Electronic supplementary information

Determination of toxic metals in cigarettes using high-resolution continuum source graphite furnace atomic absorption spectrometry

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Figure S1 Standard curves for the quantitation of Cu (A), Cd (B), Cr (C), Ni (D) and Pb (E) using HR-CS GFAAS

Table S1 Sample throughput of tobacco, ash and butts (g) (n=3)

Table S2 Concentration of Cu, Cd, Cr, Ni and Pb in different parts of cigarettes (μg per cigarette) (n = 3)

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Table S4 Contents of Cu, Cd, Cr, Ni, and Pb in the ash and its residual rate (n=3)

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Figure S1

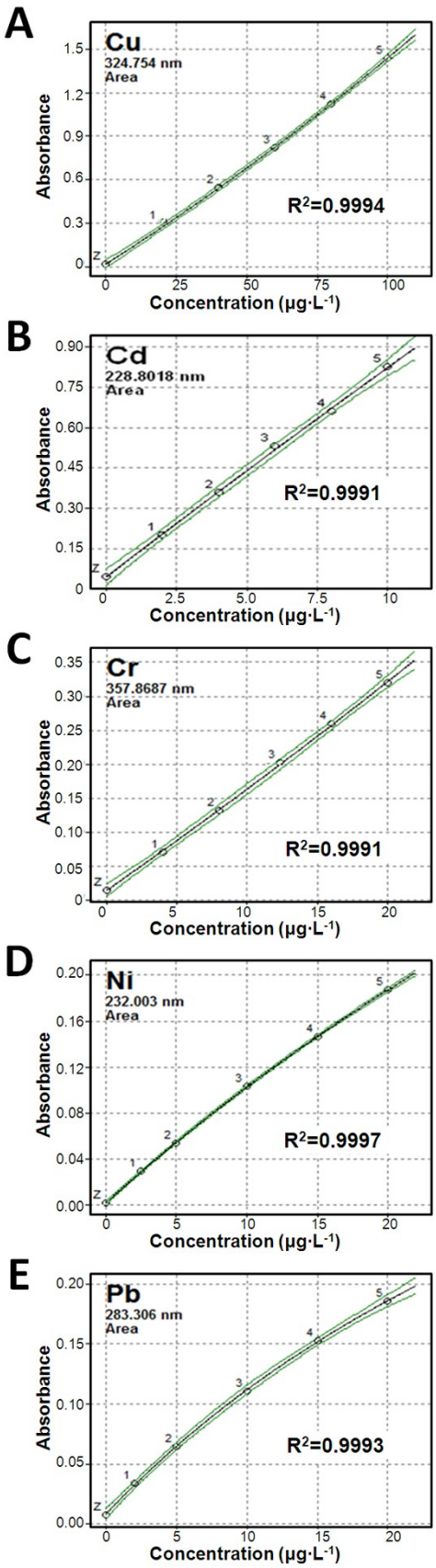
A
Cu
324.754 nm
Area
Absorbance
Concentration (µg·L-1)
R2=0.9994
B
Cd
228.8018 nm
Area
Absorbance
Concentration (µg·L-1)
R2=0.9991
C
Cr
357.8687 nm
Area
Absorbance
Concentration (µg·L-1)
R2=0.9991
D
Ni
232.003 nm
Area
Absorbance
Concentration (µg·L-1)
R2=0.9997
E
Pb
283.306 nm
Area
Absorbance
Concentration (µg·L-1)
R2=0.9993

Table S1 Sample throughput of tobacco, ash and butts (g) (n=3)

Brands	Tobacco	Ash	Butts
Honghe Panda	0.202	0.050	0.512
Hongtashan (W)	0.197	0.050	0.639
Hongtashan (R)	0.198	0.050	0.625
Baisha	0.198	0.051	0.583
Huangguoshu	0.199	0.051	0.615
Diamond	0.201	0.050	0.469
Yuxi	0.201	0.051	0.551
ChungHwa	0.204	0.050	0.579
Kent	0.201	0.050	0.624
Marlboro	0.201	0.050	0.685
Camel	0.201	0.050	0.595
Zhongnanhai	0.197	0.050	0.660

Table S2 Concentration of Cu, Cd, Cr, Ni and Pb in different parts of cigarettes (μg per cigarette) (n = 3)

Elements	Brands	Tobacco	Smoke	Ash	Butts
Cu	Honghe Panda	10.53±1.24	0.472±0.105	7.42±0.163	1.81±0.132
	Hongtashan (W)	9.81±1.19	0.531±0.182	7.83±0.272	1.08±0.148
	Hongtashan (R)	11.58±1.78	0.844±0.045	8.46±0.517	0.94±0.073
	Baisha	12.58±1.96	0.653±0.152	8.17±0.356	1.04±0.059
	Huangguoshu	13.77±1.15	0.670±0.091	8.51±0.317	2.15±0.093
	Diamond	4.75±0.94	0.372±0.063	3.32±0.045	0.77±0.065
	Yuxi	9.86±1.4	0.815±0.117	8.09±0.294	0.95±0.121
	ChungHwa	7.98±1.27	0.762±0.125	6.14±0.482	0.49±0.033
	Kent	15.25±1.93	0.933±0.158	8.00±0.573	0.30±0.164
	Marlboro	13.69±2.36	0.820±0.0812	8.32±0.284	1.02±0.057
	Camel	7.57±1.38	0.591±0.046	5.56±0.195	1.10±0.120
	Zhongnanhai	9.26±1.04	0.534±0.057	5.49±0.327	0.41±0.035
	Average	10.55	0.67	7.11	1.00
	Blank ($\mu g \cdot L^{-1}$)	0.34	0.31	0.22	0.29
Cd	Honghe Panda	1.28±0.049	0.114±0.002	0.86±0.009	0.30±0.006
	Hongtashan (W)	1.76±0.051	0.126±0.002	0.83±0.015	0.80±0.015
	Hongtashan (R)	1.62±0.082	0.113±0.003	0.78±0.016	0.64±0.018
	Baisha	1.56±0.173	0.132±0.006	0.84±0.023	0.57±0.011
	Huangguoshu	1.42±0.110	0.082±0.003	0.79±0.017	0.52±0.005
	Diamond	0.86±0.061	0.107±0.004	0.62±0.021	0.11±0.008
	Yuxi	1.16±0.094	0.092±0.002	0.69±0.014	0.29±0.008
	ChungHwa	0.69±0.031	0.082±0.002	0.45±0.023	0.12±0.006
	Kent	0.52±0.014	0.091±0.001	0.35±0.017	0.07±0.002
	Marlboro	1.30±0.022	0.064±0.002	0.68±0.008	0.04±0.005
	Camel	1.43±0.105	0.107±0.004	0.76±0.022	0.41±0.016
	Zhongnanhai	0.56±0.021	0.052±0.002	0.39±0.018	0.07±0.009
	Average	1.18	0.10	0.67	0.33
	Blank ($\mu g \cdot L^{-1}$)	0.18	0.20	0.16	0.22

Continued Table S2

Elements	Brands	Tobacco	Smoke	Ash	Butts
Cr	Honghe Panda	0.34±0.006	0.082±0.005	0.16±0.003	0.05±0.004
	Hongtashan (W)	0.56±0.009	0.113±0.002	0.16±0.015	0.14±0.006
	Hongtashan (R)	0.61±0.014	0.075±0.009	0.34±0.009	0.07±0.002
	Baisha	0.40±0.016	0.080±0.006	0.20±0.011	0.11±0.007
	Huangguoshu	0.39±0.011	0.104±0.024	0.25±0.008	0.04±0.006
	Diamond	0.40±0.021	0.091±0.002	0.21±0.012	0.05±0.008
	Yuxi	0.33±0.017	0.085±0.011	0.16±0.006	0.04±0.002
	ChungHwa	0.35±0.023	0.102±0.007	0.17±0.011	0.06±0.004
	Kent	1.86±0.062	0.393±0.012	0.86±0.035	0.51±0.016
	Marlboro	1.85±0.073	0.266±0.014	0.82±0.022	0.30±0.012
	Camel	1.00±0.069	0.132±0.005	0.74±0.018	0.12±0.009
	Zhongnanhai	0.56±0.008	0.110±0.008	0.33±0.007	0.05±0.001
	Average	0.72	0.14	0.37	0.13
	Blank ($\mu g \cdot L^{-1}$)	0.46	0.32	0.40	0.34
Ni	Honghe Panda	1.03±0.051	0.152±0.005	0.60±0.015	0.20±0.008
	Hongtashan (W)	0.58±0.013	0.161±0.008	0.25±0.005	0.14±0.007
	Hongtashan (R)	0.57±0.024	0.125±0.011	0.35±0.011	0.06±0.002
	Baisha	0.90±0.026	0.210±0.002	0.50±0.013	0.19±0.003
	Huangguoshu	0.67±0.015	0.172±0.005	0.38±0.006	0.11±0.010
	Diamond	0.71±0.012	0.131±0.004	0.39±0.004	0.16±0.012
	Yuxi	0.78±0.011	0.145±0.010	0.52±0.002	0.11±0.005
	ChungHwa	0.96±0.015	0.162±0.005	0.61±0.007	0.12±0.003
	Kent	1.05±0.036	0.183±0.007	0.66±0.005	0.16±0.009
	Marlboro	2.16±0.027	0.235±0.012	1.06±0.016	0.41±0.012
	Camel	0.93±0.023	0.152±0.004	0.60±0.007	0.14±0.006
	Zhongnanhai	1.14±0.009	0.093±0.002	0.63±0.009	0.04±0.001
	Average	0.96	0.16	0.55	0.15
	Blank ($\mu g \cdot L^{-1}$)	0.37	0.25	0.33	0.21

Continued Table S2

Elements	Brands	Tobacco	Smoke	Ash	Butts
Pb	Honghe Panda	2.02±0.135	0.405±0.011	1.08±0.047	0.51±0.011
	Hongtashan (W)	1.55±0.112	0.313±0.013	0.74±0.028	0.41±0.013
	Hongtashan (R)	1.43±0.053	0.335±0.009	0.67±0.021	0.36±0.006
	Baisha	1.08±0.045	0.272±0.014	0.48±0.017	0.20±0.009
	Huangguoshu	0.86±0.037	0.214±0.007	0.36±0.015	0.18±0.012
	Diamond	0.80±0.023	0.152±0.005	0.20±0.006	0.37±0.010
	Yuxi	2.13±0.102	0.506±0.014	0.99±0.051	0.44±0.014
	ChungHwa	0.63±0.036	0.162±0.005	0.30±0.009	0.15±0.007
	Kent	0.64±0.025	0.145±0.002	0.40±0.007	0.07±0.004
	Marlboro	0.57±0.021	0.112±0.007	0.06±0.005	0.23±0.005
	Camel	0.47±0.018	0.124±0.009	0.18±0.011	0.15±0.002
	Zhongnanhai	0.80±0.022	0.193±0.004	0.22±0.004	0.38±0.012
	Average	1.08	0.24	0.47	0.29
	Blank value ($\mu g \cdot L^{-1}$)	0.19	0.20	0.22	0.17

Table S3 Contents of Cu, Cd, Cr, Ni, and Pb in the smoke and its residual rate (n=3)

Brands	Cu (μg per cigarette)	Residual rate of Cu (%)	Cd (μg per cigarette)	Residual rate of Cd (%)	Cr (μg per cigarette)	Residual rate of Cr (%)	Ni (μg per cigarette)	Residual rate of Ni (%)	Pb (μg per cigarette)	Residual rate of Pb (%)
Honghe Panda	0.472±0.105	4.48	0.114±0.002	8.91	0.082±0.005	24.33	0.152±0.005	14.78	0.405±0.011	20.05
Hongtashan (W)	0.531±0.182	5.41	0.126±0.002	7.16	0.113±0.002	20.16	0.161±0.008	27.83	0.313±0.013	20.19
Hongtashan (R)	0.844±0.045	7.29	0.113±0.003	6.98	0.075±0.009	12.30	0.125±0.011	21.77	0.335±0.009	23.43
Baisha	0.653±0.152	5.19	0.132±0.006	8.46	0.080±0.006	19.76	0.210±0.002	23.34	0.272±0.014	25.19
Huangguoshu	0.670±0.091	4.87	0.082±0.003	5.77	0.104±0.024	26.72	0.172±0.005	25.49	0.214±0.007	24.88
Diamond	0.372±0.063	7.83	0.107±0.004	12.44	0.091±0.002	22.65	0.131±0.004	18.51	0.152±0.005	19.00
Yuxi	0.815±0.117	8.26	0.092±0.002	7.93	0.085±0.011	25.64	0.145±0.010	18.60	0.506±0.014	23.76
ChungHwa	0.762±0.125	9.55	0.082±0.002	11.88	0.102±0.007	28.93	0.162±0.005	16.90	0.162±0.005	25.71
Kent	0.933±0.158	6.12	0.091±0.001	17.50	0.393±0.012	21.08	0.183±0.007	17.44	0.145±0.002	22.66
Marlboro	0.820±0.0812	5.99	0.064±0.002	4.92	0.266±0.014	14.37	0.235±0.012	10.90	0.112±0.007	19.65
Camel	0.591±0.046	7.81	0.107±0.004	7.48	0.132±0.005	13.15	0.152±0.004	16.43	0.124±0.009	26.38
Zhongnanhai	0.534±0.057	5.77	0.052±0.002	9.29	0.110±0.008	19.60	0.093±0.002	8.15	0.193±0.004	24.13

Table S4 Contents of Cu, Cd, Cr, Ni, and Pb in the ash and its residual rate (n=3)

Brands	Cu (μg per cigarette)	Residual rate of Cu (%)	Cd (μg per cigarette)	Residual rate of Cd (%)	Cr (μg per cigarette)	Residual rate of Cr (%)	Ni (μg per cigarette)	Residual rate of Ni (%)	Pb (μg per cigarette)	Residual rate of Pb (%)
Honghe Panda	7.42±0.163	70.48	0.86±0.009	67.11	0.16±0.003	46.87	0.60±0.015	58.14	1.08±0.047	53.51
Hongtashan (W)	7.83±0.272	79.82	0.83±0.015	47.10	0.16±0.015	28.72	0.25±0.005	43.21	0.74±0.028	47.68
Hongtashan (R)	8.46±0.517	73.08	0.78±0.016	48.40	0.34±0.009	55.08	0.35±0.011	60.95	0.67±0.021	46.64
Baisha	8.17±0.356	64.95	0.84±0.023	53.78	0.20±0.011	49.40	0.50±0.013	55.24	0.48±0.017	44.81
Huangguoshu	8.51±0.317	61.80	0.79±0.017	55.42	0.25±0.008	63.20	0.38±0.006	56.33	0.36±0.015	41.74
Diamond	3.32±0.045	69.85	0.62±0.021	72.33	0.21±0.012	52.28	0.39±0.004	55.53	0.20±0.006	24.38
Yuxi	8.09±0.294	82.02	0.69±0.014	59.57	0.16±0.006	48.87	0.52±0.002	66.72	0.99±0.051	46.34
ChungHwa	6.14±0.482	76.91	0.45±0.023	65.22	0.17±0.011	48.21	0.61±0.007	63.65	0.30±0.009	48.25
Kent	8.00±0.573	52.45	0.35±0.017	67.50	0.86±0.035	46.13	0.66±0.005	63.00	0.40±0.007	62.50
Marlboro	8.32±0.284	60.79	0.68±0.008	52.31	0.82±0.022	44.52	1.06±0.016	49.21	0.06±0.005	11.05
Camel	5.56±0.195	73.46	0.76±0.022	53.22	0.74±0.018	73.51	0.60±0.007	64.84	0.18±0.011	38.30
Zhongnanhai	5.49±0.327	59.27	0.39±0.018	70.36	0.33±0.007	58.10	0.63±0.009	54.97	0.22±0.004	28.00

Table S5 Contents of Cu, Cd, Cr, Ni, and Pb in the butts and its residual rate (n=3)

Brands	Cu (μg per cigarette)	Residual rate of Cu (%)	Cd (μg per cigarette)	Residual rate of Cd (%)	Cr (μg per cigarette)	Residual rate of Cr (%)	Ni (μg per cigarette)	Residual rate of Ni (%)	Pb (μg per cigarette)	Residual rate of Pb (%)
Honghe Panda	1.81±0.132	17.23	0.30±0.006	23.20	0.05±0.004	16.02	0.20±0.008	19.64	0.51±0.011	25.15
Hongtashan (W)	1.08±0.148	10.99	0.80±0.015	45.17	0.14±0.006	24.98	0.14±0.007	24.20	0.41±0.013	26.58
Hongtashan (R)	0.94±0.073	8.12	0.64±0.018	39.57	0.07±0.002	10.98	0.06±0.002	10.45	0.36±0.006	25.24
Baisha	1.04±0.059	8.30	0.57±0.011	36.41	0.11±0.007	27.41	0.19±0.003	20.89	0.20±0.009	18.52
Huangguoshu	2.15±0.093	15.61	0.52±0.005	36.62	0.04±0.006	9.76	0.11±0.010	16.30	0.18±0.012	20.58
Diamond	0.77±0.065	16.24	0.11±0.008	12.44	0.05±0.008	13.44	0.16±0.012	21.90	0.37±0.010	45.88
Yuxi	0.95±0.121	9.60	0.29±0.008	24.66	0.04±0.002	12.97	0.11±0.005	14.11	0.44±0.014	20.52
ChungHwa	0.49±0.033	6.16	0.12±0.006	17.39	0.06±0.004	17.02	0.12±0.003	12.94	0.15±0.007	23.17
Kent	0.30±0.164	1.93	0.07±0.002	12.50	0.51±0.016	27.25	0.16±0.009	14.87	0.07±0.004	10.47
Marlboro	1.02±0.057	7.42	0.04±0.005	3.15	0.30±0.012	16.21	0.41±0.012	19.11	0.23±0.005	39.65
Camel	1.10±0.120	14.49	0.41±0.016	28.53	0.12±0.009	12.25	0.14±0.006	15.02	0.15±0.002	32.34
Zhongnanhai	0.41±0.035	4.40	0.07±0.009	11.61	0.05±0.001	8.91	0.04±0.001	3.24	0.38±0.012	47.50

Table S6 Melting and boiling temperatures of Cu, Cd, Cr, Ni and Pb [*]

Element	Melting point (˚C)	Boiling point (˚C)
Cu	1085	2562
Cd	321	767
Cr	1907	2671
Ni	1455	2730
Pb	327	1749

[*] W. M. Haynes. Handbook of Chemistry and Physics (95th Edition), 2014, CRC press.