VIETNAM NATIONAL UNIVERSITY, HANOI
VNU UNIVERSITY OF ENGINEERING AND TECHNOLOGY

SOCIALIST REPUBLIC OF VIETNAM
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INFORMATION ON DOCTORAL THESIS

1. Full name: Huynh Thi Thuy Linh 2. Sex: Female

3. Date of birth: 06/05/1986 4. Place of birth: Hue city

5. Admission decision number: 25/QĐ-CTSV . Dated: 14/01/2022

6. Official thesis title: "Research and Development of a Lab-on-a-Chip Device for Diagnosing White Spot Syndrome Virus in Penaeid Shrimps"

7. Major: Electronic Engineering 8. Code: 9520203

9. Supervisors:

- Chu Duc Trinh, Professor, Ph.D
- Cao Viet Hung, Associate Professor, Ph.D

10. Summary of the new findings of the thesis:

White spot disease caused by WSSV (White Spot Syndrome Virus) is one of the most devastating diseases affecting the shrimp farming industry, reducing productivity and causing substantial economic losses in Vietnam and many shrimp-producing countries worldwide. Although PCR (Polymerase Chain Reaction) is widely used for WSSV diagnosis with high accuracy, its reliance on specialized laboratories, expensive instrumentation, and trained personnel limits its practical use for on-site detection. In response to the urgent need for a rapid, cost-effective, and user-friendly diagnostic solution, this thesis focused on the research, design, and development of a portable electrochemical biosensing system integrated with Internet of Things (IoT) technology for the on-site detection of VP28, a specific biomarker of WSSV.

The dissertation adopted an interdisciplinary approach that combined materials technology, surface chemistry, molecular biology, electrochemistry, electronic engineering, and embedded systems. The electrode surface was enhanced by electrochemical deposition of gold nanoparticles to increase the electroactive surface area and improve charge-transfer characteristics. Subsequently, a self-assembled monolayer (SAM) of 11-Mercaptoundecanoic acid (11-MUA) was formed and activated using EDC/NHS chemistry to immobilize anti-VP28 antibodies, thereby creating a highly specific biorecognition layer. The surface modification and biosensing processes were characterized using cyclic voltammetry (CV), square wave voltammetry (SWV), and electrochemical impedance spectroscopy (EIS), together with scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), fluorescence microscopy, and Western blot analysis. In parallel, the portable electrochemical measurement device was developed based on a microcontroller platform, analog measurement circuit, and the MQTT communication protocol for real-time data acquisition, processing, and wireless transmission to computers or mobile devices.

The experimental results demonstrated that gold nanoparticle deposition significantly improved the electrochemical performance of the electrode, the 11-MUA SAM enabled efficient antibody immobilization and preserved highly specific recognition of VP28. The resulting biosensor exhibited high sensitivity, good selectivity, stable responses, and excellent repeatability. Tests performed on shrimp samples positive for WSSV produced results consistent with PCR, confirming the reliability of the proposed system. The portable electrochemical device operated stably and proved suitable for field deployment, remote monitoring, and IoT-based data integration.

The principal contribution of this thesis is the successful development of a complete electronic measurement system integrating an electrochemical biosensor, measurement hardware, signal-processing software, and an IoT communication platform for rapid WSSV detection. The findings not only provide a scientific foundation for the development of electrochemical protein biosensors but also demonstrate the capability to design, fabricate, and integrate specialized electronic systems for biological diagnostics. The proposed system has the potential to be applied in shrimp farms, hatcheries, and aquatic diagnostic laboratories, and could be further extended to detect other pathogens in agriculture, environmental monitoring, and biomedical applications. Future work will focus on improving sensitivity, long-term stability, industrial design, and integrating artificial intelligence algorithms to enhance data analysis, early warning, and real-time disease monitoring.

14. Thesis-related publications: 08 publications

A. Journal

[1] Linh Huynh Thi Thuy, Phu Nguyen Dang, Loc Do Quang, Tung Thanh Bui, Hanh Hong Mai, Chun-Ping Jen, Hung Cao, Trinh Chu Duc, *"Critical Role of 11-Mercaptoundecanoic Acid and L-Cysteine Self-Assembled Monolayers in Electrochemical Immunosensor Development"*, (2026), Journal of Applied Electrochemistry (Electronic ISSN: 1572-8838, Print ISSN: 0021-891X), Vol. 56, No. 115, https://doi.org/10.1007/s10800-026-02496-1, Impact Factor: 3.0, WoS Q2.

[2] Linh Huynh Thi Thuy, Phu Nguyen Dang, Hung Cao, Anh H. Nguyen, Jung-Chih Chiao, Chun-Ping Jen, Loc Do Quang, Trinh Chu Duc, and Tung Thanh Bui, *"Electrodeposition of Gold Nanoparticles for a Highly Sensitive Immunosensor for White Spot Syndrome Virus (WSSV) Envelope Protein VP28 Detection Based on Electrochemical Impedance Spectroscopy Technique"*, (2024), IEEE Sensors Journal (ISSN: 1530-437X/1558-1748), Vol. 24, No. 22, p36350-36357, https://doi.org/10.1109/JSEN.2024.3468318. Impact Factor: 4.32, WoS Q1.

[3] Linh Huynh Thi Thuy, Minh Le Quang Nhat, Phu Nguyen Dang, Hung Cao, Hung Anh Nguyen, Jung-Chih Chiao, Chun-Ping Jen, Loc Do Quang, Trinh Chu Duc, and Tung Thanh Bui, *"Wireless and Portable Electrochemical Measurement System Integrated with Screen-Printed Immunosensor for VP28 Protein Detection"*, (2024), IEEE Sensors Letters (ISSN: 24751472), Vol. 8, No. 10, p4503204, https://doi.org/10.1109/LSENS.2024.3432588. Impact Factor: 2.78, WoS Q2.

[4] Linh Huynh Thi Thuy, Chun-Ping Jen, Guan-Da Syu, Nha Vo Quang, Cuong Ngo Xuan, Loc Do Quang, Phu Nguyen Dang, Tung Bui Thanh, Trinh Chu Duc, *"Enhancing the Self-Assembled Monolayer Formation for Protein Detection Platform through L-Cysteine Utilization"*, (2024), Hue University Journal of Science: Techniques and Technology (pISSN: 2588-1175, eISSN: 2615-9732), Vol. 133, No. 2B, p5-15, https://doi.org/10.26459/hueunijtt.v133i2B.7366.

B. Conference Proceedings

[5] Linh Huynh Thi Thuy, Phu Nguyen Dang, Hung Cao, Hung Anh Nguyen, Jung-Chih Chiao, Chun-Ping Jen, Loc Do Quang, Trinh Chu Duc, Tung Thanh Bui, *"A Highly Sensitive Immunosensor for White Spot Syndrome Virus (WSSV) Envelope Protein VP28 Detection Based on Electrochemical Impedance Spectroscopy Technique"*, (2023), IEEE SENSORS Conference, IEEE Xplore (ISBN:979-8-3503-0387-2, ISSN: 2168-9229), p1-4, https://doi.org/10.1109/SENSORS56945.2023.10325273.

[6] Linh Huynh Thi Thuy, Phu Nguyen Dang, Chi Tran Nhu, Thuy Nguyen Tran, Trung Le Thanh, Huu Nguyen Cong, Chun-Ping Jen, Loc Do Quang, Trinh Chu Duc, Tung Thanh Bui, *"Novel Electrochemical Immunosensing Structure Based on a Functionalized Carbon Electrode with 11-MUA for NSE Protein Detection"*, (2023), International Conference on Health Science and Technology – ICHST Conference, IEEE Xplore (ISBN: 979-8-3503-1571-4), p1-4, https://doi.org/10.1109/ICHST59286.2023.10565337.

[7] Huynh Thi Thuy Linh, Nguyen Dang Phu, Tran Nhu Chi, Do Quang Loc, Bui Thanh Tung, Tran Thi Thuy Ha and Chu Duc Trinh, *"An Effective Carbon Electrode Modification Process for Protein Detection Based on Gold Nanoparticles and Immunosensing Approach"*, (2023), International Workshop on Advanced Materials and Devices – IWAMD Conference, Thai Nguyen University Publishing House (ISBN: 978-604-350-270-1), p34-37.

[8] Linh Huynh Thi-Thuy, Nha Vo Quang, Cuong Ngo Xuan, Thuan Nguyen Duy, Loc Do Quang, Tung Bui Thanh, Phu Nguyen Dang, Trinh Chu Duc, *"Application of Electrochemical Sensor System in Detecting White Spot Syndrome Virus: A Review"*, (2022), Asian Pacific Federation for Information Technology in Agriculture – APFITA Conference, Vietnam National University press, Hanoi, (ISBN: 978-604-9990-32-8), p230-238.

Date: 21/7/2026
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