A41	Fiat	Punto	2001	right/back
A42	Renault	Clio	1995	left/back
A43	Fiat	Punto	2001	right/front
A44	Hyundai	Accent	2001	left/front
A45	Subaru	Impreza	1994	right/back
A46	Renault	Clio	1995	right/back
A47	Renault	Clio	1995	right/front
A48	Hyundai	Accent	1997	right/back

Table S2. Relevant thick target gamma-ray yields (Counts/µC/Sr) of proton induced reactions of low Z elements [1]

Element	Reaction	Eγ (keV)	Yield (Counts/µC/Sr) at 4 MeV proton
Li*	^7Li (p, p' γ) ^7Li	478	8.1×10^7
	^7Li (p, n γ) ^7Be	429	2.6×10^7
Na	^{23}Na (p, p'γ)^{23}Na	440	3.9×10^7
	^{23}Na (p, p'γ)^{23}Na	1636	2.6×10^7
Mg	^{24}Mg (p, p'γ)^{24}Mg	585	1.2×10^6
	^{24}Mg (p, p'γ)^{24}Mg	1368.5	6.5×10^6
Al	^{27}Al (p, p' γ) ^{27}Al	844	7.5×10^6
	^{27}Al (p, p' γ) ^{27}Al	1014	1.6×10^7
Si	^{28}Si (p, p'γ) ^{28}Si	1779	1.0×10^7
	^{29}Si (p, p'γ) ^{29}Si	1273	8.7×10^5
Ta*	^{181}Ta (p, p'γ) ^{181}Ta	136, 165	#1.6×10^5 #1.5×10^3

Note: * - used as current normalizer; # thick target gamma-ray yield at 2.4 MeV proton beam [2]

Table S3. Relevant nuclear data of elements for INAA of glass samples

Sr No.	Element	Activation Product	Half life (T$_{1/2}$)	Gamma-ray Energy (keV)
1	Na	^{24}Na	14.95 h	1368.5
2	Al	^{28}Al	2.24 min	1778
3	Ca	^{49}Ca	8.7 min	3084
3	Sc	^{46}Sc	84 d	889.6
4	Cr	^{51}Cr	28 d	320.4
5	Mn	^{56}Mn	2.58 h	847
6	Fe	^{59}Fe	45 d	1099
7	Co	^{60}Co	5.27 y	1173, 1332
8	Zn	^{65}Zn	244 d	1115.9
9	Rb	^{86}Rb	18.6 d	1077.2
10	Zr	^{95}Zr	64 d	724, 757.1
11	Cs	^{134}Cs	751.9 d	795
13	Ba	^{131}Ba	11.8 d	496
14	La	^{140}La	1.67 d	1596
15	Ce	^{141}Ce	32 d	145.6
16	Sm	^{153}Sm	46.7 h	103.2
17	Eu	^{152}Eu	13.3 y	1408
18	Yb	^{169}Yb	32.03 d	198

19	Hf	^{181}Hf	42 d	482.5
20	Ta	^{182}Ta	114 d	1189.5, 1221.4
21	Th	^{232}Pa	27d	312, 340.6

Table S4. k-Means clustering table using k=6 as initial clustering

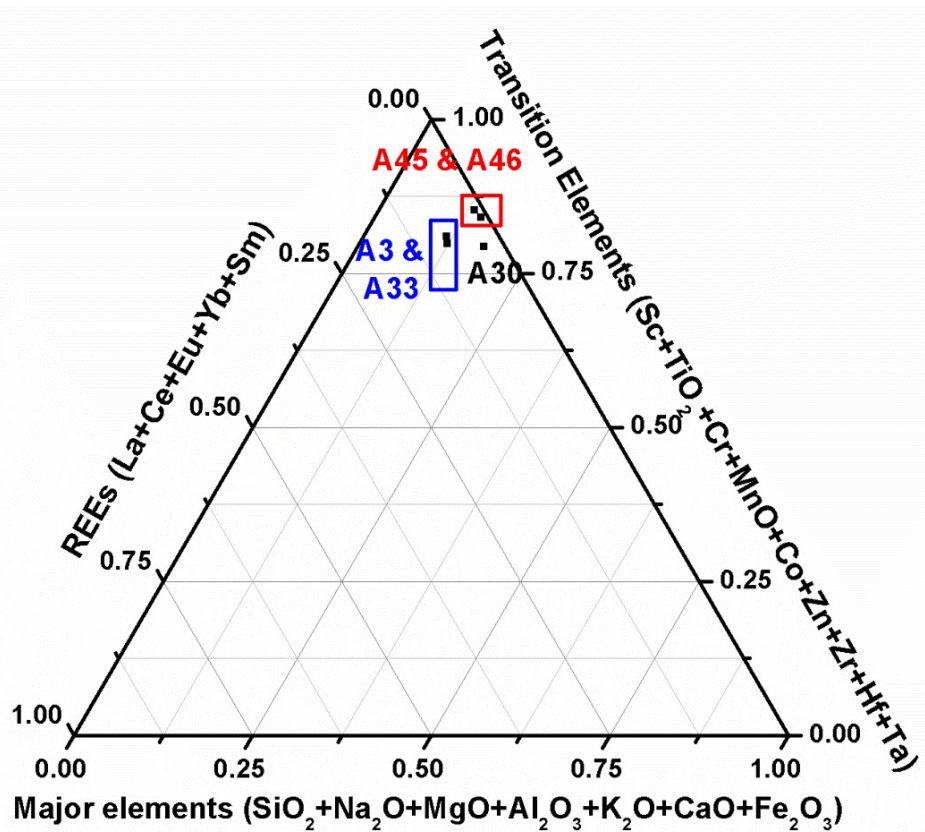| Cluster No.	Sample No.	Car Model No.	Cluster No.	Sample No.	Car Model No.
1	A01	Mazda	5	A07	Hyundai
4	A02	Mazda		A13	Hyundai
4	A03	Mazda		A16	Hyundai
	A06	Mazda		A17	Hyundai
3	A08	Honda		A19	Hyundai
	A09	Honda		A21	Hyundai
	A18	Honda	2	A12	Daewoo
	A11	Honda		A22	Daewoo
6	A15	Ford		A23	Daewoo
	A10	Ford		A20	Fiat

Figure S1. Ternary plot of five automobile glass samples utilizing REEs sum, transition sum and major elemental concentration sum (Sample A3(G1), A30 (G2), A33 (G3), A45 (G4), A46 (G5))

References:

1. A. Savidou, X. Aslanoglou, T. Paradellis, M. Pilakouta, Proton induced thick target γ-ray yields of light nuclei at the energy region Ep=1.0–4.1 MeV, Nucl. Instr. Meth. B, 1999, 152, 12.
2. J. Raisanen, and R. Hanninen, Heavy element (Z>30) thick target gamma-ray tields induced by 1.7 and 2.4 MeV protons, Nuclear Instruments and Methods 205 (1983) 259-268