Supporting information

Evidence that metal particles in cannabis vape liquids limit measurement reproducibility

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Table S1. Customer available information about cannabis vape liquids provided on the individual packaging.

Sample ID	Packaging date	Amount	THC (mg g^{-1})	Total THC (mg g^{-1})	CBD (mg g^{-1})	Total CBD (mg g^{-1})	Extract type	Ingredients
Smpl-1	13-Aug-2020	0.5 g	781.77	781.77	5.7	< 7.07	EtOH	THC distillate, flavouring agents
Smpl-2	08-Jul-2020	0.5 g	850	850	0	0	CO2	Cannabis distillate, botanical terpenes
Smpl-3	30-Nov-2020	0.5 g	819.7	819.7	< 0.1	< 0.1	EtOH	THC distillate
Smpl-4	14-Nov-2020	0.47 g	809	809	1	1	CO2	Cannabis extract, flavouring agents
Smpl-5	09-Oct-2020	0.5 g	700	700	< 30	< 30	CO2	Cannabis extract
Smpl-6	05-Nov-2020	0.5 g	696	702	1.28	1.28	CO2	Cannabis extract, flavouring agents
Smpl-7	28-Jul-2020	0.5 g	800	800	≤ 100	≤ 100	CO2	Cannabis extract, natural flavouring agents
Smpl-8	25-Oct-2020	0.5 g	236	236	565	578	CO2	Cannabis extract
Smpl-9	30-Sep-2020	0.5 g	759.1	759.1	2.1	2.1	EtOH	Cannabis extract
Smpl-10	08-Oct-2020	0.4 g	756.1	756.1	0.6	0.6	CO2	Cannabis extract, plant-based terpenes
Smpl-11	20-Oct-2020	0.5 g	756	756	1	1	CO2	Cannabis extract, terpenes
Smpl-12	02-Nov-2020	0.5 g	850	850	< 0.3	< 0.37	EtOH	Cannabis distillate, natural flavouring
Smpl-13	03-Dec-2020	0.45 g	838	838	2.56	2.56	CO2	Cannabis extract, terpenes
Smpl-14	02-Oct-2020	0.5 g	682.79	682.79	93.1	93.1	EtOH	THC distillate, CBD distillate, flavouring agents
Smpl-15	22-May-2020	0.5 g	365.85	365.85	428.56	433.39	CO2	Cannabis extract, terpenes
Smpl-16	22-Jul-2020	0.5 g	259.9	568.6	0	2.7	CO2	Cannabis extract
Smpl-17	08-Dec-2020	0.5 g	797.4	797.4	24.3	24.3	CO2	100% cannabis extract
Smpl-18	23-Nov-2020	0.45 g	680	680	210	210	EtOH	Cannabis distillate, botanical terpenes
Smpl-19	17-Jul-2020	0.5 g	858	858	0	0	CO2	Cannabis extract, flavouring agents
Smpl-20	29-Dec-2020	0.5 g	800	800	0.2	8	CO2	Cannabis extract, flavouring agents

Table S2. Mass fractions (ng g^{-1}) of regulated analytes in legal cannabis vape liquids and their associated RSD.

Sample ID	As		Cd		Pb		Hg	
	Av	RSD	Av	RSD	Av	RSD	Av	RSD
Smpl-1	5.92	51	< LOD	-	24.8	35	26.4	115
Smpl-2	5.94	19	< LOD	-	12.0	72	27.8	106
Smpl-3	4.57	8	< LOD	-	43.3	97	15.6	89
Smpl-4	23.1	79	< LOD	-	106	124	< LOD	-
Smpl-5	5.11	20	< LOD	-	5.53	96	< LOD	-
Smpl-6	12.3	68	< LOD	-	15.01	51	< LOD	-
Smpl-7	50.2	79	< LOD	-	5.59	71	< LOD	-
Smpl-8	7.62	5	< LOD	-	7.71	32	< LOD	-
Smpl-9	3.66	24	< LOD	-	20.6	15	< LOD	-
Smpl-10	8.96	114	7.65	57	14.7	52	17.6	47
Smpl-11	3.62	41	< LOD	-	33.1	35	< LOD	-
Smpl-12	4.31	51	< LOD	-	45.7	130	< LOD	-
Smpl-13	3.96	45	< LOD	-	9.84	54	< LOD	-
Smpl-14	3.23	9	< LOD	-	4.92	22	< LOD	-
Smpl-15	6.49	41	< LOD	-	106	148	22.7	102
Smpl-16	11.2	32	< LOD	-	36.6	46	< LOD	-
Smpl-17	5.88	51	< LOD	-	360	170	16.4	100
Smpl-18	6.42	54	< LOD	-	628	171	< LOD	-
Smpl-19	7.16	91	< LOD	-	41.9	131	< LOD	-
Smpl-20	100	66	< LOD	-	31.3	22	21.5	69
Min value	**3.23**		-		**4.92**		**15.6**	
Max value	**100**		**7.65**		**628**		**27.8**	
Method LOD	0.751		5.35		4.79		15.0	

Table S3. Mass fractions (ng g^{-1}) of measured analytes in illegal cannabis vape liquids and their associated RSD.

Sample ID	As		Cd		Pb		Hg	
	Av	RSD	Av	RSD	Av	RSD	Av	RSD
SmpI-21	6.40	25	< LOD	-	88.0	10	15.6	12
SmpI-22	6.06	51	< LOD	-	114	7	< LOD	-
SmpI-23	3.41	113*	< LOD	-	58.3	25	< LOD	-
SmpI-24	5.55	64	< LOD	-	271	71	20.0	26
SmpI-25	77.2	11	65.6	23	49841	41	24.3	45
SmpI-26	39.1	12	21.3	6	38293	1	< LOD	-
SmpI-27	16.2	38	9.47	9	4588	3	< LOD	-
SmpI-28	32.1	21	48.8	64	39290	68	< LOD	-
SmpI-29	4.99	107	< LOD	-	3093	1	< LOD	-
SmpI-30	7.07	188*	< LOD	-	21.3	23	< LOD	-
SmpI-31	6.63	-	< LOD	-	12.2	24	< LOD	-
SmpI-32	10.8	-	< LOD	-	1522	3	< LOD	-
SmpI-33	3.38	113	< LOD	-	373	5	< LOD	-
SmpI-34	2.87	124	< LOD	-	55.6	4	< LOD	-
SmpI-35	12.8	13	< LOD	-	370	9	< LOD	-
SmpI-36	3.91	48	< LOD	-	64.2	4	< LOD	-
SmpI-37	27.2	6	< LOD	-	48.1	3	< LOD	-
SmpI-38	27.1	4	< LOD	-	65.6	9	< LOD	-
SmpI-39	2.49	61	< LOD	-	32.3	13	< LOD	-
SmpI-40	26.6	4	< LOD	-	36.8	36	< LOD	-
SmpI-41	20.3	39	< LOD	-	12.7	62	< LOD	-
Min value	2.49		9.47		12.17		15.6	
Max value	77.2		65.6		49841		24.3	
Method LOD	0.751		5.35		4.79		15.0	

* RPD instead of RSD

Table S4. Mass fractions (μg g^{-1}) of unregulated analytes in legal cannabis vape liquids and their associated RSD.

Sample ID	Co		Cr		Cu		Fe		K		Mn		Na		Ni		V		Zn	
	Av	RSD	Av	RSD	Av	RSD	Av	RSD	Av	RSD	Av	RSD	Av	RSD	Av	RSD	Av	RSD	Av	RSD
Smpl-1	0.25	121	0.09	57	25.4	169	1.41	20	10.6	98	0.03	133	8.02	45	0.94	107	0.004	64	17.5	166
Smpl-2	0.22	141	0.30	77	0.28	40	2.20	60	15.7	73	0.05	40	6.40	50	0.67	66	0.008	76	0.90	76
Smpl-3	0.10	126	0.08	59	0.35	90	0.61	50	7.21	10	0.04	65	3.71	41	0.16	64	0.003	33	0.21	87
Smpl-4	0.19	21	0.02	62	3.05	149	1.22	134	2.70	14	0.01	103*	2.30	47	1.37	146	< LOD	-	2.90	108
Smpl-5	0.04	96	0.02	47	0.46	68	0.40	34	2.50	25	0.03	66	1.59	38	0.040	40	< LOD	-	1.20	19
Smpl-6	0.22	107	21.7	107	1.28	97	84.8	107	9.60	73	1.88	108	85.7	89	9.39	107	0.333	103	18.1	162
Smpl-7	0.06	66	0.79	163	0.12	117	3.60	124	1.96	20	0.09	139	4.34	39	0.41	126	0.008	99	0.27	80
Smpl-8	0.18	35	0.05	39	3.08	92	0.41	57	7.26	10	0.01	96	82.7	24	0.63	98	0.540	3	2.32	88
Smpl-9	0.06	113	0.41	98	0.56	76	2.07	78	724	15	1.04	17	32.0	54	0.26	69	0.005	24	0.82	56
Smpl-10	0.12	69	0.38	10	0.15	71	1.99	10	17.3	114	0.04	21	3.95	52	0.25	74	0.006	58	0.36	58
Smpl-11	0.27	26	0.17	81	0.67	51	0.97	81	2.71	46	0.01	96	3.03	75	0.34	92	0.003	33	0.64	35
Smpl-12	0.27	62	0.64	165	485	173	3.25	157	5.91	68	0.06	158	6.60	36	2.86	140	0.006	109	310	173
Smpl-13	0.10	55	0.29	65	0.15	105	1.25	55	21.2	127	0.03	71	2.04	33	0.25	99	0.003	42	0.18	56
Smpl-14	0.25	16	0.04	20	0.12	50	0.17	8	3.15	44	< LOD	-	1.72	94	0.09	36	0.004	90	0.27	61
Smpl-15	< LOD	-	0.45	109	0.36	107	2.75	120	7.06	89	0.04	55	5.19	50	0.32	120	0.005	54	1.87	125
Smpl-16	0.96	80	0.17	42	0.58	56	1.29	10	9.10	132	0.04	18	3.75	9	0.97	83	0.004	56	2.88	31
Smpl-17	< LOD	-	0.59	121	4.40	162	6.15	141	7.27	95	0.08	114	4.11	61	0.85	144	0.005	40	5.76	59
Smpl-18	0.06	76	2.02	112	12.44	168	11.65	95	8.47	108	0.20	109	17.0	70	2.55	159	0.011	81	7.62	169
Smpl-19	0.34	14	0.10	73	0.25	101	1.10	57	16.1	73	0.06	10	3.30	2	0.15	73	0.004	64	0.57	86
Smpl-20	< LOD	-	0.51	60	2.27	27	1.97	59	11.7	70	0.09	51	6.35	50	54.7	59	0.006	27	5.35	38
Min value	0.04		0.02		0.12		0.17		1.96		0.01		1.59		0.040		0.003		0.18	
Max value	0.96		21.7		485		84.83		724		1.88		85.7		54.7		0.54		310	
Method LOD	0.03		0.013		0.07		0.153		1.21		0.006		0.736		0.035		0.002		0.015	

* RPD instead of RSD

Table S5. Mass fractions (μg g^{-1}) of unregulated analytes in illegal cannabis vape liquids and their associated RSD.

Sample ID	Co		Cr		Cu		Fe		K		Mn		Na		Ni		V		Zn	
	Av	RSD	Av	RSD	Av	RSD	Av	RSD	Av	RSD	Av	RSD	Av	RSD	Av	RSD	Av	RSD	Av	RSD
Smpl-21	0.19	4	< LOD	-	1.26	8	0.40	55	2.38	99	< LOD	-	4.96	30	1.07	22	0.005	140*	2.02	5
Smpl-22	0.11	7	0.02	179*	1.06	20	0.92	102	< LOD	-	0.02	131*	1.29	54	0.27	40	< LOD	-	1.94	10
Smpl-23	0.13	3	0.06	45*	0.81	67	0.57	73	1.24	26	0.01	62	2.90	4	0.55	53	0.003	94*	1.21	30
Smpl-24	0.19	15	0.02	22*	4.59	137	0.73	41	3.65	98	0.02	145	2.62	32	3.18	165	< LOD	-	5.72	78
Smpl-25	0.61	28	0.11	42	237	37	2.29	67	654	6	0.53	21	71.5	6	44.6	32	0.06	32	426	24
Smpl-26	0.13	11	0.06	25	119	1	1.22	15	863	5	0.60	4	58.5	9	495	3	0.09	1	297	3
Smpl-27	0.17	6	0.05	60	37.6	5	1.33	12	2.93	37	0.02	21	11.8	13	540	5	0.01	27	46.5	4
Smpl-28	0.08	8	0.43	33	10.6	6	3.69	96	12.5	51	0.06	11	38.5	53	493	12	0.004	53	42.8	32
Smpl-29	0.05	8	0.04	16	2.64	10	2.20	16	< LOD	-	0.04	4	1.87	18	0.85	38	0.005	5	2.51	6
Smpl-30	< LOD	-	0.03	106*	0.36	14	0.64	19	< LOD	-	< LOD	-	0.96	45	0.43	5	0.005	55	0.33	12
Smpl-31	< LOD	-	0.02	140*	1.26	145	0.30	39	< LOD	-	< LOD	-	0.82	31	0.15	9	< LOD	-	2.28	151
Smpl-32	0.22	12	0.05	63	12.3	22	0.82	13	2.62	79	0.23	5	1.87	10	2.15	99	0.01	-	17.2	125
Smpl-33	< LOD	-	0.03	31	0.55	10	0.71	60	6.95	2	0.02	29	8.70	13	5.73	3	< LOD	-	2.03	20
Smpl-34	< LOD	-	< LOD	1	1.09	44	0.71	21	7.81	11	0.01	64	8.23	25	6.96	8	< LOD	-	1.49	21
Smpl-35	0.27	2	0.03	45	2.06	18	1.00	15	6.77	3	0.02	4	7.02	20	677	0	0.003	68	14.6	6
Smpl-36	< LOD	-	0.09	152*	0.31	15	1.05	53	7.36	7	0.01	51	9.89	13	7.22	4	0.003	92	3.22	60
Smpl-37	0.24	2	0.08	51	0.38	9	0.98	27	< LOD	-	0.01	22	15.4	5	0.58	5	0.003	33	1.27	7
Smpl-38	0.20	5	0.10	81	0.45	4	0.67	38	1.32	32	0.02	32	17.0	6	1.01	12	< LOD	-	1.09	13
Smpl-39	< LOD	-	< LOD	-	0.34	42	0.53	39	2.87	6	0.01	8	3.06	6	1.37	14	< LOD	-	0.99	32
Smpl-40	0.36	1	0.04	114	0.38	33	1.30	58	< LOD	-	0.01	69	18.6	3	0.08	17	0.004	45	1.66	24
Smpl-41	0.16	23	0.27	122	9.98	169	1.03	103	65.1	5	0.83	8	4.72	23	4.58	146	0.003	39	9.10	106
Min value	0.05		0.02		0.313		0.305		1.24		0.01		0.825		0.076		0.003		0.334	
Max value	0.61		0.43		237		3.69		863		0.60		71.5		677		0.09		426	
Method LOD	0.03		0.013		0.07		0.153		1.21		0.006		0.736		0.035		0.002		0.015	

* RPD instead of RSD

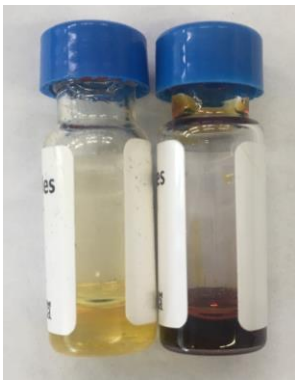

Figure S1. Sample 16 from vape device #1 (left, duplicate analysis 16_a and 16_b) and sample 16 obtained from vape device #2 (right, single analysis 16_c) are nominally identical cannabis vape liquids taken from two legal vape devices purchased at the same time of the same lot.

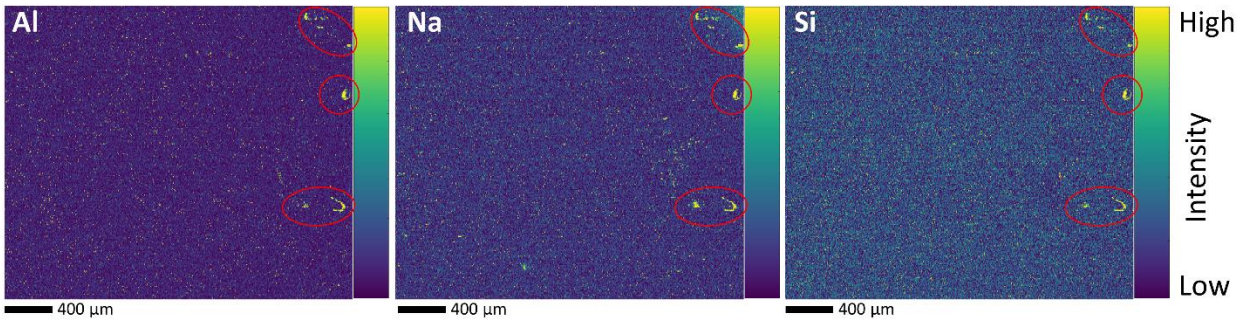

Figure S2. Elemental map of Al, Na and Si by LA-ICP-MS with several hotspots of high intensity, characteristic for metal particles in sample 18.

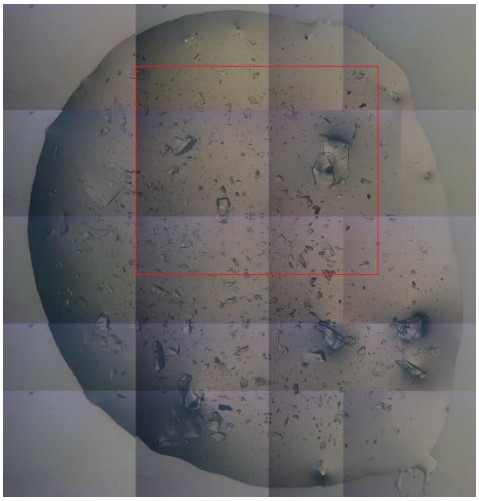

Figure S3. Light transmitted image of the drop of sample 18 on a glass slide before LA-ICP-MS analysis. The red square identifies the area ablated by LA-ICP-MS.

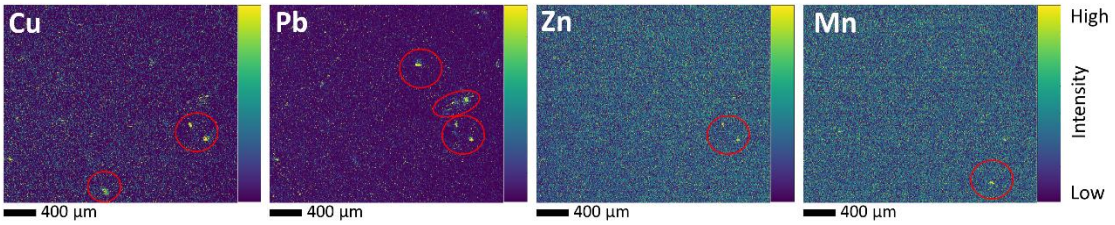

Figure S4. Elemental map of Cu, Pb, Zn and Mn by LA-ICP-MS with several hotspots of high intensity, characteristic for metal particles in sample 18.

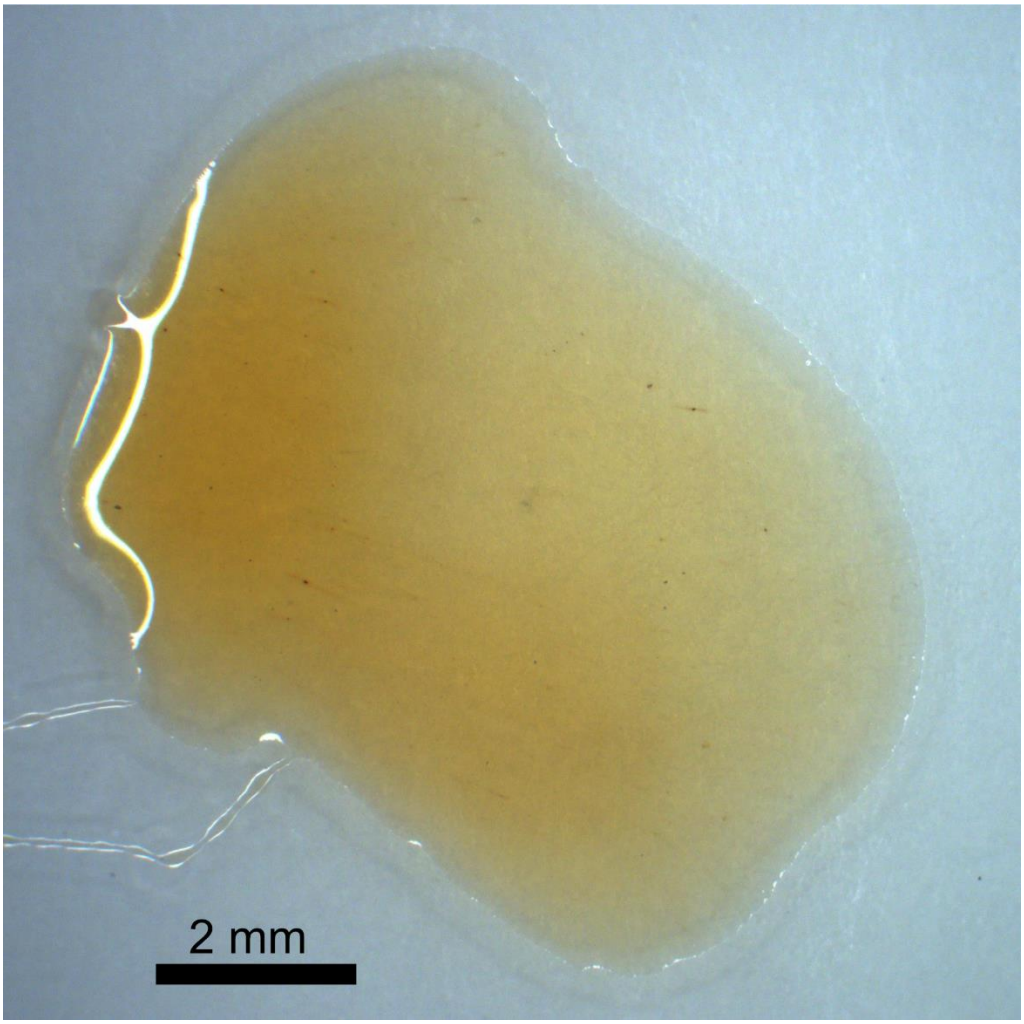

Figure S5. Microscopic image on cannabis vape liquid 41, 8 months after the laser ablation analysis showing distinct streaking of metals particles.