

Supplementary Material

Rapid screening pharmaceutical products for elemental impurities by high-resolution portable energy dispersive X-ray fluorescence spectrometer using efficient fundamental parameter method

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Table S1 The concentrations of each element in the solid standard stock sample by using ICP-MS reference analysis

Elements	Concentration ($\mu\text{g/g}$)		
	1	2	Mean
V	50.66	51.39	51.02
Cr	51.32	50.13	50.73
Co	49.01	54.23	51.62
Ni	49.37	48.13	48.75
Cu	52.06	51.90	51.98
As	49.78	48.57	49.17
Se	45.82	50.44	48.13
Mo	52.85	50.42	51.64
Ru	48.20	50.30	49.25
Rh	49.64	50.72	50.18
Pd	50.01	51.22	50.61
Ag	51.49	49.77	50.63
Cd	48.14	49.64	48.89
Sn	49.76	48.93	49.35
Sb	49.71	49.56	49.63
Os	50.99	50.91	50.95
Ir	49.01	52.82	50.91
Pt	49.46	49.54	49.50
Au	49.30	49.20	49.25
Hg	49.68	48.44	49.06
Tl	49.67	51.23	50.45
Pb	50.66	49.35	50.01

Table S2 PDE for oral drug products and concentration limits at 10 g maximum daily intake of 22 elemental impurities

Elements	PDE for oral drug products ($\mu\text{g}/\text{day}$)	Concentration limits ($\mu\text{g}/\text{g}$) at 10 g maximum daily intake
Cd	5	0.5
Pb	5	0.5
As	15	1.5
Hg	30	3
Co	50	5
V	100	10
Ni	200	20
Tl	8	0.8
Au	100	10
Pd	100	10
Ir	100	10
Os	100	10
Rh	100	10
Ru	100	10
Se	150	15
Ag	150	15
Pt	100	10
Sb	1200	120
Mo	3000	300
Cu	3000	300
Sn	6000	600
Cr	11000	1100

Table S3 Sample information

Sample type	Matrix material	Elements for detection	Concentration ($\mu\text{g/g}$)
Calibration sample	Cellulose	Cr, Ni, Co, V, Ni, Pb, As, Hg, Tl, Au, Pd, Ir, Os, Rh, Ru, Se, Cu, Ag, Sb, Mo, Sn	1.0, 2.0, 5.0, 10
Verification sample	Cellulose	Cd, Pb	0.2, 0.5, 1.0, 2.0, 5.0, 10
	Aztreonam, MRX	Cr, Ni, Co, V, Ni, Pb, As, Hg, Tl, Au, Pd, Ir, Os, Rh, Ru, Se, Cu, Ag, Sb, Mo, Sn	1.0, 2.0, 5.0, 10
	Aztreonam, MRX	Cd, Pb	0.2, 0.5, 1.0, 2.0, 5.0, 10

Table S4 Results of homogeneity verification

Elements	Concentration ($\mu\text{g/g}$)									Mean	%RSD
	1	2	3	4	5	6	7	8	9		
Cd	49.45	49.51	49.67	49.67	49.47	49.62	49.50	49.58	49.49	49.55	0.17
Pb	46.26	45.83	47.24	47.29	46.08	46.72	45.57	46.52	46.66	46.46	1.27
As	55.14	56.07	55.05	54.94	55.98	55.79	56.38	55.50	55.53	55.60	0.89
Hg	45.62	45.96	45.80	45.97	45.88	45.70	45.64	45.45	45.75	45.75	0.37
Co	53.25	53.16	53.47	53.46	53.23	53.44	53.66	53.48	53.46	53.40	0.29
V	49.51	49.39	48.84	48.82	49.55	49.22	49.52	49.59	48.84	49.25	0.67
Ni	52.92	53.09	53.08	52.95	53.09	52.99	52.94	53.05	53.11	53.02	0.14
Tl	46.36	46.25	46.44	46.56	46.36	46.25	46.50	45.99	46.36	46.34	0.36
Au	56.27	56.20	56.30	56.44	56.57	56.56	56.53	56.56	56.28	56.41	0.26
Pd	53.06	52.94	53.03	53.16	53.06	53.17	52.96	53.06	53.20	53.07	0.17
Ir	45.46	45.75	44.97	44.70	43.91	46.29	44.16	45.76	46.68	45.30	2.07
Os	44.70	44.34	44.54	44.79	45.12	44.53	44.59	44.84	44.68	44.68	0.50
Rh	54.40	54.55	54.53	54.54	54.69	54.46	54.43	54.39	54.63	54.51	0.19
Ru	57.32	57.85	57.90	57.61	57.32	57.46	57.68	57.40	57.42	57.55	0.38
Se	55.99	56.45	56.14	56.06	56.29	56.15	57.01	56.26	56.20	56.28	0.54
Ag	51.51	51.74	51.43	51.73	51.70	51.75	51.53	51.61	51.54	51.62	0.23
Pt	42.26	42.15	41.44	42.71	41.69	43.53	39.69	41.69	42.07	41.91	2.49
Sb	46.47	46.63	46.15	46.49	46.22	46.16	46.32	46.30	46.45	46.36	0.36
Mo	45.31	45.33	45.22	45.27	45.14	45.13	45.52	45.26	45.26	45.27	0.26
Cu	57.02	56.45	56.46	56.71	56.93	56.89	57.08	56.89	57.13	56.84	0.44
Sn	48.97	48.87	48.73	48.92	48.82	48.66	49.16	48.82	48.39	48.82	0.44
Cr	51.6	51.74	51.52	51.76	51.25	51.26	51.42	51.58	51.45	51.51	0.36

Table S5 Accuracy and precision results for Pd and Cd in the cellulose matrix

Elements	Concentration ($\mu\text{g/g}$)	Concentration					
		0.2	0.5	1.0	2.0	5.0	10
Pb	1	0.26	0.55	1.03	1.94	5.75	11.03
	2	0.30	0.48	0.94	2.13	6.00	10.89
	3	0.22	0.53	0.95	2.12	6.05	10.95
	4	0.27	0.46	0.94	1.96	5.15	10.75
	5	0.22	0.55	0.96	1.91	5.82	10.38
	6	0.31	0.47	1.08	1.94	5.29	10.95
	Mean	0.26	0.50	0.98	2.00	5.68	10.83
	RSD (%)	14.31	8.21	6.14	4.98	6.58	2.19
	Recovery (%)	130.42	100.93	98.27	99.94	113.57	108.25
Cd	1	0.19	0.50	0.91	2.01	5.07	9.23
	2	0.20	0.49	0.94	1.96	4.79	9.16
	3	0.26	0.56	0.90	1.99	4.65	9.12
	4	0.20	0.50	0.94	1.90	4.67	9.19
	5	0.23	0.47	0.98	2.03	4.79	8.99
	6	0.24	0.56	0.97	2.06	4.77	9.08
	Mean	0.22	0.51	0.94	1.99	4.79	9.13
	RSD (%)	12.12	7.54	3.44	2.82	3.16	0.97
	Recovery (%)	110.08	102.33	93.95	99.65	95.81	91.33

Table S6 Accuracy and precision results for 20 elemental impurities in the cellulose matrix

Elements	Concentration ($\mu\text{g/g}$)	1	2	5	10	Elements	Concentration ($\mu\text{g/g}$)	1	2	5	10
Hg	1	0.97	2.02	5.09	10.89	As	1	0.94	2.33	4.62	10.46
	2	0.93	2.18	5.28	10.49		2	0.82	2.33	3.98	10.46
	3	1.17	2.29	5.09	10.83		3	1.04	2.00	5.02	10.03
	4	1.31	2.39	5.22	11.11		4	0.93	2.08	4.66	9.45
	5	1.17	2.11	5.49	11.07		5	1.06	2.26	4.72	9.68
	6	0.94	2.09	5.07	11.06		6	0.95	2.06	4.87	9.69
	Mean	1.08	2.18	5.21	10.91		Mean	0.96	2.17	4.64	9.96
	RSD (%)	14.48	6.30	3.14	2.13		RSD (%)	9.06	6.76	7.74	4.29
Recovery (%)	108.31	109.02	104.12	109.09	Recovery (%)	95.57	108.72	92.88	99.62		
Co	1	0.71	2.14	5.48	11.64	V	1	1.05	1.94	6.02	10.31
	2	0.64	2.20	5.26	11.75		2	0.88	2.00	6.29	9.93
	3	0.78	2.18	5.67	11.63		3	1.05	2.18	6.07	10.38
	4	0.68	2.05	5.23	11.33		4	1.16	2.12	6.47	10.30
	5	0.85	2.08	5.64	11.55		5	1.12	2.22	6.43	10.34
	6	0.80	2.11	5.60	11.87		6	0.89	2.09	6.49	10.05
	Mean	0.74	2.13	5.48	11.63		Mean	1.02	2.09	6.29	11.37
	RSD (%)	10.40	2.76	3.54	1.58		RSD (%)	11.03	5.01	3.25	1.78
Recovery (%)	74.17	106.31	109.62	116.28	Recovery (%)	102.47	104.59	125.88	102.17		
Ni	1	0.86	2.16	6.94	11.45	Tl	1	0.90	1.87	4.74	9.20
	2	0.93	2.27	6.82	11.45		2	1.00	1.97	4.56	9.27
	3	1.04	2.12	6.64	11.64		3	0.94	1.83	4.59	9.14
	4	0.94	2.16	6.85	11.73		4	1.10	1.92	4.52	9.50
	5	0.90	2.24	6.59	11.58		5	0.98	1.93	4.57	9.22
	6	0.85	2.10	6.62	11.31		6	1.01	1.86	4.37	9.28
	Mean	0.92	2.17	6.74	11.53		Mean	0.99	1.90	4.56	9.27
	RSD (%)	7.44	3.05	2.14	1.32		RSD (%)	6.72	2.76	2.61	1.35
Recovery (%)	91.98	108.65	134.86	115.27	Recovery (%)	98.91	94.83	91.14	92.67		
Au	1	0.78	1.80	5.08	10.11	Pd	1	0.93	2.12	5.21	9.52
	2	0.79	2.12	5.17	10.31		2	0.89	2.02	5.00	9.59
	3	0.96	1.97	4.80	10.44		3	0.91	2.03	4.84	9.47
	4	1.24	2.05	5.00	10.23		4	0.97	2.06	4.96	9.55

	5	1.11	2.46	4.94	10.04		5	0.92	2.08	4.94	9.51
	6	0.90	1.96	4.80	10.19		6	0.97	2.10	4.96	9.64
	Mean	0.96	2.06	4.96	10.22		Mean	0.93	2.07	4.98	9.55
	RSD (%)	18.90	10.88	3.02	1.40		RSD (%)	3.23	1.92	2.44	0.64
	Recovery (%)	96.23	103.04	99.28	102.20		Recovery (%)	93.02	103.26	99.67	95.45
Ir	1	0.89	1.94	5.42	10.41	Os	1	0.77	2.03	5.09	10.95
	2	1.05	2.17	5.20	11.07		2	1.08	2.02	5.17	10.80
	3	0.74	2.14	5.10	10.80		3	1.05	1.79	4.99	11.09
	4	1.05	1.79	5.07	11.40		4	0.87	1.98	5.42	10.79
	5	0.82	1.96	5.35	10.76		5	0.95	1.82	5.04	10.38
	6	0.91	1.74	4.97	11.05		6	0.97	1.81	5.08	11.05
	Mean	0.91	1.96	5.19	10.92		Mean	0.95	1.91	5.13	10.84
	RSD (%)	13.48	8.94	3.36	3.10		RSD (%)	12.03	5.94	2.95	2.40
	Recovery (%)	90.85	97.84	103.75	109.15		Recovery (%)	94.75	95.49	102.66	108.42
Rh	1	0.91	2.15	4.85	9.55	Ru	1	1.06	2.32	5.23	9.87
	2	0.95	2.06	4.55	9.22		2	0.97	2.26	4.95	9.47
	3	0.96	2.12	4.64	8.96		3	1.02	2.27	4.96	9.85
	4	1.00	2.12	4.78	9.39		4	1.02	2.16	5.14	9.76
	5	0.96	2.28	4.81	9.11		5	1.02	2.28	5.23	9.69
	6	1.02	2.07	4.81	8.97		6	1.07	2.23	5.27	9.72
	Mean	0.97	2.13	4.74	9.20		Mean	1.02	2.25	5.13	9.73
	RSD (%)	4.13	3.81	2.48	2.54		RSD (%)	3.48	2.37	2.75	1.48
	Recovery (%)	96.55	106.61	94.81	91.99		Recovery (%)	102.32	112.72	102.60	97.25
Se	1	0.80	2.13	5.94	11.69	Ag	1	0.89	2.04	4.90	10.05
	2	0.89	2.09	5.54	11.27		2	0.79	1.93	4.69	10.10
	3	0.92	2.14	5.70	11.24		3	0.87	1.96	4.54	9.98
	4	0.74	2.20	5.60	11.28		4	0.83	1.80	4.60	10.07
	5	0.84	2.00	5.60	11.53		5	0.84	1.96	4.59	9.99
	6	0.77	2.16	5.51	11.45		6	0.86	1.96	4.73	10.02
	Mean	0.83	2.12	5.65	11.41		Mean	0.85	1.94	4.67	10.03
	RSD (%)	8.48	3.22	2.84	1.57		RSD (%)	4.20	4.11	2.75	0.48
	Recovery (%)	82.78	105.93	112.95	114.10		Recovery (%)	84.87	97.13	93.48	100.34
Pt	1	0.87	2.12	5.44	9.99	Sb	1	1.19	2.34	5.08	10.51
	2	1.36	2.22	5.46	10.40		2	1.12	2.05	5.03	10.43
	3	1.07	2.31	5.16	10.20		3	1.20	2.06	4.97	11.23

	4	1.15	2.17	5.59	10.35		4	1.19	2.26	4.94	10.70
	5	1.46	2.38	5.47	9.82		5	1.29	2.16	5.58	10.99
	6	1.20	2.05	5.37	9.98		6	1.13	2.18	5.45	10.72
	Mean	1.19	2.21	5.41	10.12		Mean	1.19	2.18	5.18	10.76
	RSD (%)	17.54	5.59	2.62	2.29		RSD (%)	4.99	5.17	5.21	2.79
	Recovery (%)	118.57	110.48	108.28	101.22		Recovery (%)	118.71	108.82	103.50	107.64
Mo	1	1.07	2.48	5.28	10.92	Sn	1	0.77	1.90	4.80	8.92
	2	1.10	2.33	4.68	10.50		2	0.89	1.94	4.57	9.10
	3	1.07	2.07	4.89	10.81		3	0.81	1.88	4.81	9.21
	4	1.32	2.12	4.71	10.66		4	0.82	1.83	4.75	8.98
	5	1.13	1.99	5.39	9.98		5	0.78	2.04	4.72	9.03
	6	1.31	2.41	4.96	10.38		6	0.87	1.99	4.59	9.13
	Mean	1.17	2.23	4.99	10.54		Mean	0.82	1.93	4.70	9.06
	RSD (%)	10.11	8.96	5.89	3.21		RSD (%)	5.86	3.93	2.19	1.17
	Recovery (%)	116.65	111.60	99.72	105.42		Recovery (%)	82.32	96.43	94.06	90.62
Cr	1	1.25	2.36	5.68	11.37	Cu	1	0.89	2.57	5.51	11.20
	2	1.15	2.46	5.60	10.73		2	0.94	2.92	5.06	11.62
	3	1.07	2.18	4.99	11.29		3	1.05	3.05	5.21	11.85
	4	0.97	2.40	5.44	11.46		4	1.08	3.12	5.68	11.76
	5	0.94	2.25	5.46	11.36		5	1.15	2.80	5.28	11.82
	6	1.08	2.50	5.51	11.32		6	1.22	2.87	5.29	11.86
	Mean	1.08	2.36	5.45	11.26		Mean	1.05	2.89	5.34	11.69
	RSD (%)	10.59	5.15	4.44	2.34		RSD (%)	11.70	6.74	4.15	2.17
	Recovery (%)	107.64	117.92	108.92	112.55		Recovery (%)	105.43	144.47	106.77	116.85

Table S7 Linearity results of the proposed EDXRF method for the screening of 15 elemental impurities

Elements	1 µg/g	2 µg/g	5 µg/g	10 µg/g	Regression equations	R-value
Hg	1.08	2.18	5.21	10.91	$y = 1.0894x - 0.0572$	0.99965
Ni	0.92	2.17	6.74	11.53	$y = 1.1865x + 0.0006$	0.99373
As	0.96	2.17	4.64	9.96	$y = 0.986x - 0.0046$	0.99860
V	1.02	2.09	6.29	11.37	$y = 1.1609x - 0.0316$	0.99725
Co	0.74	2.13	5.48	11.63	$y = 1.1998x - 0.4041$	0.99975
Se	0.83	2.12	5.65	11.41	$y = 1.1709x - 0.2666$	0.99990
Tl	0.99	1.90	4.56	9.27	$y = 0.9194x + 0.0428$	0.99990
Ag	0.85	1.94	4.67	10.03	$y = 1.0138x - 0.1895$	0.99940
Au	0.96	2.06	4.96	10.22	$y = 1.0241x - 0.0584$	0.99985
Ir	0.91	1.96	5.19	10.92	$y = 1.1137x - 0.2665$	0.99985
Os	0.95	1.91	5.13	10.84	$y = 1.1038x - 0.2595$	0.99970
Pd	0.93	2.07	4.98	9.55	$y = 0.9507x + 0.1043$	0.99955
Pt	1.19	2.21	5.41	10.12	$y = 0.9934x + 0.2623$	0.99955
Ru	1.02	2.25	5.13	9.73	$y = 0.9568x + 0.2267$	0.99935
Rh	0.97	2.13	4.74	9.20	$y = 0.9031x + 0.1962$	0.99955

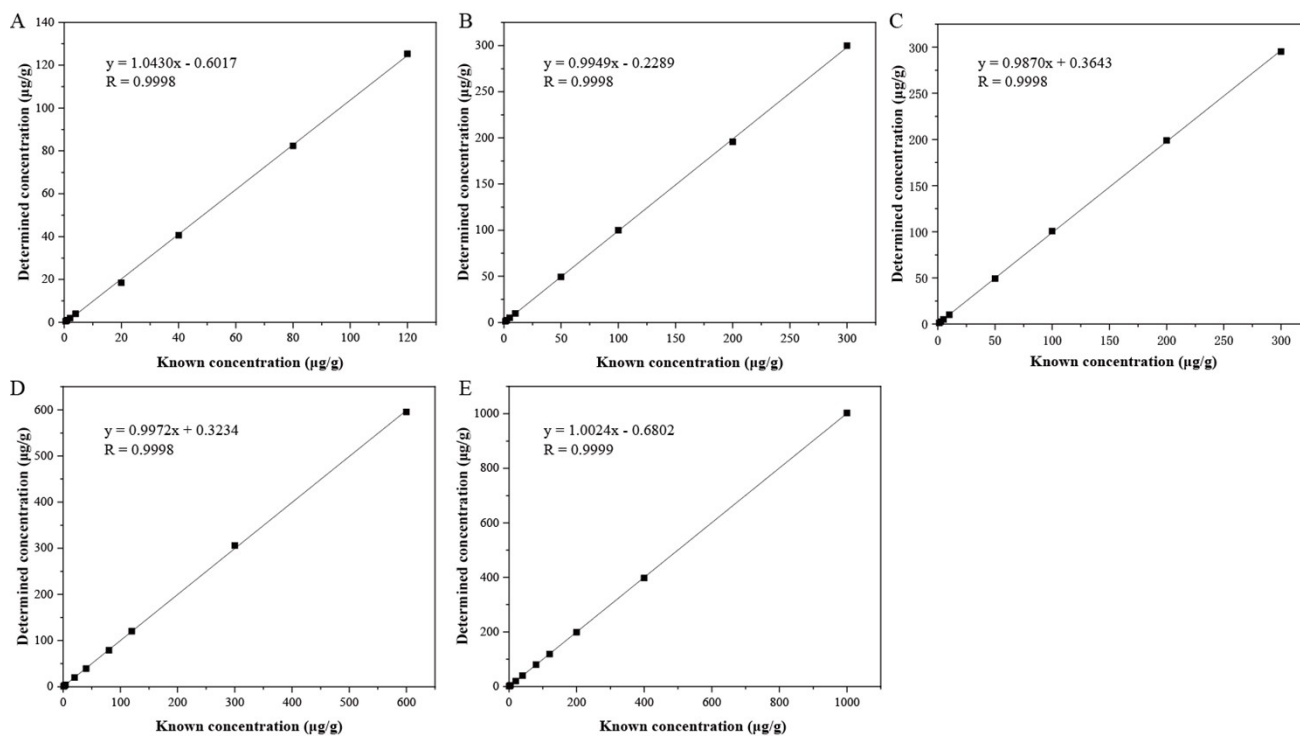


Fig. S1 Linearity results of the proposed EDXRF method for the screening of Sb (A), Mo (B), Cu (C), Sn (D), and Cr (E)

Table S8 Accuracy and precision results for Pd and Cd in the contezolid matrix

Elements	Concentration	0.2	0.5	1.0	2.0	5.0	10
	($\mu\text{g/g}$)						
Pb	1	0.28	0.52	0.85	1.77	4.89	9.959
	2	0.23	0.41	1.12	1.69	4.77	10.3
	3	0.23	0.44	1.08	1.69	4.72	9.833
	4	0.19	0.49	0.87	1.84	4.46	10
	5	0.29	0.61	1.04	1.72	4.84	10.49
	6	0.20	0.45	0.91	1.64	4.67	10.47
	Mean	0.24	0.49	0.98	1.73	4.73	10.175
	RSD (%)	18.14	15.00	11.80	4.10	3.25	2.77
	Recovery (%)	117.92	97.20	97.62	86.37	94.53	101.75
Cd	1	0.22	0.47	1.33	2.12	5.13	10.01
	2	0.24	0.52	1.26	2.02	5.18	10.16
	3	0.23	0.49	1.28	2.08	5.08	10.09
	4	0.24	0.52	1.28	2.00	5.06	10.31
	5	0.22	0.54	1.27	2.04	5.14	10.25
	6	0.20	0.47	1.28	2.04	5.11	10.18
	Mean	0.22	0.50	1.28	2.05	5.12	10.167
	RSD (%)	6.66	5.62	1.92	2.16	0.88	1.06
	Recovery (%)	111.67	100.17	128.23	102.58	102.32	101.67

Table S9 Accuracy and precision results for 19 elemental impurities in the contezolid matrix

Elements	Concentration ($\mu\text{g/g}$)	1	2	5	10	Elements	Concentration ($\mu\text{g/g}$)	1	2	5	10
Hg	1	1.30	1.59	5.02	10.74	As	1	1.27	1.93	4.98	10.68
	2	0.95	1.85	4.95	10.86		2	0.85	1.90	5.26	10.61
	3	1.03	1.71	4.90	10.63		3	1.13	1.81	5.11	10.51
	4	1.03	1.78	4.91	10.54		4	1.02	2.06	4.79	10.92
	5	1.14	1.86	4.84	10.94		5	0.86	1.72	5.15	10.93
	6	1.19	1.78	4.82	10.87		6	1.11	2.11	5.03	11.45
	Mean	1.11	1.76	4.91	10.77		Mean	1.04	1.92	5.05	10.85
	RSD (%)	11.27	5.73	1.49	1.42		RSD (%)	15.79	7.78	3.20	3.12
Recovery (%)	110.66	88.06	98.12	107.65	Recovery (%)	103.98	96.04	101.05	108.50		
Co	1	0.98	1.45	5.05	11.38	Ni	1	1.57	2.11	5.68	11.69
	2	0.77	1.40	4.89	11.35		2	1.44	2.08	5.31	11.69
	3	0.78	1.70	4.62	11.21		3	1.35	2.29	5.16	11.60
	4	0.84	1.75	4.93	11.5		4	1.31	2.45	5.69	11.71
	5	0.85	1.53	4.84	11.83		5	1.53	2.17	5.57	11.79
	6	0.77	1.61	4.64	11.22		6	1.45	2.12	5.49	11.54
	Mean	0.83	1.57	4.83	11.415		Mean	1.44	2.20	5.48	11.67
	RSD (%)	9.65	8.96	3.49	2.02		RSD (%)	7.08	6.39	3.86	0.75
Recovery (%)	83.13	78.62	96.58	114.15	Recovery (%)	144.10	110.15	109.68	116.70		
Tl	1	0.92	1.61	4.61	9.38	Au	1	1.15	1.76	5.15	10.87
	2	0.86	1.59	4.78	9.75		2	1.16	1.68	5.22	10.90
	3	0.88	1.65	4.80	9.68		3	1.06	1.85	5.17	10.44
	4	0.96	1.58	4.68	9.30		4	1.05	1.74	4.97	11.01
	5	0.93	1.67	4.88	9.39		5	1.13	1.87	5.24	10.63
	6	1.01	1.51	4.80	9.43		6	1.19	1.74	5.21	10.98
	Mean	0.92	1.60	4.76	9.49		Mean	1.12	1.77	5.16	10.81
	RSD (%)	5.84	3.46	2.06	1.92		RSD (%)	5.14	4.00	1.90	2.07
Recovery (%)	92.46	80.15	95.15	94.86	Recovery (%)	112.35	88.62	103.14	108.05		
Pd	1	1.38	2.09	5.45	10.58	Ir	1	0.93	1.45	4.92	9.48
	2	1.34	2.07	5.41	10.58		2	1.01	1.32	5.02	9.18
	3	1.38	2.10	5.45	10.70		3	0.75	1.75	5.11	9.19
	4	1.36	2.09	5.30	10.74		4	1.01	1.51	4.92	9.55

	5	1.33	2.18	5.43	10.68		5	0.90	1.72	5.13	9.47
	6	1.40	2.16	5.41	10.71		6	0.69	1.76	4.97	9.72
	Mean	1.36	2.12	5.41	10.67		Mean	0.88	1.58	5.01	9.43
	RSD (%)	2.10	2.17	1.03	0.64		RSD (%)	15.25	11.58	1.84	2.25
	Recovery (%)	136.37	105.76	108.17	106.65		Recovery (%)	88.08	79.22	100.26	94.31
Os	1	0.99	1.77	4.51	10.03	Rh	1	1.33	2.08	5.29	10.43
	2	0.99	2.06	4.28	9.69		2	1.34	2.12	5.29	10.65
	3	0.78	1.54	4.40	9.62		3	1.38	2.13	5.30	10.81
	4	0.68	1.78	4.64	9.56		4	1.36	2.21	5.18	10.65
	5	0.69	2.26	4.39	9.40		5	1.33	2.17	5.40	10.49
	6	0.72	1.85	4.27	9.54		6	1.38	2.13	5.43	10.76
	Mean	0.81	1.87	4.42	9.64		Mean	1.35	2.14	5.32	10.63
	RSD (%)	17.92	13.40	3.23	2.21		RSD (%)	1.70	2.05	1.65	1.39
	Recovery (%)	80.87	93.72	88.32	96.41		Recovery (%)	135.28	106.91	106.30	106.32
Ru	1	1.48	2.20	5.67	10.56	Se	1	1.33	1.93	4.88	9.90
	2	1.45	2.19	5.73	10.61		2	1.13	1.82	5.01	9.90
	3	1.44	2.33	5.74	10.89		3	1.09	1.92	5.21	9.92
	4	1.45	2.28	5.63	10.83		4	1.33	1.83	4.78	10.22
	5	1.51	2.24	5.77	10.69		5	1.20	1.78	4.82	9.73
	6	1.50	2.22	5.78	10.53		6	1.22	1.84	5.06	10.14
	Mean	1.47	2.24	5.72	10.69		Mean	1.22	1.85	4.96	9.97
	RSD (%)	2.01	2.38	1.05	1.38		RSD (%)	8.02	3.24	3.35	1.83
	Recovery (%)	147.17	112.01	114.38	106.85		Recovery (%)	121.63	92.68	99.16	99.69
Ag	1	1.22	1.98	5.12	10.07	Pt	1	1.02	1.90	4.86	10.16
	2	1.18	1.90	4.97	10.06		2	0.90	1.94	5.15	10.35
	3	1.08	1.88	5.09	10.13		3	1.02	2.05	5.12	10.00
	4	1.20	1.92	5.02	10.10		4	0.96	2.25	5.03	10.14
	5	1.22	1.93	5.07	10.06		5	0.89	2.38	5.05	10.45
	6	1.26	1.98	5.11	10.18		6	1.03	2.05	5.05	10.37
	Mean	1.19	1.93	5.06	10.10		Mean	0.97	2.10	5.04	10.24
	RSD (%)	4.97	2.09	1.09	0.47		RSD (%)	6.40	8.74	2.04	1.69
	Recovery (%)	119.15	96.65	101.26	101.00		Recovery (%)	96.97	104.77	100.84	102.44
Sb	1	1.26	1.95	5.06	10.32	Mo	1	1.37	2.36	5.99	11.87
	2	1.26	2.04	5.07	10.00		2	1.42	2.43	6.03	11.89
	3	1.14	2.10	5.49	10.42		3	1.38	2.44	6.15	11.69

	4	1.36	1.95	5.03	10.18		4	1.41	2.37	5.95	11.89
	5	1.23	2.06	5.29	10.02		5	1.43	2.41	6.06	11.53
	6	1.33	2.03	5.07	10.00		6	1.42	2.43	6.11	11.89
	Mean	1.26	2.02	5.17	10.16		Mean	1.40	2.41	6.05	11.79
	RSD (%)	6.04	3.00	3.56	1.79		RSD (%)	1.83	1.41	1.21	1.28
	Recovery (%)	126.08	101.13	103.41	101.57		Recovery (%)	140.48	120.33	120.96	117.93
Sn	1	1.32	1.98	5.20	10.22	Cr	1	1.27	2.04	5.92	11.62
	2	1.29	2.03	5.00	10.24		2	0.82	2.10	5.92	11.55
	3	1.35	1.99	5.20	10.12		3	1.14	2.22	6.57	11.48
	4	1.34	2.03	5.32	10.18		4	1.06	2.32	6.18	11.77
	5	1.23	1.92	5.13	10.20		5	1.27	1.90	6.12	11.21
	6	1.19	2.13	5.26	10.20		6	1.07	2.33	5.80	11.39
	Mean	1.29	2.01	5.18	10.19		Mean	1.11	2.15	6.09	11.50
	RSD (%)	4.87	3.37	2.12	0.41		RSD (%)	15.19	7.98	4.50	1.68
	Recovery (%)	128.68	100.69	103.67	101.93		Recovery (%)	110.50	107.57	121.72	115.03
Cu	1	0.79	1.72	5.75	11.80						
	2	0.81	1.83	5.59	11.47						
	3	0.97	1.79	5.44	11.38						
	4	0.97	2.17	5.23	11.33						
	5	0.72	1.91	5.61	11.73						
	6	0.81	2.20	5.51	11.71						
	Mean	0.85	1.94	5.52	11.57						
	RSD (%)	12.17	10.46	3.22	1.74						
	Recovery (%)	84.50	96.79	110.41	115.70						

Table S10 Accuracy and precision results for Pd and Cd in the aztreonam matrix

Elements	Concentration ($\mu\text{g/g}$)	Concentration					
		0.2	0.5	1.0	2.0	5.0	10
Pb	1	0.22	0.75	1.10	2.22	5.00	9.59
	2	0.32	0.73	1.02	2.11	5.22	9.24
	3	0.29	0.61	0.96	2.06	5.36	9.11
	4	0.25	0.61	1.25	2.22	5.12	9.38
	5	0.25	0.75	1.20	2.23	5.30	9.53
	6	0.29	0.58	1.09	2.16	5.02	9.19
	Mean	0.27	0.67	1.10	2.17	5.17	9.34
	RSD (%)	13.10	12.17	9.84	3.21	2.91	2.06
	Recovery (%)	135.22	134.52	110.32	108.25	103.41	93.41
Cd	1	0.20	0.43	0.98	1.97	5.01	9.89
	2	0.24	0.49	0.91	1.98	4.95	9.96
	3	0.19	0.46	0.92	2.01	5.01	9.99
	4	0.22	0.51	0.95	2.00	4.97	9.81
	5	0.20	0.50	0.93	2.11	4.99	9.80
	6	0.27	0.45	0.91	2.03	5.05	9.97
	Mean	0.22	0.47	0.93	2.02	5.00	9.90
	RSD (%)	13.49	6.43	2.95	2.43	0.72	0.84
	Recovery (%)	110.17	94.93	93.22	100.85	99.93	99.05

Table S11 Accuracy and precision results for 20 elemental impurities in the aztreonam matrix

Elements	Concentration ($\mu\text{g/g}$)	1	2	5	10	Elements	Concentration ($\mu\text{g/g}$)	1	2	5	10
Hg	1	0.71	1.85	4.19	9.76	As	1	0.93	1.73	4.51	10.27
	2	0.73	1.98	4.09	9.91		2	1.06	2.15	4.47	10.46
	3	0.82	1.97	4.19	10.29		3	0.92	1.82	4.33	10.17
	4	0.73	1.96	4.30	10.22		4	0.84	1.70	4.56	10.17
	5	0.90	1.97	4.26	10.23		5	1.04	1.72	4.27	10.75
	6	0.85	1.95	4.18	10.25		6	0.86	1.75	4.35	10.38
	Mean	0.79	1.95	4.20	10.11		Mean	0.94	1.81	4.42	10.37
	RSD (%)	9.99	2.59	1.75	2.18		RSD (%)	9.88	9.43	2.55	2.12
	Recovery (%)	79.20	97.40	84.02	101.08		Recovery (%)	94.30	90.61	88.35	103.68
Co	1	0.77	1.78	5.16	9.98	V	1	1.27	2.13	5.20	10.74
	2	0.72	1.81	5.12	10.20		2	1.05	2.26	5.53	10.20
	3	0.80	1.84	5.06	10.06		3	1.16	2.27	5.48	10.18
	4	0.73	1.83	5.06	10.14		4	1.06	2.28	5.56	10.43
	5	0.82	1.77	5.31	9.88		5	1.23	2.01	5.50	10.12
	6	0.73	1.89	5.22	10.15		6	1.05	2.25	5.27	10.39
	Mean	0.76	1.82	5.16	10.07		Mean	1.14	2.20	5.42	10.34
	RSD (%)	5.26	2.43	1.93	1.21		RSD (%)	8.84	4.92	2.75	2.22
	Recovery (%)	76.28	91.08	103.12	100.67		Recovery (%)	113.60	109.91	108.47	103.43
Ni	1	0.94	2.08	5.06	10.01	Tl	1	0.95	1.90	4.70	10.38
	2	0.77	1.86	5.07	10.15		2	0.75	1.91	5.00	10.50
	3	0.81	1.94	5.21	9.78		3	0.71	1.92	4.67	10.49
	4	0.74	1.96	5.07	10.14		4	0.82	1.96	4.68	10.63
	5	0.93	1.84	5.13	10.02		5	0.79	1.92	4.81	10.72
	6	0.86	1.90	4.95	10.06		6	0.71	1.95	4.65	10.45
	Mean	0.84	1.93	5.08	10.03		Mean	0.79	1.93	4.75	10.53
	RSD (%)	10.02	4.49	1.67	1.33		RSD (%)	11.46	1.16	2.86	1.19
	Recovery (%)	84.02	96.43	101.64	100.27		Recovery (%)	78.81	96.39	95.05	105.30
Au	1	0.84	1.84	4.68	9.05	Pd	1	0.95	2.03	5.28	9.21
	2	0.72	1.75	4.89	8.91		2	0.95	2.01	5.32	9.30
	3	0.82	1.76	4.52	9.05		3	0.98	2.00	5.29	9.33
	4	0.87	1.63	4.68	9.20		4	0.95	2.05	5.39	9.27

	5	0.83	1.78	4.46	9.03		5	0.97	2.00	5.24	9.16
	6	0.79	1.67	4.44	8.99		6	0.89	2.08	5.30	9.16
	Mean	0.81	1.74	4.61	9.04		Mean	0.95	2.03	5.30	9.24
	RSD (%)	6.51	4.38	3.73	1.07		RSD (%)	3.18	1.62	0.94	0.77
	Recovery (%)	81.04	86.89	92.28	90.39		Recovery (%)	94.65	101.38	106.02	92.39
Ir	1	0.93	1.88	4.67	10.28	Os	1	0.88	1.57	4.48	9.49
	2	0.81	1.72	4.69	10.87		2	0.79	1.54	4.91	9.88
	3	0.66	1.95	4.62	10.34		3	0.76	1.57	4.36	9.10
	4	0.97	1.61	4.32	10.89		4	0.90	1.44	5.03	9.17
	5	0.78	1.66	4.50	10.83		5	0.67	1.56	4.49	9.10
	6	0.70	1.53	4.15	10.18		6	0.70	1.79	4.46	10.02
	Mean	0.81	1.73	4.49	10.57		Mean	0.78	1.58	4.62	9.46
	RSD (%)	15.19	9.25	4.82	3.16		RSD (%)	11.83	7.21	5.94	4.33
	Recovery (%)	80.76	86.37	89.84	105.65		Recovery (%)	78.21	78.88	92.42	94.61
Rh	1	0.92	2.01	5.16	9.16	Ru	1	0.96	2.16	5.45	9.61
	2	0.91	2.04	5.09	9.17		2	0.92	2.19	5.34	9.67
	3	0.96	2.12	5.20	9.14		3	0.98	2.09	5.45	9.63
	4	1.01	2.06	5.10	8.97		4	0.98	2.16	5.36	9.59
	5	0.95	2.04	5.17	9.14		5	1.00	2.13	5.41	9.66
	6	1.00	2.05	5.29	9.33		6	1.07	2.18	5.47	9.72
	Mean	0.96	2.06	5.17	9.15		Mean	0.99	2.15	5.41	9.65
	RSD (%)	4.04	1.84	1.44	1.28		RSD (%)	5.05	1.71	0.93	0.48
	Recovery (%)	95.72	102.80	103.35	91.49		Recovery (%)	98.63	107.55	108.26	96.45
Se	1	0.89	1.72	4.11	8.77	Ag	1	8.86	4.72	1.85	0.92
	2	0.89	1.80	3.99	9.09		2	8.91	4.76	1.87	0.81
	3	0.78	1.77	4.17	8.72		3	8.90	4.88	1.91	0.79
	4	0.89	1.75	4.16	9.05		4	8.80	4.89	1.85	0.83
	5	0.80	1.84	4.21	8.94		5	8.75	4.82	1.92	0.86
	6	1.03	1.88	4.40	8.99		6	8.80	4.83	1.93	0.86
	Mean	0.88	1.79	4.18	8.93		Mean	8.84	4.82	1.89	0.84
	RSD (%)	9.96	3.23	3.21	1.72		RSD (%)	0.71	1.40	1.87	5.47
	Recovery (%)	88.07	89.63	83.51	89.27		Recovery (%)	88.38	96.32	94.38	84.42
Pt	1	0.77	2.24	4.53	9.59	Sb	1	0.90	2.19	4.80	8.86
	2	0.85	2.01	4.31	9.30		2	0.89	2.34	4.51	8.53
	3	0.72	2.27	4.22	9.60		3	0.89	2.25	5.02	8.72

	4	0.98	2.29	4.30	9.78		4	1.01	2.35	5.00	8.75
	5	0.96	2.05	4.27	9.38		5	0.83	2.23	4.93	8.75
	6	0.88	2.19	4.21	9.51		6	1.00	2.26	4.87	8.63
	Mean	0.86	2.17	4.31	9.53		Mean	0.92	2.27	4.85	8.71
	RSD (%)	11.86	5.42	2.70	1.80		RSD (%)	7.87	2.66	3.88	1.31
	Recovery (%)	86.00	108.68	86.11	95.25		Recovery (%)	92.02	113.43	97.09	87.07
Mo	1	1.09	2.19	4.91	10.04	Sn	1	0.99	2.07	5.10	9.14
	2	1.08	2.25	4.94	10.01		2	0.82	2.00	5.09	9.11
	3	1.03	2.22	4.96	10.10		3	0.92	1.97	5.07	9.14
	4	1.08	2.22	4.96	10.12		4	0.84	2.13	5.01	9.11
	5	1.06	2.23	5.03	10.09		5	0.92	2.01	5.14	9.09
	6	1.04	2.22	4.98	9.98		6	0.93	1.97	5.09	9.14
	Mean	1.06	2.22	4.96	10.06		Mean	0.90	2.03	5.08	9.12
	RSD (%)	2.39	0.82	0.79	0.55		RSD (%)	6.83	3.04	0.82	0.23
	Recovery (%)	106.30	111.07	99.23	100.57		Recovery (%)	90.20	101.25	101.66	91.22
Cr	1	0.90	1.96	5.40	10.51	Cu	1	0.75	1.57	4.45	10.17
	2	1.13	2.69	5.48	10.18		2	0.81	1.69	4.35	9.86
	3	1.24	2.49	5.37	10.59		3	0.73	1.90	4.27	9.91
	4	1.22	2.22	5.30	10.77		4	0.79	1.61	4.59	9.87
	5	1.30	2.53	5.29	10.21		5	0.91	1.76	4.39	10.30
	6	1.13	2.37	5.92	10.82		6	0.67	1.71	4.28	10.07
	Mean	1.15	2.38	5.46	10.51		Mean	0.78	1.71	4.39	10.03
	RSD (%)	12.36	10.88	4.32	2.58		RSD (%)	10.49	6.82	2.73	1.80
	Recovery (%)	115.15	118.86	109.18	105.13		Recovery (%)	77.88	85.27	87.78	100.30

Table S12 Determination of elemental impurities in drug products.

Elements	Concentration (µg /g)											
	Avibactam 1		Avibactam 2		Zafatek 1		Zafatek 2		Abiraterone acetate 1		Abiraterone acetate 2	
	ICP-MS	Present Method	ICP-MS	Present Method	ICP-MS	Present Method	ICP-MS	Present Method	ICP-MS	Present Method	ICP-MS	Present Method
Cd	-	-	-	-	-	-	-	-	-	-	-	-
Pb	0.01	-	0.02	-	0.02	-	0.04	-	0.02	-	0.01	-
As	-	-	-	-	0.01	-	-	-	-	-	-	-
Hg	-	-	-	-	-	-	-	-	-	-	-	-
Co	0.01	-	0.01	-	-	-	0.01	-	-	-	-	-
V	0.01	-	0.01	-	0.01	-	0.01	-	-	-	-	-
Ni	0.23	0.30	0.31	0.36	2.22	2.61	0.50	0.60	0.01	-	0.01	-
Tl	-	-	-	-	-	-	-	-	-	-	-	-
Au	-	-	-	-	0.01	-	-	-	-	-	-	-
Pd	1.30	1.30	1.76	1.64	-	-	-	-	11.03	10.16	9.36	9.01
Ir	-	-	-	-	-	-	-	-	-	-	-	-
Os	-	-	-	-	-	-	0.97	0.86	-	-	-	-
Rh	-	-	-	-	-	-	-	-	-	-	-	-
Ru	-	-	-	-	-	-	-	-	-	-	-	-
Se	-	-	-	-	-	-	-	-	0.01	-	-	-
Ag	-	-	-	-	-	-	-	-	-	-	-	-
Pt	-	-	-	-	-	-	-	-	0.00	-	-	-
Sb	-	-	-	-	0.02	-	0.00	-	-	-	-	-
Mo	0.02	-	0.05	-	0.05	-	0.07	-	0.00	-	-	-
Cu	0.17	-	-	-	0.13	-	0.12	-	-	-	0.10	-
Sn	0.12	0.12	0.10	0.13	0.07	-	0.02	-	0.12	0.10	0.13	0.11
Cr	2.12	2.21	1.54	1.28	0.82	0.53	1.14	0.97	0.23	-	0.13	-