Supplementary Material

A sustainable and highly sensitive voltammetric method for the simultaneous determination of indigo carmine and carmoisine using the boron-doped diamond electrode

Bruna Coldibeli [a] and Elen Romão Sartori [a]*

[a] Universidade Estadual de Londrina (UEL), Centro de Ciências Exatas, Departamento de Química, Rodovia Celso Garcia Cid, PR 445 Km 380, Londrina – PR, C.P. 10.011, 86057-970, Brazil.

*Corresponding author.
Tel.: +55 43 3371-4366; Fax: +55 43 3371-4286
E-mail address: elensartori@uel.br (E.R. Sartori)

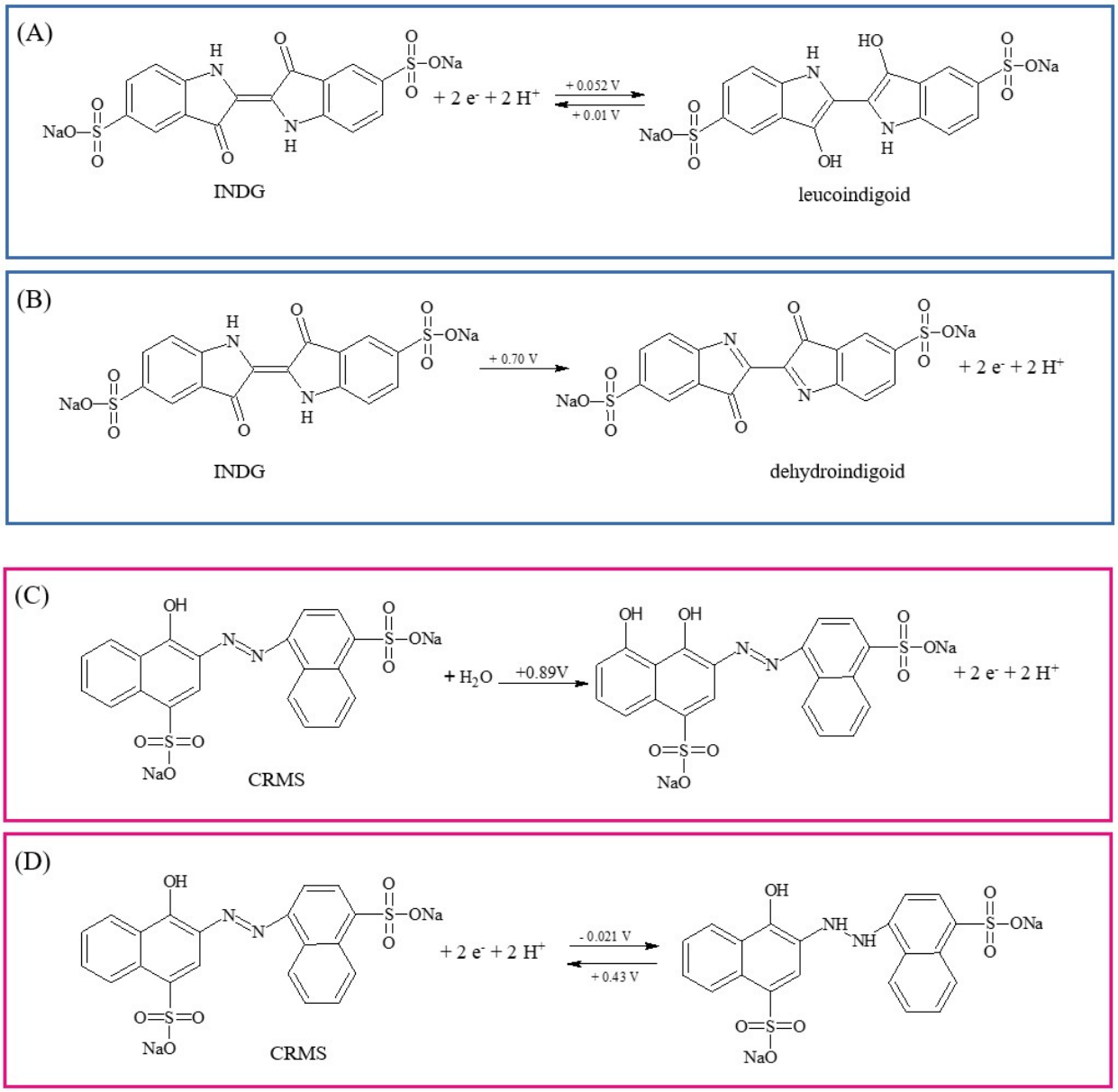

Figure S1. Proposed redox reactions for (A) the reversible electrochemical process of INDG (AP_1 and CP) [1], (B) the irreversible oxidation of INDG (AP_2) [1,2], (C) the irreversible oxidation of CRMS (AP_1) [3], and (D) the irreversible reduction of CRMS (CP) and the re-oxidation of the CRMS reduction product (AP_2) [4–6].

Table S1. RSD (%) values for the alterations in voltammetric signals of INDG and CRMS in the presence of the interfering compounds studied with varying molar ratios.

	Molar ratio (INDG:INTER)					**Molar ratio (CRMS:INTER)**				
Interfering compound	**1:1**	**1:10**	**1:100**	**1:1000**	**1:10000**	**1:1**	**1:10**	**1:100**	**1:1000**	**1:10000**
NO_3^-	-	1.30	2.90	5.79	13.96	-	0.56	1.52	1.28	2.39
NH_4^+	-	3.08	2.47	2.00	1.19	-	1.76	0.70	0.17	1.22
Cu^{2+}	-	1.49	4.00	4.65	4.32	-	0.42	2.70	3.29	4.87
Zn^{2+}	-	1.99	3.34	2.89	6.51	-	0.07	1.15	1.12	1.80
Fe^{2+}	-	4.77	2.83	73.98	99.80	-	1.62	0.03	70.77	94.71
Fe^{3+}	-	4.41	4.35	3.15	4.11	-	4.15	0.43	4.23	2.78
Mn^{2+}	-	0.15	0.52	2.80	0.72	-	5.36	4.91	2.30	3.35
Tartaric acid	-	2.02	0.63	3.02	8.35	-	1.51	1.70	0.86	0.23
Citric acid	-	0.08	1.88	4.37	7.80	-	1.07	2.58	2.97	1.75
Saccharose	-	1.00	2.12	0.60	5.37	-	0.24	0.96	2.89	0.92
Ascorbic acid	-	0.43	2.83	1.54	52.06	-	0.37	0.46	64.38	66.81
Sunset Yellow	3.84	5.42	56.16	-	-	1.16	41.68	109.79	-	-
Tartrazine	4.39	10.47	49.56	-	-	1.82	1.78	1.46	-	-
Allura red	5.14	27.77	100.4	-	-	2.90	56.72	125.14	-	-
Amaranth	6.10	25.63	107.81	-	-	23.10	102.58	133.50	-	-

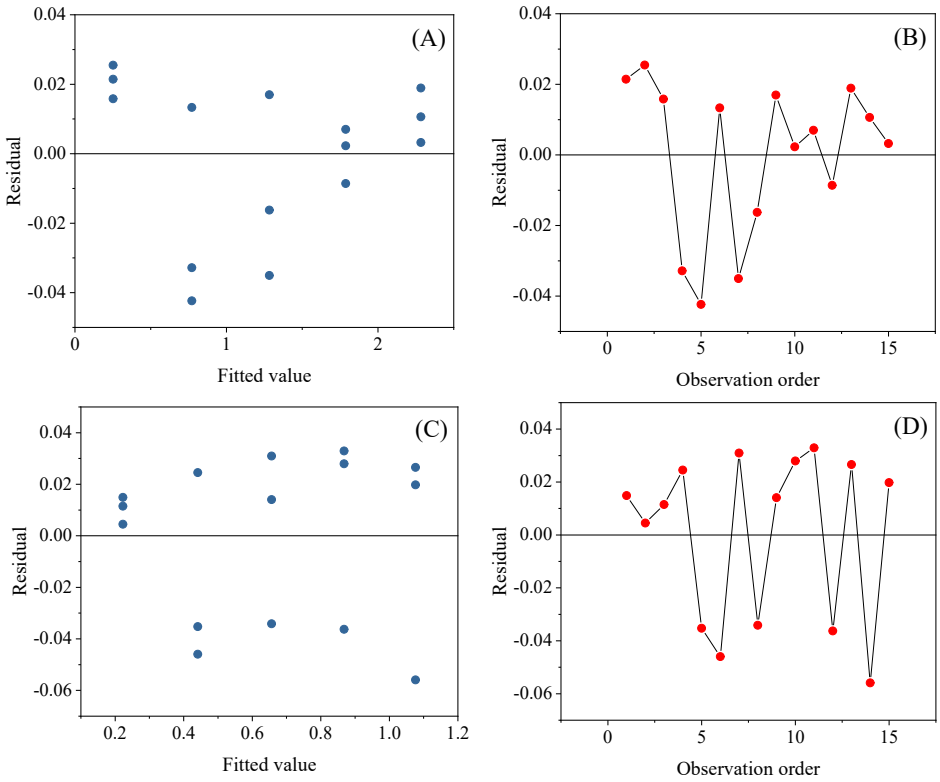

Figure S2. Plots of (A and C) residual against fitted value and (B and D) residual against observation order from the linear regression analysis of the external standard analytical curve for the simultaneous determination of INDG and CRMS.

Table S2. Comparison between the voltammetric method developed with other chromatographic methods reported in the literature for the simultaneous determination of INDG and CRMS.

Technique	INDG / µmol L^{-1}		CRMS / µmol L^{-1}		Ref.
	Linear range	LOD	Linear range	LOD	
RP-HPLC-DAD	0.0536 – 81.484	0.0173	0.0259 – 110.0	0.00866	[7]
HPLC-DAD	0.268 – 8.577	0.107	0.199 – 19.903	0.179	[8]
HPLC-UV	2.144 – 21.443	0.172	3.981 – 49.758	2.23	[9]
UPLC-PDA	0.536 – 107.216	0.214	0.498 – 99.516	0.199	[10]
HPLC-DAD-IT-TOF/MS	0.435 – 43.744	0.219	0.147 – 47.967	0.0239	[11]
RP-HPLC-UV	10.722 – 107.216	1.205	9.952 – 99.516	1.738	[12]
IP-HPLC-DAD	0.107 – 5.447	0.0686	0.0995 – 5.055	0.0935	[13]
HPLC-DAD	0.150 – 107.216	0.0429	0.0398 – 99.516	0.00995	[14]
HPLC-PDA	0.0107 – 2.144	0.0000858	0.00995 – 1.99	0.0000398	[15]
HPLC-DAD	1.0722 – 21.443	0.101	0.995 – 19.903	0.0975	[16]
DPV/CP-BDDE	0.00199 – 0.0213	0.000598	0.00099 – 0.0126	0.000273	This study

Abbreviations: RP – reversed-phase; DAD – diode-array detector; PDA - photodiode array detector; IT-TOF – ion trap time of flight; MS – mass spectrometry; IP – ion pair.

References

1 S. G. Fogang, G. Deffo, L. S. Guenang, R. C. T. Temgoua, E. Njanja, I. K. Tonle, A. Bhaumik and E. Ngameni, *Anal. Lett.*, 2024, **57**, 1241–1256.

2 T. A. Silva, G. F. Pereira, O. Fatibello-Filho, K. I. B. Eguiluz and G. R. Salazar-Banda, *J. Electroanal. Chem.*, 2016, **769**, 28–34.

3 R. Sokolová, Š. Ramešová, I. Degano, M. Hromadová, M. Szala, J. Wantulok, J. E. Nycz and M. Valášek, *Electrochim. Acta*, 2018, **270**, 509–516.

4 L. Micheletti, B. Coldibeli, C. A. R. Salamanca-Neto, L. C. Almeida and E. R. Sartori, *Talanta*, 2020, **220**, 121417.

5 M. R. J. Sarvestani and Z. Doroudi, *Food Anal. Methods*, 2022, **15**, 1565–1574.

6 J. Yu, J. Jia and Z. Ma, *J. Chinese Chem. Soc.*, 2004, **51**, 1319–1324.

7 K. S. Minioti, C. F. Sakellariou and N. S. Thomaidis, *Anal. Chim. Acta*, 2007, **583**, 103–110.

8 S. Dixit, S. K. Khanna and M. Das, *J. AOAC Int.*, 2010, **93**, 1503–1514.

9 M. Khanavi, M. Hajimahmoodi, A. M. Ranjbar, M. R. Oveisi, M. R. S. Ardekani and G. Mogaddam, *Food Anal. Methods*, 2012, **5**, 408–415.

10 Y. Yang, J. Zhang and B. Shao, *Anal. Methods*, 2014, **6**, 5872–5878.

11 X. Q. Li, Q. H. Zhang, K. Ma, H. M. Li and Z. Guo, *Food Chem.*, 2015, **182**, 316–326.

12 F. Z. Mazdeh, A. R. Khorrami, Z. Moradi-Khatoonabadi, F. EsmaeiliAftabdari, M. R. S. Ardekani, G. Moghaddam and M. Hajimahmoodi, *Trop. J. Pharm. Res.*, 2016, **15**, 173.

13 M. Zahedi, A. Shakerian, E. Rahimi and R. Sharafati Chaleshtori, *J. Shahrekord Univ. Med. Sci.*, 2020, **22**, 126–134.

14 S. Hamidi, M. Nemati and F. Lotfipour, *J. Microbiol. Biotechnol. food Sci.*, 2021, **11**, e3785.

15 Z. Gholami, M. H. Marhamatizadeh, S. Yousefinejad, M. Rashedinia and S. M. Mazloomi, *Microchem. J.*, 2021, **170**, 106671.

16 A. I. Palianskikh, S. I. Sychik, S. M. Leschev, Y. M. Pliashak, T. A. Fiodarava and L. L. Belyshava, *Food Chem.*, 2022, **369**, 130947.