ESI

Determination of Fe(III) using digital images: Study of corrosion in steel plates using a polyester laser printed devices

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Analysis of spot colors using chromaticity diagrams[1]

The relationship between the coordinates of the chromaticity diagram and the variables R, G, and B could be described using:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = M \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad \text{(Eq. 1)}$$

where x, y, and z are the values of the chromaticity coordinates, M is the proportionality matrix, which is dependent on the theoretical blank value and the illumination rate used, and R, G, and B are values corresponding to the red, green, and blue components. In this way, it was possible to convert the variables R, G, and B to coordinates x, y, and z in the chromaticity diagram. In this work, the reference used was the CIE 1931 diagram, considering the coordinates of the diagram to be equidistant (x = y = z = 1). This conversion procedure resulted in a set of linear equations (Eqs. 2-4).

$$x = \frac{0.490R + 0.310G + 0.200B}{0.667R + 1.132G + 1.200B} \quad \text{(Eq. 2)}$$

$$y = \frac{0.117R + 0.812G + 0.010B}{0.667R + 1.132G + 1.200B} \quad \text{(Eq. 3)}$$

$$z = \frac{0.000R + 0.010G + 0.990B}{0.667R + 1.132G + 1.200B} \quad \text{(Eq. 4)}$$

Eqs. 2-5 were used to convert the values of the average vectors R, G, and B of the image matrix into chromaticity coordinates x, y, and z, resulting in a spatial position within the axes of the chromaticity diagram. This approach avoided the occurrence of any false positive concentrations produced by analytical signals for solutions with colors different to that expected, and also enabled the identification of outliers by the prior establishment of a calibration set using samples with known concentrations of Fe^{3+}.

Table 1. Figures of merit for the proposed methods using a cellphone and a scanner.

Fe^{3+} concentration range (mmol L^{-1})			y = a [Fe^{3+} x 10^{-3} mmol L^{-1}]		Sum of squares	Residual sum of squares	N	RSD Curve (%)
				error(a)				
Cellphone	0.12 - 1.26	Gray		29	0.32	0.0103	15	0.040
		Green		13	0.25	0.0022	15	0.021
		Blue		45	1.1	0.0253	21	0.071
Scanner	0.12 - 1.26	Gray		8.2	0.17	0.0008	15	0.013
		Green		7.3	0.25	0.0007	15	0.012
		Blue		8.1	0.61	0.0008	15	0.013

Parameters for model validation

	Scanner				***Cellphone***			
	G	B	Grayscale	ED	G	B	Grayscale	ED
PRESS	7.3E-09	3.7E-09	1.4E-08	2.4E-08	4.0E-08	4.6E-08	6.2E-08	1.5E-08
RMSEP	2.2E-05	1.6E-05	3.1E-05	4.0E-05	6.7E-05	7.2E-05	8.3E-05	3.2E-05
MSEC	4.9E-10	2.5E-10	9.4E-10	1.6E-09	4.4E-09	5.1E-09	6.8E-09	1.0E-09

Table 2. Relative errors, comparing the image analysis methods with the reference gravimetric method.

Cell phone

	Fe (g) Gravimetry		Fe (g) GrayScale		Fe (g) Green		Fe (g) Blue		Fe (g) ED		Relative error (%)			
Time (h)	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Grey	Green	Blue	ED
1.5	0.0150	0.0008	0.0165	0.0062	0.0159	0.0020	0.0183	0.0075	0.0157	0.0017	9.50	5.70	21.6	4.10
3	0.0305	0.0018	0.0226	0.0040	0.0373	0.0039	0.0326	0.0028	0.0409	0.0049	25.9	22.5	7.00	34.1
6	0.0502	0.0067	0.0329	0.0214	0.0615	0.0076	0.0450	0.0177	0.0654	0.0086	34.3	22.5	10.3	30.4
9	0.0714	0.0153	0.0444	0.0057	0.0800	0.0095	0.0701	0.0024	0.0859	0.0106	37.8	12.0	1.90	20.3
12	0.0939	0.0012	0.0937	0.0155	0.1141	0.0095	0.1092	0.0024	0.1115	0.0113	0.200	21.6	16.3	18.8
15	0.1080	0.0016	0.0983	0.0095	0.0972	0.0207	0.1185	0.0060	0.0855	0.0117	9.0	10.1	9.70	20.9
18	0.1271	0.0047	0.1457	0.0028	0.1112	0.0101	0.1361	0.0047	0.1356	0.0124	14.6	12.5	7.00	6.60
21	0.1398	0.0063	0.1416	0.0058	0.1045	0.0078	0.1362	0.0046	0.1294	0.0120	1.30	25.3	2.60	7.50

Scanner

	Fe (g) Gravimetry		Fe (g) GrayScale		Fe (g) Green		Fe (g) Blue		Fe (g) ED		Relative error (%)			
Time (h)	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Grey	Green	Blue	ED
1.5	0.0150	0.0008	0.0169	0.0008	0.0159	0.0020	0.0156	0.0005	0.0181	0.0022	12.3	5.70	3.80	20.4
3	0.0305	0.0018	0.0399	0.0016	0.0373	0.0039	0.0374	0.0011	0.0424	0.0052	31.1	22.5	22.6	39.3
6	0.0502	0.0067	0.0664	0.0042	0.0615	0.0076	0.0621	0.0039	0.0711	0.0099	32.3	22.5	23.9	41.7
9	0.0714	0.0153	0.0839	0.0055	0.0800	0.0095	0.0790	0.0045	0.0889	0.0112	17.5	12.0	10.6	24.5
12	0.0939	0.0012	0.0988	0.0025	0.1141	0.0095	0.0984	0.0045	0.0972	0.0115	5.30	21.6	4.80	3.50
15	0.1080	0.0016	0.0879	0.0018	0.0972	0.0207	0.0972	0.0019	0.0784	0.0106	18.6	10.1	10.1	27.5
18	0.1271	0.0047	0.1350	0.0039	0.1112	0.0101	0.1249	0.0026	0.1447	0.0112	6.20	12.5	1.80	13.9
21	0.1398	0.0063	0.1597	0.0032	0.1045	0.0078	0.1494	0.0021	0.1698	0.0105	14.2	25.3	6.90	21.4

References

1 J. Passaretti Filho, J. F. da Silveira Petrucci and A. Alves Cardoso, *Talanta*, 2015, **140**, 73–80.