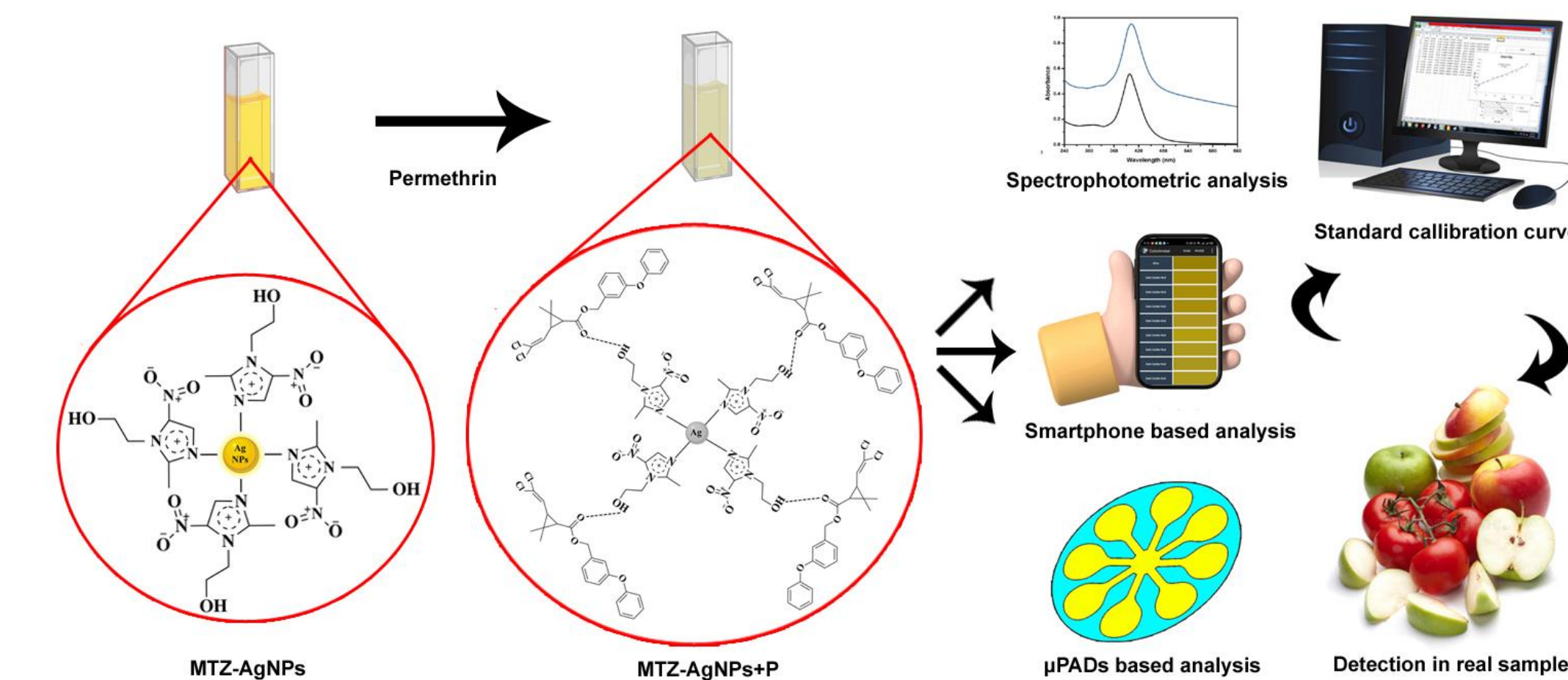


# Smartphone-Integrated Optical Sensing Devices for Detection of Permethrin Residues Using Functionalized Nanoparticles

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## Introduction and Objectives

Pesticide residues pose health risks, including hormone disruption, cancer, asthma, and allergies. Permethrin is classified as a restricted-use substance due to suspected carcinogenicity. Conventional methods require specialized equipment and trained personnel. Next generation sensors, including colorimetric techniques with noble metal nanoparticles, offer accurate on-site detection. The current research introduces metronidazole functionalized silver nanoparticles (MTZ-AgNPs) for permethrin detection, featuring colorimetric changes and smartphone integration.

## Methodology

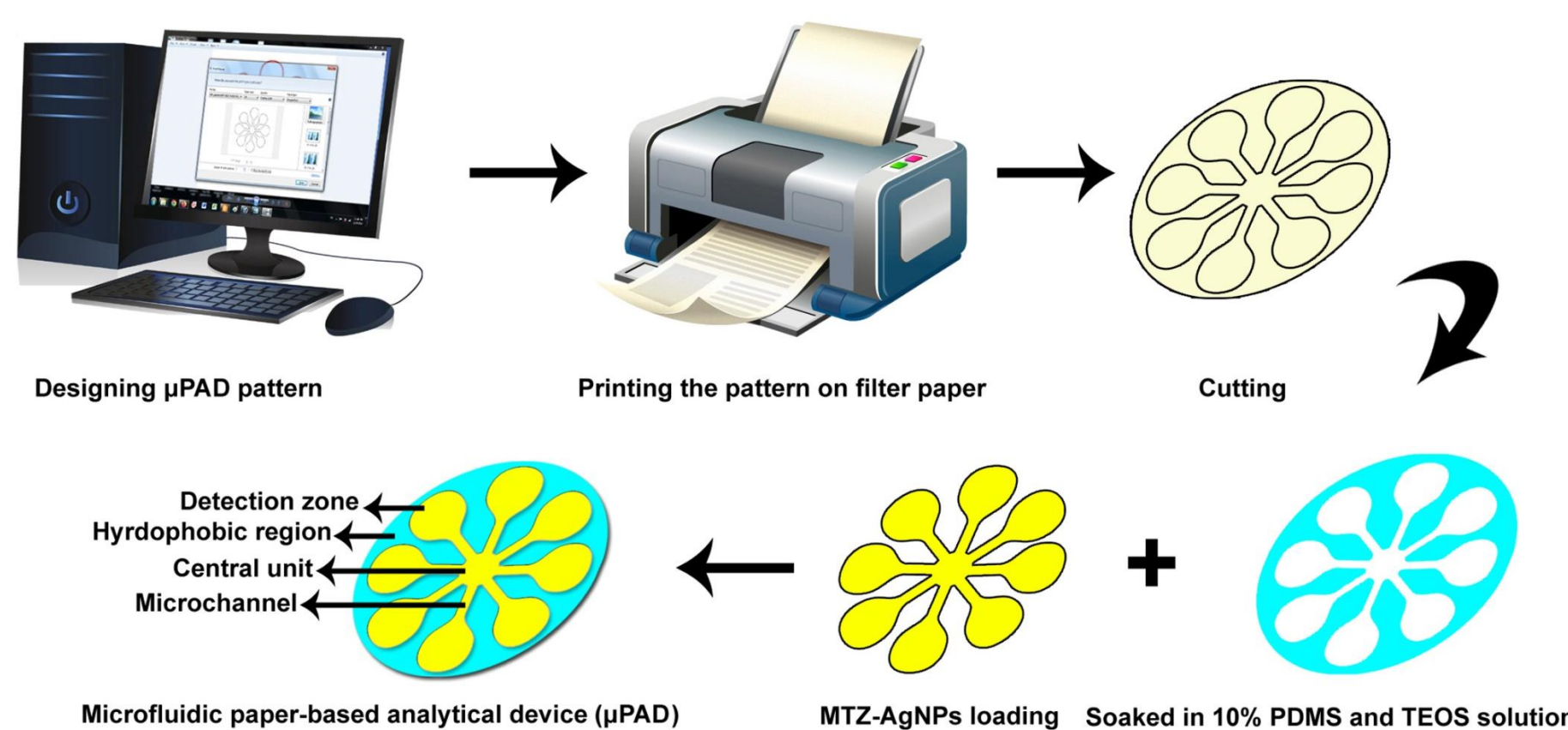
**Synthesis of MTZ-AgNPs:** Colloidal MTZ-AgNPs were prepared using  $\text{AgNO}_3$ ,  $\text{NaBH}_4$ , and metronidazole, resulting in a bright yellow solution with confirmed LSPR.

**Spectrophotometric & Colorimetric Sensing:** Permethrin induced increased LSPR absorbance and color change in MTZ-AgNPs, allowing concentration-dependent detection.

**Smartphone-Assisted Detection:** A smartphone-based method analyzed images to determine permethrin concentration using RGB data and calibration plots.



**Microfluidic Paper-Based Analytical Device (μPAD):** μPADs were fabricated with hydrophobic barriers. MTZ-AgNPs were loaded, and permethrin solutions induced color changes, quantified through image analysis.



## Results & Discussion

### Detection strategies of Permethrin:

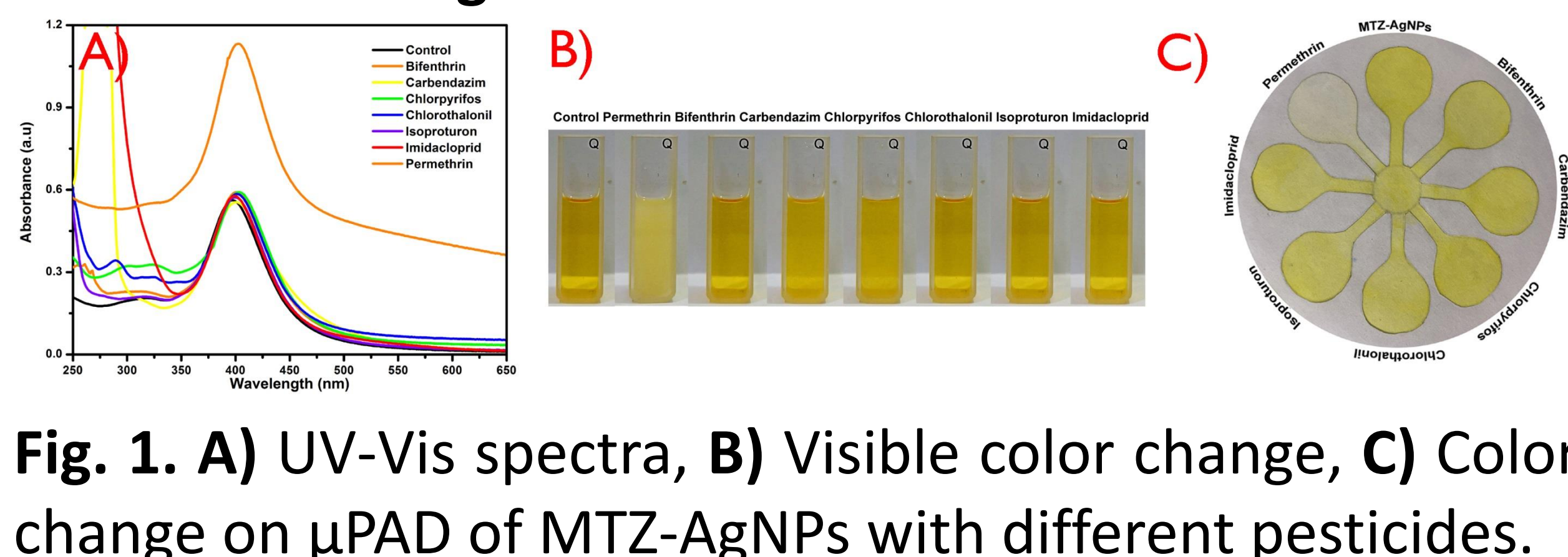


**Fig. 1.** A) UV-Vis spectra, B) Visible color change, C) Color change on μPAD of MTZ-AgNPs with different pesticides.

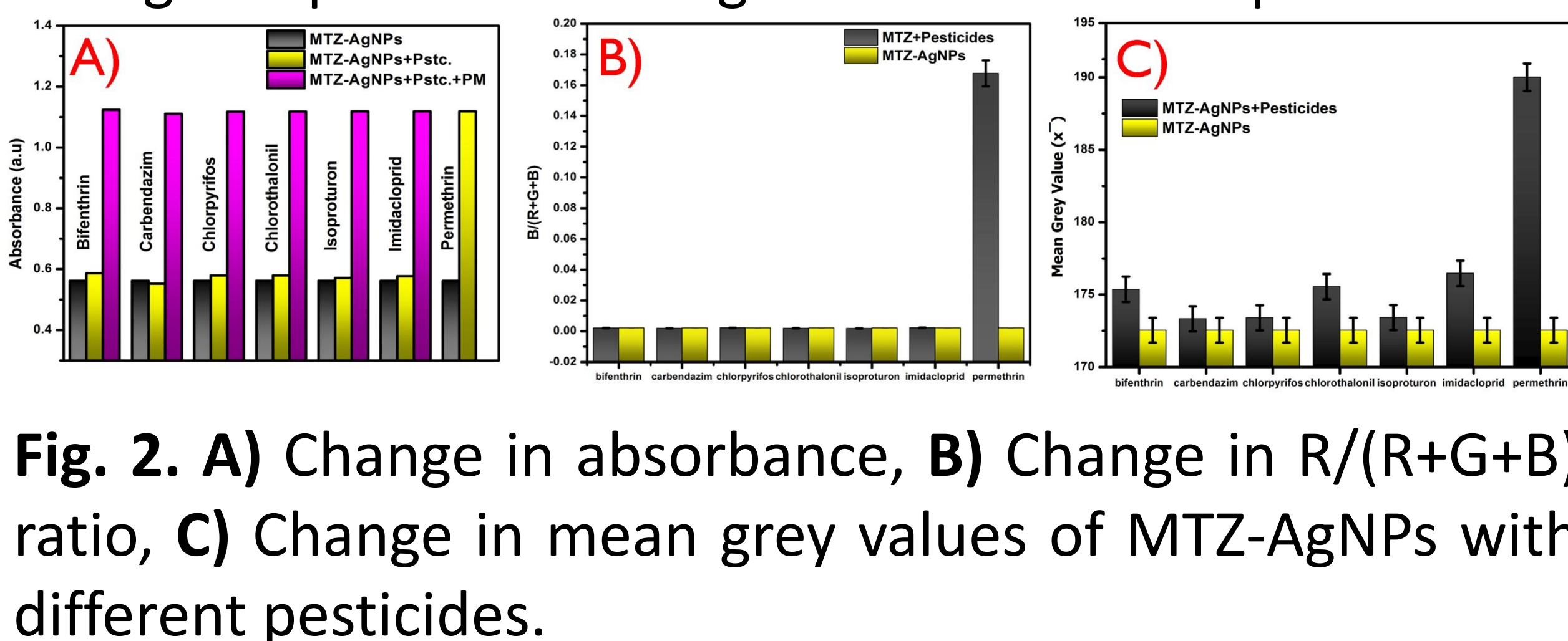


**Fig. 2.** A) Change in absorbance, B) Change in R/(R+G+B) ratio, C) Change in mean grey values of MTZ-AgNPs with different pesticides.

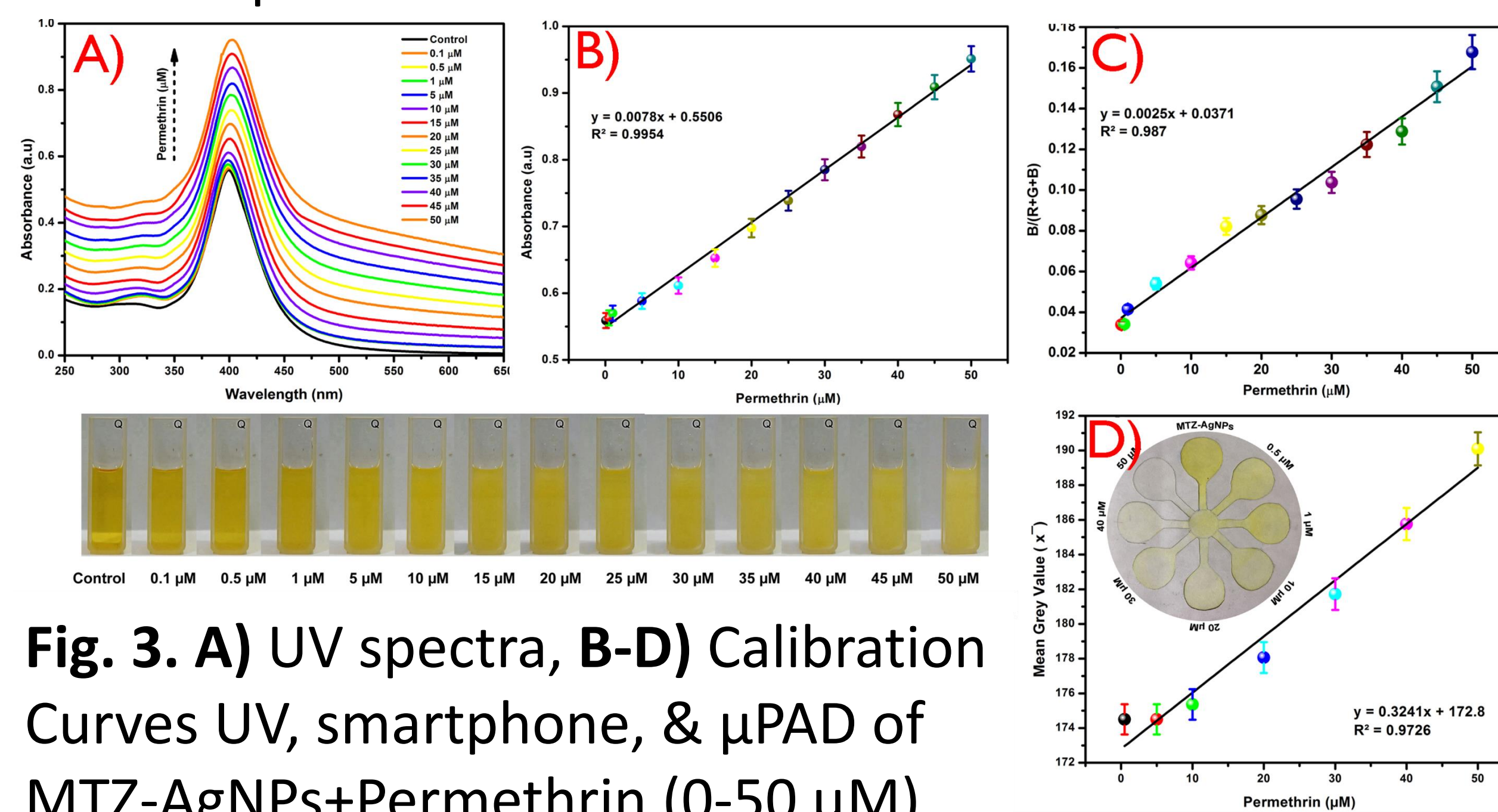


**Fig. 3.** A) UV spectra, B-D) Calibration Curves UV, smartphone, & μPAD of MTZ-AgNPs+Permethrin (0-50 μM).

### Characterization:

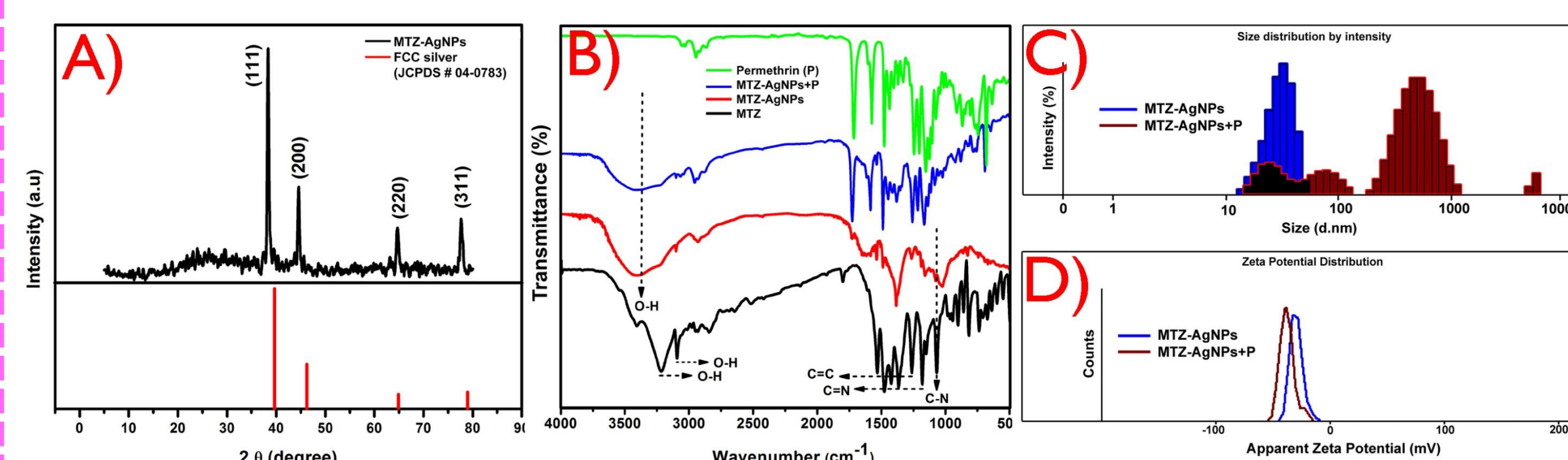


**Fig. 4.** A) XRD pattern of MTZ-AgNPs, B) FTIR Spectra of MTZ, MTZ-AgNPs+Permethrin, C-D) DLS and Zeta Potential spectra of MTZ-AgNPs and MTZ-AgNPs+Permethrin.

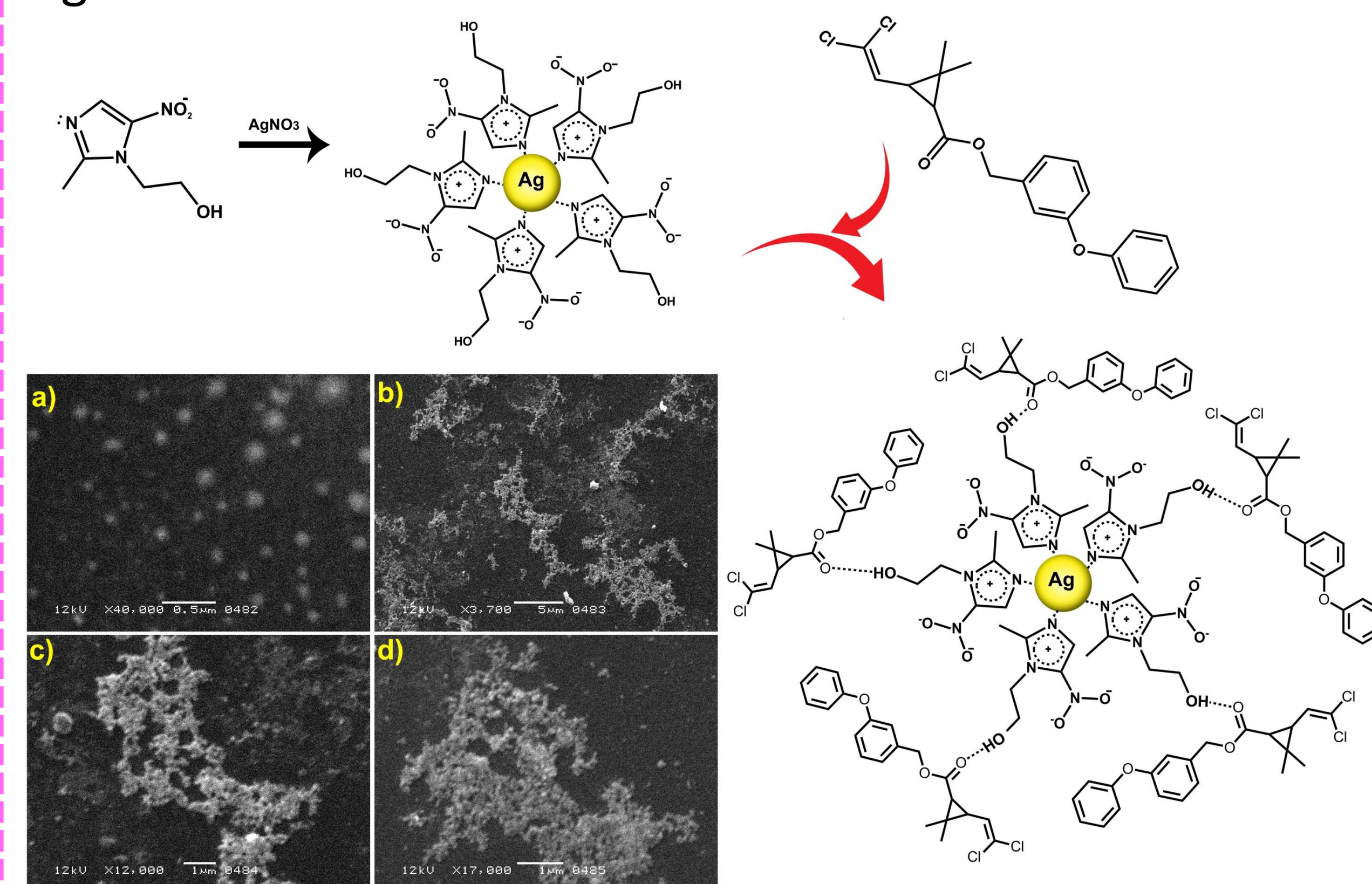


**Fig. 5.** SEM micrographs of MTZ-AgNPs (a), MTZ-AgNPs+Permethrin (b-c) and mechanism of Permethrin detection.

## Conclusion

MTZ-AgNPs enable efficient permethrin detection. Color changes are integrated with smartphones for rapid onsite detection. μPADs offer practical onsite testing for permethrin. Noble metal nanoparticles, especially silver, enhance colorimetric sensing. This research opens doors to user-friendly pesticide detection methods. Contributes to food safety, environmental protection, and public health.

## References

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