Development of a Simple Electrochemical Sensor for Determination of Trace Cadmium in Durian

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Abstract

This research presents the development of a simple electrochemical sensor for determination of cadmium contamination in durian. The sensor was constructed by modifying the surface of a screen-printed carbon electrode with carbon black. Differential Pulse Anodic Stripping Voltammetry (DPASV) was employed as the analytical technique. This study conducted systematic investigations to optimize the electrode surface modification and experimental conditions to improve analytical performance. The parameters examined included the type of modifier used for electrode surface modification, volume of the deposited modifier, concentration of bismuth solution, pH of the supporting electrolyte, deposition potential, deposition time, and rotation speed of the stirrer. The optimized sensor demonstrated a linear range of 5-100 ppb. The limit of detection (LOD) was 1.3 ppb, and the limit of quantification (LOQ) was 4.3 ppb. The precision of the method, expressed as the relative standard deviation (%RSD) cadmium was in the range of 4.51 to 9.38. Application of developed method to the determination of cadmium in durian samples resulted in percentage recoveries of cadmium ranging from 85.30 to 96.56. Furthermore, when compared with the standard method based on Graphite Furnace Atomic Absorption Spectroscopy (GFAAS), percentage recoveries of cadmium ranging from 99.45 to 99.60 were found. The results of the analysis showed that there was no statistically significant difference between the two methods at the 99% confidence level, indicating the reliability of the method.

Introduction

CADMIUM
≤ 0.05 mg/kg



The accumulation of cadmium in the soil-plant environment mainly through anthropogenic activities. Cadmium exposure has been reported to be associated with chronic kidney disease and cancer. Strict regulatory standards have been established to control cadmium contamination in food products. For the export of Thai durian to China, compliance with GB 2762-2022, is required. For fresh fruits such as durian, the maximum allowable cadmium level is 0.05 mg/kg.

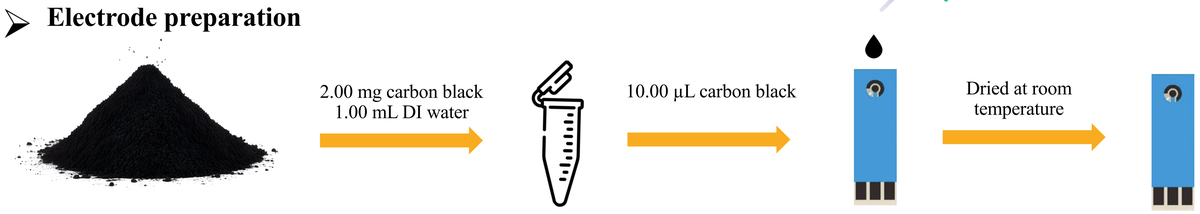
Differential Pulse Anodic Stripping Voltammetry (DPASV)

Preconcentration step $Cd^{2+} + 2e^- \rightarrow Cd^0$

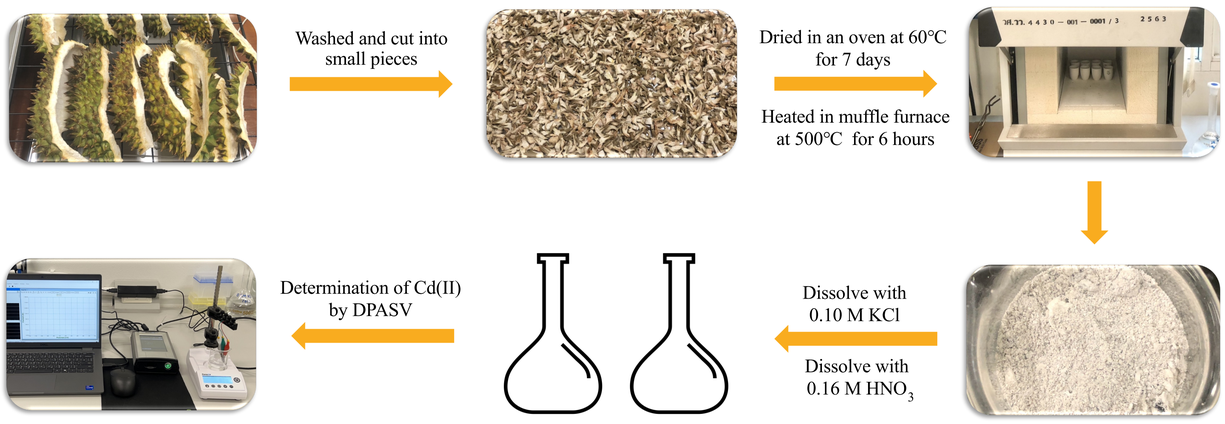
Stripping step $Cd^0 \rightarrow Cd^{2+} + 2e^-$

Experiment

➢ **Electrode preparation**



➢ **Sample preparation and analysis**



Results and Discussion

➢ **The optimal conditions for cadmium(II) analysis by DPASV**

Table 1 The optimal conditions for cadmium(II) analysis by DPASV

Experimental parameters	Optimal conditions
Composite material	Carbon black
Volume of carbon black (uL)	10.0
pH of acetate buffer	4.0
Concentration of bismuth (ppb)	400
Deposition potential (mV)	-1200
Deposition time (s)	180
Rotation speed of stirrer (rpm)	800

➢ **Analytical performance**

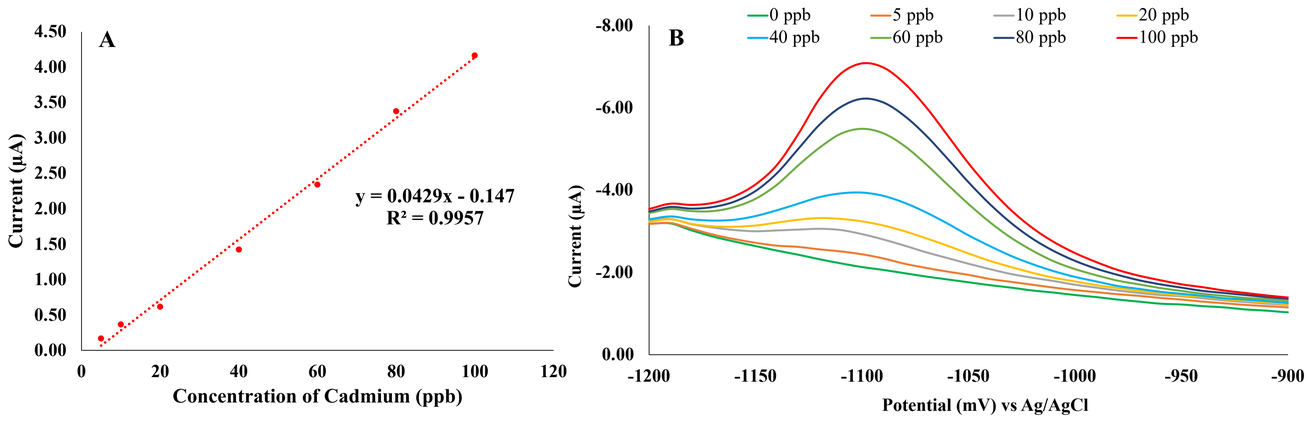


Fig. 1. A) The corresponding calibration plots for the determination of cadmium(II) B) Differential pulse voltammogram of 0-100 ppb of cadmium(II)

Table 2 Validation parameters for the determination of cadmium(II)

Analytical parameters for Cd(II) (ppb)	
Linearity	5-100
LOD	1.30
LOQ	4.30
Precision	4.51

➢ **Real sample analysis**

Table 3 Cadmium(II) in durian samples by the developed method (DPASV)

Sample	Spiked Cd(II) (ppb)	Found (ppb)	Developed method recovery (%)	Standard method recovery (%)
Durian ash in 0.10 M KCl	0	n.d.	-	-
	20	18.48	92.40	99.45
	30	26.36	87.86	99.57
Durian ash in 0.16 M HNO_3	0	n.d.	-	-
	20	17.06	85.30	99.60
	30	28.97	96.56	99.53

Conclusions

- ❑ The screen-printed carbon electrode (SPCE) was developed by modifying the working electrode surface with carbon black to increase surface area and improve sensitivity.
- ❑ The percentage recoveries of cadmium in spiked samples were 92.40 and 87.86 for the sample in 0.10 M KCl and 85.30 and 96.56 for sample in 0.16 M HNO_3
- ❑ The analytical results from the developed method were in excellent agreement with those obtained from the standard method, indicating the reliability of the developed method

References

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Acknowledgements

I would like to express my sincere gratitude to my project advisor, Assoc. Prof. Dr. Jaroon Jakmunee, for his guidance and support throughout this project. I would also like to extend my heartfelt appreciation to Dr. Jaroon Junsomboon, Dr. Pijika Mool-Am-Kha, and Dr. Tharinee Sridara at the Department Science Service (DSS) for their supervision and assistance during the cooperative education training.