Internship Report on

“Nano-Enabled Forensic Approaches for Pesticide Residue Analysis and Toxicological Investigations”

To

K.R. MANGALAM UNIVERSITY

Completed at

Idyllic Futuristic Technologies LLP, Noida

Internship period: 1st April 2025 to 30th April 2025

Submitted by:

Ayush Tyagi [2403212004]

Internship Certificate

Certified that **Mr. Ayush Tyagi,** B.Sc. Forensic Science (Enrollment no. 2403212004.) from K.R. Manglam University, Gurugram, Haryana has successfully Completed Internship from Idyllic Futuristic technologies LLP, Noida (U.P), from 1/04/2025 to 30/04/2025

During the internship period, he was involved in various tasks and projects related to **Department of Forensic Science**.He demonstrated a keen interest in learning and showed enthusiasm, punctuality, and professionalism throughout the tenure.

The internship was undertaken as part of academic/professional training and has been completed satisfactorily.

Date- 12.05.2025

Air. Cmdr. R. N. Gaekwad
Director
(Idyllic Futuristic Technologies LLP)

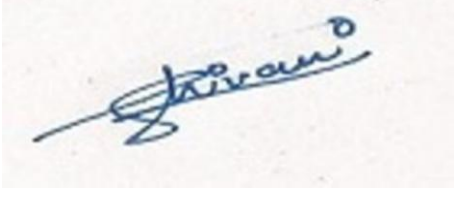
Declaration

I declare that this written submission represents work in my own words and where others' ideas or words have been included. I also declare that I have adhered to all academic principals of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/Source in my Submission. I understand that any violation of the above will be Cause for Disciplinary action by the university and can also evoke penal action from whom proper permission has not been taken when needed



Student Name: Ayush Tyagi

Roll Number: 2403212004'



Dr. Shivani Sehgal

Assistant Professor

SBAS

Acknowledgement

I extend my heartfelt thanks to my supervisor, Air. Cmdr. R. N. Gaekwad (Director), for his mentorship and for entrusting me with this exciting project. My gratitude also goes to the entire team at Idyllic Futuristic Technologies LLP for their constant support and guidance and exposing me with real life knowledge. Finally, I thank K.R. Mangalam University for facilitating this invaluable industry exposure.



Student Name: Ayush Tyagi

Roll Number: 2403212004’

Date: 03-07-2025

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Abstract

The study investigates the application of nanotechnology in forensic science, specifically for pesticide residue detection and analysis as well as their toxicological impacts. The use of nanomaterials, including carbon nanotubes, gold nanoparticles, and quantum dots, provides more sensitivity and specificity in trace pesticide detection in biological and environmental samples. By exploiting the special characteristics of nanomaterials—high surface area, enhanced reactivity, and modifiable optical and electrical behaviour—this method enhances the precision and efficiency of forensic analysis. The study encompasses the fabrication of Nano-enabled sensors for pesticide detection, with subsequent toxicological studies to analyse the effect of the residues on human health and the environment. The studies seek to develop new, high-throughput approaches in forensic toxicology, in the long term, impacting public safety and environmental protection.

Introduction

Purpose of the Internship: This internship was aimed at exploring advanced analytical techniques in forensic toxicology. The goal was to understand and apply nanotechnology-based methods for the rapid and sensitive detection of pesticide residues in environmental or biological samples.

Company/Organization: Idyllic Futuristic Technologies: is a multi-disciplinary R&D start up. While focused on defence, its expertise in material science and futuristic technologies provides a unique environment for developing dual-use innovations, including advanced sensors for forensic and environmental monitoring.

My Role: As a Research Intern, my responsibilities included the synthesis and characterization of gold nanoparticles (AuNPs), conducting a literature review on Nano-sensors, and performing experimental work to develop a colorimetric assay for pesticide detection.

Motivation: My academic curriculum in forensic chemistry and toxicology sparked a strong interest in trace evidence analysis. This internship was a perfect opportunity to work with cutting-edge nanotechnology and see its direct application in creating more efficient and field-deployable forensic tools.

Organization Profile

Idyllic Futuristic Technologies LLP is an active limited liability partnership incorporated on November 9, 2022, and based in Vadodara, Gujarat, India. Specializing in the manufacturing of machinery and equipment as well as cutting-edge technology solutions, the organization leverages the expertise of industry veterans to support innovation in fields such as aerospace, defence, artificial intelligence, cyber security, and precision engineering. With a paid-up capital of ₹1,00,000 and a dynamic team of partners, Idyllic Futuristic Technologies LLP is committed to advancing indigenous technologies through the "Make in India" initiative and fostering collaborations between industry, academia, and MSMEs for national and commercial impact.

Work/Project Description

Key Responsibilities:

- Synthesizing Gold Nanoparticles (AuNPs) using the Turkevich method.
- Characterizing the synthesized AuNPs using UV-Visible Spectroscopy.
- Preparing standard solutions of the organophosphate pesticide, Malathion.
- Developing and optimizing a colorimetric detection method for Malathion.
- Analyzing and documenting the spectral and visual data obtained.

Project Overview:

The project focused on developing **colorimetric Nano sensor for Malathion detection**. Gold nanoparticles exhibit a distinct ruby-red colour due to a phenomenon called Surface Plasmon Resonance (SPR). The principle of this project is that in the presence of pesticides like Malathion, these nanoparticles aggregate or clump together. This aggregation alters their optical properties, causing the SPR to shift and resulting in a visible colour change from **red to blue/purple**. This colour change can be observed visually for qualitative screening and measured with a spectrophotometer for quantitative analysis.

Tools/Technologies Used:

- UV-Visible Spectrophotometer
- Magnetic Stirrer with Hot Plate
- Glassware (Conical flasks, Beakers, Pipettes)
- pH meter
- Analytical Weighing Balance

Skills and Knowledge Acquired

Skills Developed:

- **Technical Skills:** Gained hands-on experience in nanoparticle synthesis (wet chemistry), operation of a UV-Visible Spectrophotometer, preparation of micro-molar analytical standards, and data interpretation
- **Soft Skills:** Developed critical thinking for troubleshooting experiments, meticulous record-keeping, and the ability to present complex scientific data in a clear and concise manner.

Key Takeaways: The most significant takeaway was the immense potential of nanotechnology in revolutionizing forensic science. The ability to create a simple, rapid, and highly sensitive visual detection system for toxic substances has profound implications for field investigations and environmental protection.

Challenges and Solutions

Challenges Faced:

1. Stability of Nanoparticles: The initial batches of synthesized AuNPs were unstable and would aggregate prematurely, even without the pesticide, leading to false-positive results.
2. Reproducibility: Achieving the exact same particle size and concentration across different synthesis batches was challenging, affecting the consistency of results.
3. Potential Interference: There was a concern that other ions or organic matter in a real-world sample (e.g., soil extract) could interfere with the assay.

- How I Overcame Them:

1. The stability issue was resolved by carefully controlling the pH and temperature during synthesis and by ensuring the glassware was scrupulously clean. A citrate buffer was also used to stabilize the final solution.

2. A strict Standard Operating Procedure (SOP) was established for the synthesis process, precisely controlling reaction time, temperature, and the rate of reagent addition to improve batch-to-batch reproducibility.
3. For future work, a sample pre-treatment step (e.g., Solid Phase Extraction) was proposed to minimize matrix interference before analysis with the Nano sensor.

Observations and Reflections

Colorimetric Detection of Malathion using Gold Nanoparticles

The synthesized AuNPs showed a characteristic ruby-red colour with an SPR peak at 520 nm. Upon introducing varying concentrations of Malathion, a distinct colour change was observed, and the SPR peak shifted to longer wavelengths (a "red-shift").

Conclusion

- Summary of the Experience: The internship at Idyllic Futuristic Technologies LLP was an exceptional learning journey. It provided me with a unique opportunity to work at the intersection of nanotechnology and forensic science. The project successfully demonstrated a proof-of-concept for a Nano-enabled sensor, enhancing my practical skills and research acumen
- Impact on Future Plans: This experience has solidified my desire to pursue a career in forensic research and development. I am now keen on exploring master's programs that focus on advanced forensic analytical techniques or nanotechnology. My goal is to contribute to the development of next-generation tools that can make forensic investigations faster, more accurate, and more accessible.