



Cite this: *Analyst*, 2018, **143**, 777

DOI: 10.1039/c7an90101a

[rsc.li/analyst](http://rsc.li/analyst)

## Correction: Chemical analysis in saliva and the search for salivary biomarkers – a tutorial review

Kamonwad Ngamchuea, Korbua Chaisiwamongkhol,  
Christopher Batchelor-McAuley and Richard G. Compton\*

Correction for 'Chemical analysis in saliva and the search for salivary biomarkers – a tutorial review' by Kamonwad Ngamchuea, *et al.*, *Analyst*, 2018, **143**, 81–99.

In the published article some errors were present in Tables 1, 2 and 4.

The concentrations of blood glucose were misplaced into the 'Saliva' column. They are now moved to the correct 'Other biological fluids' column. A full, corrected Table 1 is reproduced here.



**Table 1** Components of authentic human saliva and a comparison of the normal range of the concentrations between saliva and other biological fluids

Real saliva composition		Normal range		Ref.
		Saliva	Other biological fluids	
1. Inorganic compounds	Na <sup>+</sup>	20–80 mmol L <sup>-1</sup>	Plasma 145 mmol L <sup>-1</sup>	11
	K <sup>+</sup>	20 mmol L <sup>-1</sup>	4 mmol L <sup>-1</sup>	
	Ca <sup>2+</sup>	1–4 mmol L <sup>-1</sup>	2.2 mmol L <sup>-1</sup>	
	Cl <sup>-</sup>	30–100 mmol L <sup>-1</sup>	120 mmol L <sup>-1</sup>	
	HCO <sub>3</sub> <sup>-</sup>	15–80 mmol L <sup>-1</sup>	25 mmol L <sup>-1</sup>	
	Phosphate	4 mmol L <sup>-1</sup>	1.2 mmol L <sup>-1</sup>	
	Mg <sup>2+</sup>	0.2 mmol L <sup>-1</sup>	1.2 mmol L <sup>-1</sup>	
	SCN <sup>-</sup>	2 mmol L <sup>-1</sup>	<0.2 mmol L <sup>-1</sup>	
	NH <sub>3</sub>	3 mmol L <sup>-1</sup>	0.05 mmol L <sup>-1</sup>	
2. Organic compounds (non-protein and lipids)	Uric acid	3.38 ± 0.21 mg dL <sup>-1</sup> 217.2 ± 110.3 mol L <sup>-1</sup> 0.1–7.5 mg dL <sup>-1</sup>	Serum 6.31 ± 0.24 mg dL <sup>-1</sup>	21–23
	Bilirubin	0.5–5.0 µmol L <sup>-1</sup>	Serum 0.2–1.2 mg dL <sup>-1</sup>	
	Creatinine	0.12 ± 0.06 mg dL <sup>-1</sup> 0.05–0.2 mg dL <sup>-1</sup>	Serum 0.89 ± 0.17 mg dL <sup>-1</sup> Serum 0.6–1.5 mg dL <sup>-1</sup>	
	Glucose	4–13 mg dL <sup>-1</sup>	Blood 80–120 mg dL <sup>-1</sup> Blood 88.6 ± 8.0 mg dL <sup>-1</sup>	22 and 26
	Cholesterol	0.02–5.46 µmol L <sup>-1</sup>	Serum <5 mmol L <sup>-1</sup>	
	Lactate	0.3–1.8 mM 0.1 to 2.5 mmol L <sup>-1</sup>	Serum 0.5–1.0 mM	27 28 and 29
3. Protein/polypeptide compounds	α-Amylase	19–308 U mL <sup>-1</sup> <sup>a</sup> 93 ± 62 U L <sup>-1</sup> <sup>a</sup> 2.64 ± 1.8 mg mL <sup>-1</sup>	Serum 0.05–0.125 U mL <sup>-1</sup> <sup>a</sup>	23 and 30
	Albumin	0.2 ± 0.1 mg mL <sup>-1</sup>	Serum 3.5–5.5 g dL <sup>-1</sup>	
	Secretory-IgA	80–717 mg dL <sup>-1</sup> 124.3–333.5 µg mL <sup>-1</sup>	Serum 70–400 mg dL <sup>-1</sup>	
	Mucin group	MUC5B: 2.4 ± 1.7 U mL <sup>-1</sup> 1.19 ± 0.17 mg mL <sup>-1</sup>	Serum 9.9 ± 0.8 ng mL <sup>-1</sup>	31 and 33
	Lysozyme	3–50 µg mL <sup>-1</sup> 59.7 to 1062.3 µg mL <sup>-1</sup>	Serum 7.4 ± 1.8 mg mL <sup>-1</sup> Serum 4–9 µg mL <sup>-1</sup>	
	Total proteins	7.1–223.2 mg dL <sup>-1</sup> 0.9 ± 0.2 mg mL <sup>-1</sup>	Serum 6–8 g dL <sup>-1</sup>	23 and 31
4. Hormones	Cortisol	3.5–27.0 mg dL <sup>-1</sup>	Serum 2–25 mg dL <sup>-1</sup>	35
	Testosterone	32–55 pg mL <sup>-1</sup>	Serum 320–600 ng dL <sup>-1</sup>	36
	Progesterone	Luteal phase 436 ± 34 pmol L <sup>-1</sup> Follicular phase 22.1 ± 2.7 pmol L <sup>-1</sup>	Serum male: <1 ng mL <sup>-1</sup> Serum female: 0.1–20 ng mL <sup>-1</sup>	37
	Estrogen (Estradiol)	Luteal phase 20.6 ± 0.4 pmol L <sup>-1</sup>	Serum male: 15–60 pg mL <sup>-1</sup> Serum female: 15–370 pg mL <sup>-1</sup>	37

<sup>a</sup> U mL<sup>-1</sup>: enzymatic activity per unit (mL) of saliva.

The concentration of CaCl<sub>2</sub>·2H<sub>2</sub>O (ref. Fusayama-Meyer<sup>16</sup>) was given incorrectly. The concentration of NH<sub>4</sub>Cl (ref. SAGF<sup>17,18</sup>) was missing. A full, corrected Table 2 is reproduced here.



Table 2 Compositions of different artificial saliva recipes

Artificial saliva compositions		Concentration (g L <sup>-1</sup> )				
		AFNOR <sup>14,15</sup>	Fusayama-Meyer <sup>16</sup>	SAGF <sup>17,18</sup>	Klimek <sup>19</sup>	Shellis <sup>12</sup>
1. Inorganic compounds	NaCl	6.70	0.40	0.13	0.58	—
	KCl	1.20	0.40	0.96	1.27	1.16
	Na <sub>2</sub> HPO <sub>4</sub>	0.26	—	—	0.34	0.375
	KH <sub>2</sub> PO <sub>4</sub>	0.20	—	0.66	0.33	0.35
	NaHCO <sub>3</sub>	1.50	0.10	0.63	—	0.54
	KSCN	0.33	—	0.19	0.16	0.22
					(NaSCN)	
	CaCl <sub>2</sub> ·2H <sub>2</sub> O	—	0.795	0.23	0.17	0.21
	Na <sub>2</sub> S·9H <sub>2</sub> O	—	0.005	—	—	—
	Urea	—	1.00	0.20	0.20	0.17
	NaH <sub>2</sub> PO <sub>4</sub> ·H <sub>2</sub> O	—	0.69	—	—	—
	NH <sub>4</sub> Cl	—	—	0.18	0.16	0.233
	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	—	—	0.76	—	—
	MgCl <sub>2</sub> ·6H <sub>2</sub> O	—	—	—	—	0.043
	Sodium citrate	—	—	—	—	0.013
2. Organic compounds	Ascorbic acid	—	—	—	0.002	—
	Glucose	—	—	—	0.03	—
	Uric acid	—	—	—	—	0.0105
	Creatinine	—	—	—	—	0.0001
	Choline	—	—	—	—	0.013
	Mixture of vitamins	—	—	—	—	0.0008
3. Protein/polypeptide compounds	Mucin	—	—	—	2.70 <sup>a</sup>	—
	Glycoprotein	—	—	—	—	2.5
	Alpha amylase	—	—	—	—	3 × 10 <sup>5</sup> Somogyi's unit L <sup>-1</sup> <sup>b</sup>
	Albumin	—	—	—	—	0.025
	Mixture of amino acids	—	—	—	—	0.041

<sup>a</sup> Bacto-Mucin bacteriological. <sup>b</sup> Somogyi's unit/L is a measure of the level of activity of amylase in blood serum. One Somogyi unit is defined as the amount of amylase required to produce the equivalent of 1 mg of glucose when acting on a standard starch solution under a defined condition.<sup>38</sup>

Incorrect values were given for linear ranges, LOD and the pH of the buffers for some of the detection methods in Table 4. The specific changes relate to Phosphate (linear range and buffer pH), caffeine (LOD for the molecularly imprinted electrode and linear range for the SWNCT/CC electrode), glutathione (medium for the Prussian blue/SPE electrode and linear range for the caffeic acid/GC electrode) and uric acid (LOD). A full, corrected Table 4 is reproduced here.



**Table 4** Examples of methods of electroanalytical detection available for possible salivary biomarkers (listed in Table 3)

Biomarkers	Methods	Electrodes	Linear range	LOD	Medium	Ref.
<b>Chemicals</b>						
Calcium	ISE	Calcium-specific electrode	2.2–8 mg per 100 mL	—	Aqueous, serum	179
Potassium	ISE	Potassium electrode with polymer membrane	115 mM–180 mM <sup>a</sup>	—	Whole blood, serum	180
Phosphate	AMP, CV	Molybdate anions in chitosan/GC	0.79 $\mu$ M–3.96 $\mu$ M 19 $\mu$ M–95 $\mu$ M	—	Deaerated Tris buffer (pH 7.2)	187
Cotinine	MPA	BDD	0.5 $\mu$ M–100 $\mu$ M	0.06 $\mu$ M	PBS (pH 7.0), saliva	188
Nicotine	SWV	Anti-cotinine antibody/C-SPE	1–100 ng mL <sup>-1</sup>	1.0 ng mL <sup>-1</sup>	Serum	189
	AMP, CV	MWCNT/alumina-coated silica nanocomposite	—	1.42 $\mu$ M	PBS (pH 8)	190
	AMP	TiO <sub>2</sub> /GC	0 $\mu$ M–5000 $\mu$ M	4.9 $\mu$ M	PBS (pH 7.4)	191
	CV	MWCNT/BPPG	up to 1 mM	1.5 $\mu$ M	BR (pH 8)	192
	CV	CNT/SPE	10 $\mu$ M–1000 $\mu$ M	2 $\mu$ M	Buffer (pH 7), artificial saliva	193
Nitrate (NO <sub>3</sub> <sup>-</sup> )	DPV	BDD	0.5 $\mu$ M–200 $\mu$ M	0.3 $\mu$ M	BR (pH 8)	194
	EIS	Polydopamine imprinted film	1 $\mu$ M–25 $\mu$ M	0.5 $\mu$ M	PBS (pH 7.4), serum	195
Nitrite (NO <sub>2</sub> <sup>-</sup> )	LSV	Cu plated-/BDD microelectrode array	1.2 $\mu$ M–124 $\mu$ M	0.76 $\mu$ M	0.1 M Na <sub>2</sub> SO <sub>4</sub> (pH 3)	196
	AMP	Cellulose acetate membrane/Pt Poly(1,8-diaminonaphthalene) film/Pt	1 $\mu$ M–100 $\mu$ M 0.5 $\mu$ M–100 $\mu$ M	0.5 $\mu$ M 0.1 $\mu$ M	Acetate buffer (pH 4.0)	197
Caffeine	AMP, DPV	Carbon black paste electrode	0.01 $\mu$ M–4 $\mu$ M	0.005 $\mu$ M	Acetate buffer (pH 4.6)	198
	DPV, LSV	Carbon black SPE	0.1 $\mu$ M–8.8 $\mu$ M	0.097 $\mu$ M	Saliva, urine	199
	CV	GC	4 mM–80 mM	6 $\mu$ M	PBS (pH 7.0)	200
	CV, SWV	Nafion/GC	up to 7.0 mM	0.04 $\mu$ M	PBS (pH 7.0)	201
	DPV	Pseudo CP	1 $\mu$ M–1 mM	0.348 $\mu$ M	PBS (pH 6.5)	202
	DPV	Molecularly imprinted polymer	0.5 nM–0.16 $\mu$ M	90 pM	0.01 M H <sub>2</sub> SO <sub>4</sub> (pH 1.7)	203
	DPV	SWCNT/CC	0.25 $\mu$ M–0.1 mM	0.12 $\mu$ M	PBS (pH 7.2), urine	204
	SWV	EPPG	0.02 $\mu$ M–100 $\mu$ M	0.008 $\mu$ M	PBS (pH 7.2), urine	204
Thiocyanate (SCN <sup>-</sup> )	CV, DPV	Ag-MWCNT/GC	2.5 nM–50 nM 50 nM–1.0 $\mu$ M	1.0 nM	PBS (pH 6.0), saliva, urine	205
	CV, AMP	Ag@Cu nanorods/GC	1 mM–10 mM	10 nM	PBS (pH 6.0)	206
<b>Anti-oxidants</b>						
Glutathione (GSH) <sup>b</sup>	CV	Copper hydroxide/CILE	1 $\mu$ M–50 $\mu$ M 0.1 mM–1.8 mM	30 nM	PBS (pH 7.0)	207
	CV, AMP	Ordered mesoporous carbon	0 mM–2.5 mM <sup>a</sup>	0.09 $\mu$ M	PBS (pH 7.16)	208
	CV, AMP	Carbon microfiber	5 $\mu$ M–65 $\mu$ M <sup>a</sup>	0.5 $\mu$ M	PBS (pH 7.5)	158
	CV	Poly(caffeic acid) nanocarbon composite/GC	0.5 $\mu$ M–5.0 mM	0.5 $\mu$ M	PBS (pH 7.0)	209
	CV	GC	6 $\mu$ M–59 $\mu$ M	1 $\mu$ M	Tissue media (pH 7)	210
	CV	Prussian blue/SPE	2 $\mu$ M–0.5 mM	2.0 $\mu$ M	PBS (pH 7.4), blood	211
	CV	Nanocarbon paste	2 $\mu$ M–120 $\mu$ M <sup>a</sup>	2.0 $\mu$ M	PBS (pH 7.5)	212
	CV	Caffeic acid/GC	>1.0 mM	2.2 $\mu$ M	PBS (pH 7.0)	213
Glutathione disulfide (GSSG)	CV, SWV	CNT-SPE	10 $\mu$ M–60 $\mu$ M <sup>a</sup>	3.0 $\mu$ M	PBS (pH 7.0), saliva	156
	CV	Copper hydroxide/CIL	0.4 $\mu$ M–120 $\mu$ M	15 nM	PBS (pH 7.0)	207
	CV, DPV	Graphene-Pt/GC	0.15 $\mu$ M–34 $\mu$ M	0.15 $\mu$ M	PBS (pH 7.0)	214
	DPV	Nitrogen doped graphene	5.0 $\mu$ M–1.3 mM	2.2 $\mu$ M	PBS (pH 6.0)	215
	CV, LSV	SWCNH/GC	30 $\mu$ M–400 $\mu$ M	5 $\mu$ M	PBS (pH 7.0)	216
Ascorbic acid	CV, DPV	Poly(acid chrome blue K)/GC	50.0–1000.0 $\mu$ M	10.0 $\mu$ M	PBS (pH 4.0), urine	217
	CV, DPV	Graphene-Pt/GCE	0.05 $\mu$ M–12 $\mu$ M	0.05 $\mu$ M	PBS (pH 7.0)	214
	CE/AMP	Poly(dimethylsiloxane) (PDMS)/glass microchip	15 $\mu$ M–110 $\mu$ M	1 $\mu$ M	MES (pH 5.5), urine	218
	DPV	Nitrogen doped graphene	0.1 $\mu$ M–20 $\mu$ M	45 nM	PBS (pH 6.0)	215
	SWV	Clay colloids/GC	0.5 $\mu$ M–10 $\mu$ M 10 $\mu$ M–100 $\mu$ M	0.2 $\mu$ M	Citrate buffer (pH 1.0)	219
Uric acid	DPV	CIL	2.0 $\mu$ M–0.2 mM	1.0 $\mu$ M	PBS (pH 6.8), urine	220
	CV, DPV	Poly(acid chrome blue K)/GC	1.0 $\mu$ M–120 $\mu$ M	0.5 $\mu$ M	PBS (pH 4.0),	217



Table 4 (Contd.)

Biomarkers	Methods	Electrodes	Linear range	LOD	Medium	Ref.
	CV, LSV	SWCNH/GC	0.06 $\mu\text{M}$ –10 $\mu\text{M}$	20 nM	PBS (pH 7.0)	216
	SWV	Electrochemically activated GC	0.04 $\mu\text{M}$ –2.0 $\mu\text{M}$	9 nM	0.5 M $\text{H}_2\text{SO}_4$ , urine	221
<b>Therapeutic drugs</b>						
Theophylline	CV	MWCNT/GC	0.3 $\mu\text{M}$ –10.0 $\mu\text{M}$	50 nM	PBS (pH 5.8)	222
	DPV	Graphene/Nafion/GC	10 nM –1.0 $\mu\text{M}$	6.0 nM	0.1 M $\text{H}_2\text{SO}_4$	223
Acetaminophen (paracetamol)	DPV	Cobalt phthalocyanine NP/CP	0.4 $\mu\text{M}$ –0.1 mM	0.14 $\mu\text{M}$	PBS (pH 7.4)	224
	DPV	Urchin-like CdSe microparticles/GC	$\mu\text{M}$ –40 $\mu\text{M}$	0.4 $\mu\text{M}$	PBS (pH 6.0)	225
	SWV	Nafion/lead–ruthenium oxide pyrochlore	40 $\mu\text{M}$ –700 $\mu\text{M}$ up to 100 $\mu\text{M}$	0.1 $\mu\text{M}$	PBS (pH 3)	226
	CV	Nafion/TiO <sub>2</sub> –graphene/GC	1 $\mu\text{M}$ –100 $\mu\text{M}$	0.21 $\mu\text{M}$	PBS (pH 7.0)	227
	DPV	Pd/graphite oxide/GC	5 nM–0.5 $\mu\text{M}$	2.2 nM	PBS (pH 6.8)	228
	DPV	BiO/graphite SPE	0.5 $\mu\text{M}$ –1.250 $\mu\text{M}$	30 nM	BR buffer (pH 2.0), saliva	229
	DPV	SWCNT–graphene/GC	0.05 $\mu\text{M}$ –65 $\mu\text{M}$	38 nM	PBS (pH 7.0), serum	230
	DPV	Functionalized MWCNT	0.45 $\mu\text{M}$ –90.0 $\mu\text{M}$	0.35 $\mu\text{M}$	PBS (pH 7.0), saliva	231
	SWV	CoNP/MWCNT	5.2 nM–0.45 $\mu\text{M}$	1.0 nM	PBS (pH 7.0)	232
	SWV	MWCNT/BPPG	$\mu\text{M}$ –2 $\mu\text{M}$	10 nM	PBS (pH 7.5)	233
	SWV	Graphene/GC	2 $\mu\text{M}$ –20 $\mu\text{M}$ 0.1 $\mu\text{M}$ –20 $\mu\text{M}$	32 nM	$\text{NH}_3\cdot\text{H}_2\text{O}$ – $\text{NH}_4\text{Cl}$ (pH 9.3)	234
<b>pH</b>						
pH	CV	Carbon fibre microelectrode	pH 2.5–8 (buffer), pH 4–8.5 (artificial saliva)	<b>Sensitivity:</b> –61 mV/pH (buffer) –73 mV/pH (artificial saliva)	Buffer, artificial saliva, saliva	235
	EIS	Iridium oxide	pH 4–8	<b>Sensitivity:</b> –47 mV/pH (artificial saliva)	Artificial saliva	236
	ISE	Poly(3-octylthiophene-2,5-diyl) regiorandom/SPCE	pH 4–8	<b>Sensitivity:</b> –53.4 mV/pH (buffer)	Buffer, saliva	237
	ISE	Poly(terthiophene benzoic acid)/AuZnO <sub>x</sub> /SPCE	pH 2–13	<b>Sensitivity:</b> 59.2 $\pm$ 0.5 mV/pH (buffer)	Buffer, saliva, urine	238

The methods highlighted in grey and blue have been validated in artificial saliva and real saliva, respectively. **Methods:** AMP: amperometry, CA: chronoamperometry, CE: capillary electrophoresis, CV: cyclic voltammetry, DPV: differential pulse voltammetry, EIS: electrochemical impedance spectroscopy, ISE: ion-selective electrode, LSV: linear sweep voltammetry, MPA: multiple-pulse amperometry, SWV: square wave voltammetry. **Electrodes:** BDD: boron-doped diamond, BPPG: basal plane pyrolytic graphite, CC: carbon ceramic, CIL: carbon ionic liquid, CNF: carbon nanofiber, CP: carbon paste, EPPG: edge plane pyrolytic graphite, GC: glassy carbon electrode, MWCNT: multi-walled carbon nanotube, NP: nanoparticle, SPE: screen-printed electrode, SWCNT: single-walled carbon nanotube, SWCNH: single-walled carbon nanohorn.<sup>a</sup> Not stated in the text – values are taken from calibration curves present in the papers.





## References

- 11 J. K. M. Aps and L. C. Martens, *Forensic Sci. Int.*, 2005, **150**, 119–131.
- 12 R. P. Shellis, *Arch. Oral Biol.*, 1978, **23**, 485–489.
- 14 K. Elagli, M. Traisnel and H. F. Hildebrand, *Electrochim. Acta*, 1993, **38**, 1769–1774.
- 15 F. C. Giacomelli, C. Giacomelli and A. Spinelli, *J. Braz. Chem. Soc.*, 2004, **15**, 541–547.
- 16 J.-M. Meyer, *Corros. Sci.*, 1977, **17**, 971–982.
- 17 B. Levallois, Y. Fovet, L. Lapeyre and J. Y. Gal, *Dent. Mater.*, 1998, **14**, 441–447.
- 18 J.-Y. Gal, Y. Fovet and M. Adib-Yadzi, *Talanta*, 2001, **53**, 1103–1115.
- 19 J. Klimek, E. Hellwig and G. Ahrens, *Caries Res.*, 1982, **16**, 156–161.
- 21 K. Shibasaki, M. Kimura, R. Ikarashi, A. Yamaguchi and T. Watanabe, *Metabolomics*, 2012, **8**, 484–491.
- 22 M. Soukup, I. Biesiada, A. Henderson, B. Idowu, D. Rodeback, L. Ridpath, E. G. Bridges, A. M. Nazar and K. G. Bridges, *Diabetol. Metab. Syndr.*, 2012, **4**, 14–14.
- 23 O. Hershkovich and R. M. Nagler, *Arch. Oral Biol.*, 2004, **49**, 515–522.
- 24 E. De Corso, S. Baroni, S. Agostino, G. Cammarota, G. Mascagna, A. Mannocci, M. Rigante and J. Galli, *Ann. Surg.*, 2007, **245**, 880–885.
- 25 R. Venkatapathy, V. Govindarajan, N. Oza, S. Parameswaran, B. Pennagaram Dhanasekaran and K. V. Prashad, *Int. J. Nephrol.*, 2014, **2014**, 6.
- 26 S. Kumar, S. Padmashree and R. Jayalekshmi, *Contemp. Clin. Dent.*, 2014, **5**, 312–317.
- 27 S. Karjalainen, L. Sewón, E. Soderling, B. Larsson, I. Johansson, O. Simell, H. Lapinleimu and R. Seppänen, *J. Dent. Res.*, 1997, **76**, 1637–1643.
- 28 R. Segura, C. Javierre, J. L. Ventura, M. A. Lizarraga, B. Campos and E. Garrido, *Br. J. Sports Med.*, 1996, **30**, 305–309.
- 29 C. G. J. Schabmueller, D. Loppow, G. Piechotta, B. Schütze, J. Albers and R. Hintsche, *Biosens. Bioelectron.*, 2006, **21**, 1770–1776.
- 30 A. L. Mandel, C. Peyrot des Gachons, K. L. Plank, S. Alarcon and P. A. S. Breslin, *PLoS One*, 2010, **5**, e13352.
- 31 A. Almståhl, M. Wikström and J. Groenink, *Oral Microbiol. Immunol.*, 2001, **16**, 345–352.
- 32 V. Ng, D. Koh, Q. Fu and S.-E. Chia, *Clin. Chim. Acta*, 2003, **338**, 131–134.
- 33 S. Kejriwal, R. Bhandary, B. Thomas and S. Kumari, *J. Clin. Diagn. Res.*, 2014, **8**, ZC56–ZC60.
- 34 H. Tomita, S. Sato, R. Matsuda, Y. Sugiura, H. Kawaguchi, T. Niimi, S. Yoshida and M. Morishita, *Lung*, 1999, **177**, 161–167.
- 35 L. Manetti, G. Rossi, L. Grasso, V. Raffaelli, I. Scattina, S. Del Sarto, M. Cosottini, A. Iannelli, M. Gasperi, F. Bogazzi and E. Martino, *Eur. J. Endocrinol.*, 2013, **168**, 315–321.
- 36 M. Yasuda, S. Honma, K. Furuya, T. Yoshii, Y. Kamiyama, H. Ide, S. Muto and S. Horie, *J. Mens Health*, 2008, **5**, 56–63.
- 37 Y. C. Lu, G. R. Bentley, P. H. Gann, K. R. Hodges and R. T. Chatterton, *Fertil. Steril.*, 1999, **71**, 863–868.
- 38 M. Somogyi, *J. Biol. Chem.*, 1938, **125**, 399–414.
- 156 P. T. Lee, L. M. Goncalves and R. G. Compton, *Sens. Actuators, B*, 2015, **221**, 962–968.
- 158 K. Ngamchuea, C. Lin, C. Batchelor-McAuley and R. G. Compton, *Anal. Chem.*, 2017, **89**, 3780–3786.
- 179 H. D. Schwartz, *Clin. Chim. Acta*, 1975, **64**, 227–239.
- 180 S. M. Friedman, S. L. Wong and J. H. Walton, *J. Appl. Physiol.*, 1963, **18**, 950–954.
- 187 S. Berchmans, R. Karthikeyan, S. Gupta, G. E. J. Poinern, T. B. Issa and P. Singh, *Sens. Actuators, B*, 2011, **160**, 1224–1231.
- 188 M. F. Alecrim, F. M. Oliveira, T. J. Guedes, C. D. c. Neves, V. A. Mendonça, E. S. Gil, R. M. Verly and W. T. P. dos Santos, *Electrochim. Acta*, 2016, **222**, 331–337.
- 189 H. Nian, J. Wang, H. Wu, J. G. Lo, K. H. Chiu, J. G. Pounds and Y. Lin, *Anal. Chim. Acta*, 2012, **713**, 50–55.
- 190 S.-J. Wang, H.-W. Liaw and Y.-C. Tsai, *Electrochem. Commun.*, 2009, **11**, 733–735.
- 191 C. T. Wu, P. Y. Chen, J. G. Chen, V. Suryanarayanan and K. C. Ho, *Anal. Chim. Acta*, 2009, **633**, 119–126.
- 192 M. J. Sims, N. V. Rees, E. J. F. Dickinson and R. G. Compton, *Sens. Actuators, B*, 2010, **144**, 153–158.
- 193 L. Highton, R. O. Kadara, N. Jenkinson, B. Logan Riehl and C. E. Banks, *Electroanalysis*, 2009, **21**, 2387–2389.
- 194 L. Švorc, D. M. Stanković and K. Kalcher, *Diamond Relat. Mater.*, 2014, **42**, 1–7.
- 195 K. Liu, W. Z. Wei, J. X. Zeng, X. Y. Liu and Y. P. Gao, *Anal. Bioanal. Chem.*, 2006, **385**, 724–729.
- 196 S. Ward-Jones, C. E. Banks, A. O. Simm, L. Jiang and R. G. Compton, *Electroanalysis*, 2005, **17**, 1806–1815.
- 197 M. Badea, A. Amine, G. Palleschi, D. Moscone, G. Volpe and A. Curulli, *J. Electroanal. Chem.*, 2001, **509**, 66–72.
- 198 S. I. R. Malha, J. Mandli, A. Ourari and A. Amine, *Electroanalysis*, 2013, **25**, 2289–2297.
- 199 J. Davis, K. J. McKeegan, M. F. Cardosi and D. H. Vaughan, *Talanta*, 1999, **50**, 103–112.
- 200 A. C. Torres, M. M. Barsan and C. M. Brett, *Food Chem.*, 2014, **149**, 215–220.
- 201 G. A. M. Mersal, *Food Anal. Methods*, 2011, **5**, 520–529.
- 202 X. Kan, T. Liu, C. Li, H. Zhou, Z. Xing and A. Zhu, *J. Solid State Electrochem.*, 2012, **16**, 3207–3213.
- 203 B. Habibi, M. Abazari and M. H. Pournaghi-Azar, *Chin. J. Catal.*, 2012, **33**, 1783–1790.



- 204 R. N. Goyal, S. Bishnoi and B. Agrawal, *J. Electroanal. Chem.*, 2011, **655**, 97–102.
- 205 P. Yang, W. Wei and C. Tao, *Anal. Chim. Acta*, 2007, **585**, 331–336.
- 206 J. S. Easow, P. Gnanaprakasam and T. Selvaraju, *Res. Chem. Intermed.*, 2015, **42**, 2539–2551.
- 207 A. Safavi, N. Maleki, E. Farjami and F. A. Mahyari, *Anal. Chem.*, 2009, **81**, 7538–7543.
- 208 J. C. Ndamaniha, J. Bai, B. Qi and L. Guo, *Anal. Biochem.*, 2009, **386**, 79–84.
- 209 P. T. Lee, K. R. Ward, K. Tschulik, G. Chapman and R. G. Compton, *Electroanalysis*, 2014, **26**, 366–373.
- 210 N. Lawrence, J. Davis and R. G. Compton, *Talanta*, 2001, **53**, 1089–1094.
- 211 F. Ricci, F. Arduini, C. S. Tuta, U. Sozzo, D. Moscone, A. Amine and G. Palleschi, *Anal. Chim. Acta*, 2006, **558**, 164–170.
- 212 D. Lowinsohn, P. T. Lee and R. G. Compton, *Int. J. Electrochem. Sci.*, 2014, **9**, 3458–3472.
- 213 P. T. Lee and R. G. Compton, *Electroanalysis*, 2013, **25**, 1613–1620.
- 214 C. L. Sun, H. H. Lee, J. M. Yang and C. C. Wu, *Biosens. Bioelectron.*, 2011, **26**, 3450–3455.
- 215 Z. H. Sheng, X. Q. Zheng, J. Y. Xu, W. J. Bao, F. B. Wang and X. H. Xia, *Biosens. Bioelectron.*, 2012, **34**, 125–131.
- 216 S. Zhu, H. Li, W. Niu and G. Xu, *Biosens. Bioelectron.*, 2009, **25**, 940–943.
- 217 R. Zhang, G.-D. Jin, D. Chen and X.-Y. Hu, *Sens. Actuators, B*, 2009, **138**, 174–181.
- 218 J. C. Fanguy and C. S. Henry, *Electrophoresis*, 2002, **23**, 767–773.
- 219 J. M. Zen and P. J. Chen, *Anal. Chem.*, 1997, **69**, 5087–5093.
- 220 A. Safavi, N. Maleki, O. Moradlou and F. Tajabadi, *Anal. Biochem.*, 2006, **359**, 224–229.
- 221 K. Shi and K.-K. Shiu, *Electroanalysis*, 2001, **13**, 1319–1325.
- 222 Y.-H. Zhu, Z.-L. Zhang and D.-W. Pang, *J. Electroanal. Chem.*, 2005, **581**, 303–309.
- 223 Y. Li, S. Wu, P. Luo, J. Liu, G. Song, K. Zhang and B. Ye, *Anal. Sci.*, 2012, **28**, 497–502.
- 224 G. J. Yang, K. Wang, J. J. Xu and H. Y. Chen, *Anal. Lett.*, 2007, **37**, 629–643.
- 225 H. Yin, X. Meng, H. Su, M. Xu and S. Ai, *Food Chem.*, 2012, **134**, 1225–1230.
- 226 J. Zen, *Talanta*, 1999, **50**, 635–640.
- 227 Y. Fan, J. H. Liu, H. T. Lu and Q. Zhang, *Colloids Surf., B*, 2011, **85**, 289–292.
- 228 J. Li, J. Liu, G. Tan, J. Jiang, S. Peng, M. Deng, D. Qian, Y. Feng and Y. Liu, *Biosens. Bioelectron.*, 2014, **54**, 468–475.
- 229 B. G. Mahmoud, M. Khairy, F. A. Rashwan and C. E. Banks, *Anal. Chem.*, 2017, **89**, 2170–2178.
- 230 X. Chen, J. Zhu, Q. Xi and W. Yang, *Sens. Actuators, B*, 2012, **161**, 648–654.
- 231 M. Amiri-Aref, J. B. Raoof and R. Ojani, *Colloids Surf., B*, 2013, **109**, 287–293.
- 232 A. Kutluay and M. Aslanoglu, *Anal. Chim. Acta*, 2014, **839**, 59–66.
- 233 R. T. Kachosangi, G. G. Wildgoose and R. G. Compton, *Anal. Chim. Acta*, 2008, **618**, 54–60.
- 234 X. Kang, J. Wang, H. Wu, J. Liu, I. A. Aksay and Y. Lin, *Talanta*, 2010, **81**, 754–759.
- 235 K. Chaisiwamongkhon, C. Batchelor-McAuley and R. G. Compton, *Analyst*, 2017, **142**, 2828–2835.
- 236 F. Contu, M. Vega-Arroyo and S. R. Taylor, *Int. J. Mater. Sci.*, 2014, **4**, 8–13.
- 237 C. Zuliani, G. Matzeu and D. Diamond, *Electrochim. Acta*, 2014, **132**, 292–296.
- 238 D.-M. Kim, S. J. Cho, C.-H. Cho, K. B. Kim, M.-Y. Kim and Y.-B. Shim, *Biosens. Bioelectron.*, 2016, **79**, 165–172.

The Royal Society of Chemistry apologises for these errors and any consequent inconvenience to authors and readers.

