



Develop the Nanoscale Bacteriostatic and Phosphate fertilizers for Agriculture applications

Che-Kuang Chang¹, Hui-Lin Su¹, Yi-Chan Chang¹, Bo-Yan Lin¹, Yi-Hsin Chien^{1*}

¹ Department of Materials Science and Engineering, Feng Chia University, Taichung, Taiwan

E-mail address: yhchien@fcu.edu.tw

Abstract

Recently, the excessive use of chemical fertilizers and pesticides often cause soil acidification and human body damage. In the view of the toxicity issue, the policy of "Halving Chemical Pesticides in ten years" have been announced from Taiwan government. Meanwhile, the concept of green growth and sustainable development has gradually become a global trend, especially green agri-food is one of the key development projects. Therefore, many researchers are dedicated to optimize new methods of making fertilizer and pesticides which not only stabilized the ecological diversity of the soil, but also enhanced the crop yield efficiently. In this study, we synthesized nano-hydroxyapatite (nHA) with high biocompatibility by the sol-gel method, as the phosphate fertilizer in *Ipomoea aquatica* that could be absorbed effectively in organic farming. In addition, we developed eco-friendly and biodegradable nano-antibacterial composite material—silver nanoparticles doped chitosan hydrogel (Ag-CS), which inhibited the growth of *Ralstonia solanacearum* bacteria. During Ag-CS incubate with bacterial, those Ag⁺ can be released and effectively inhibit the growth of *Ralstonia solanacearum* at the 100ppm Ag NPs addition for over 84 hours.

Methods and Results

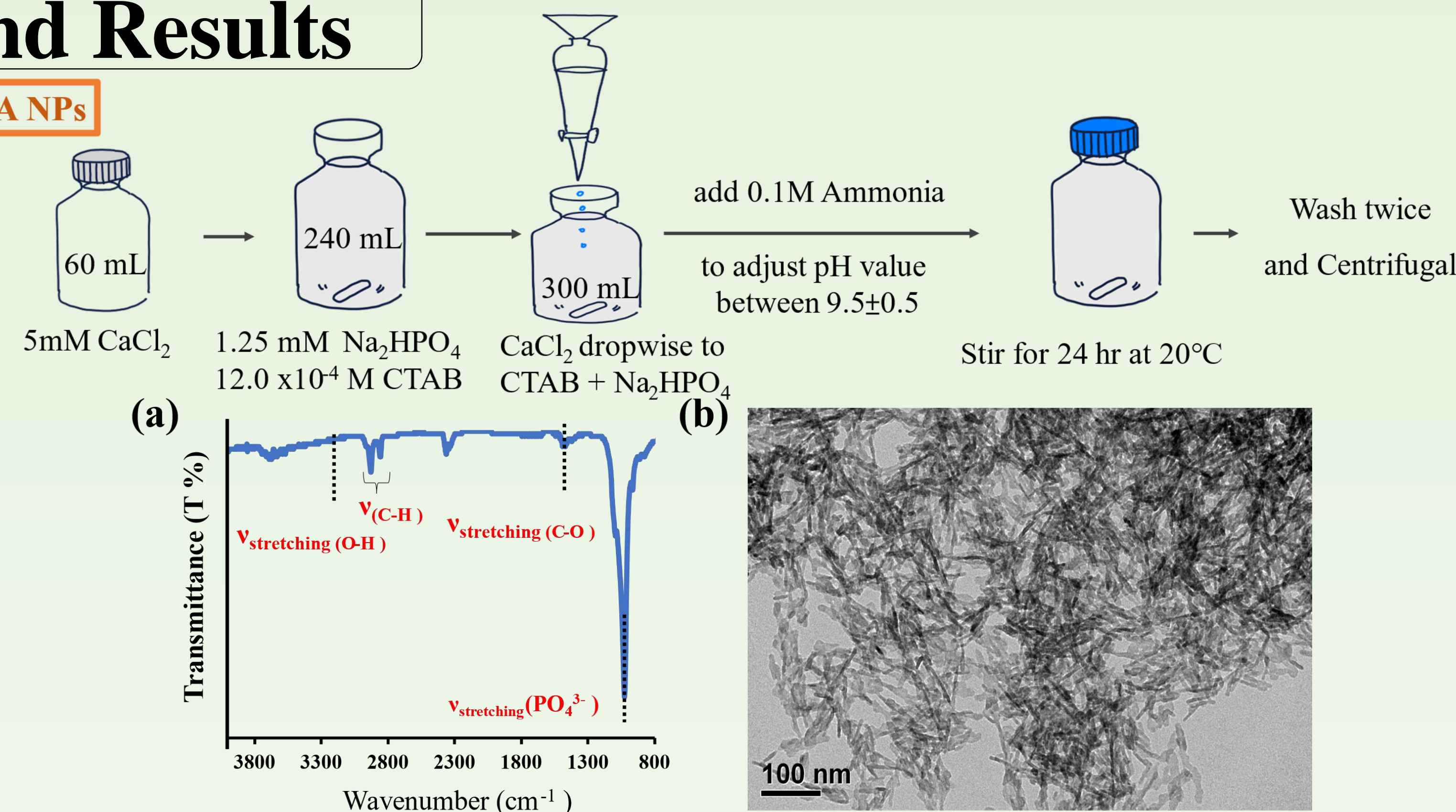
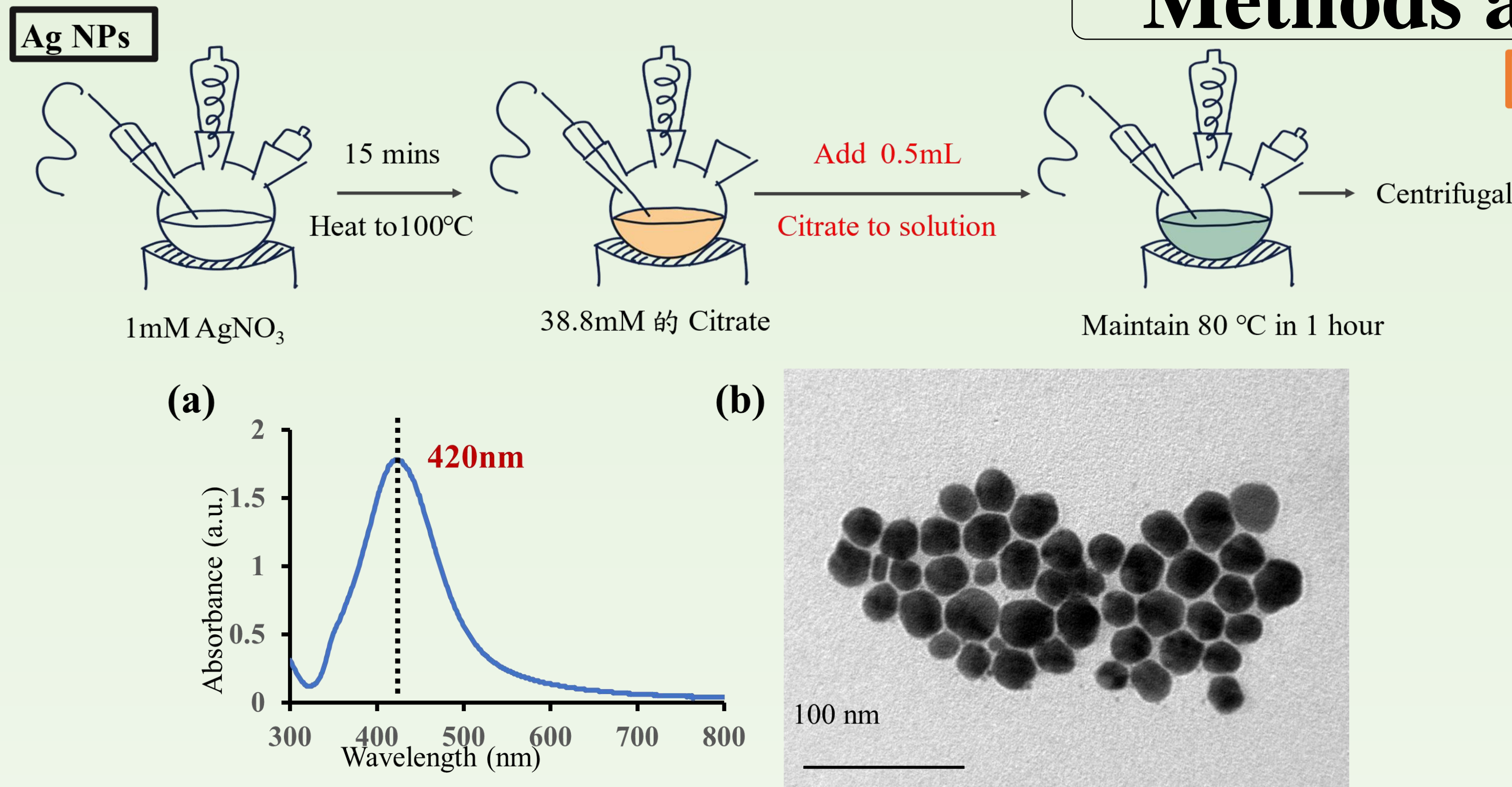


Figure 1. (a) UV-vis spectra of AgNPs (b) TEM image of AgNPs

Figure 2. (a) FTIR spectra of HaNPs (b) TEM image of HaNPs

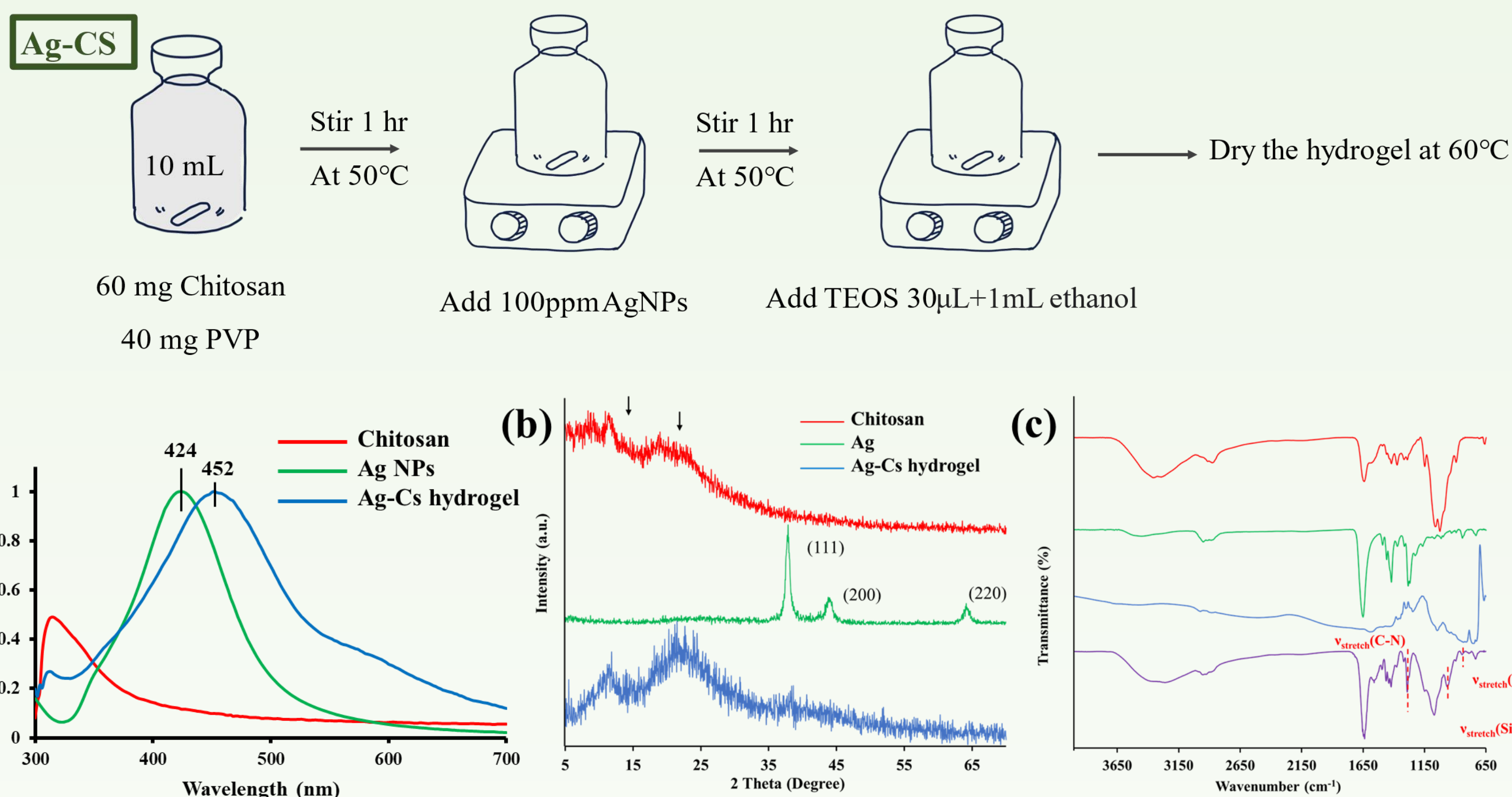


Figure 4. (a) UV-vis spectra of Ag-CS (b) XRD spectra of Ag-CS (c) FTIR spectra of Ag-CS

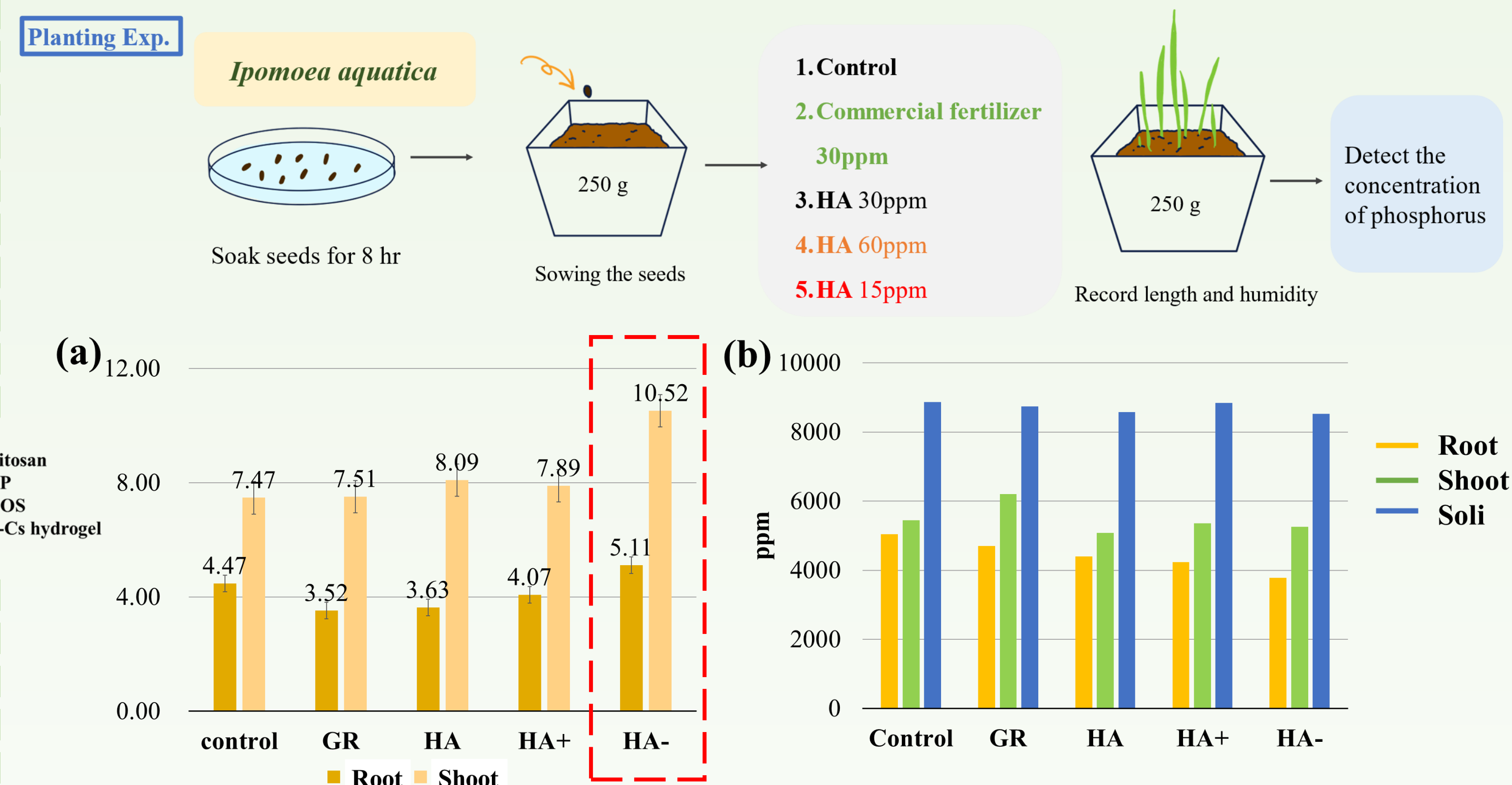


Figure 3. (a) Average length of shoots and roots of *Ipomoea aquatica* under the treatment of control, commercial fertilizer (GR), 30ppm nHA (HA), 60ppm nHA (HA+) and 15ppm nHA (HA-). (b) Residual phosphorus content in the soil, shoots and roots.

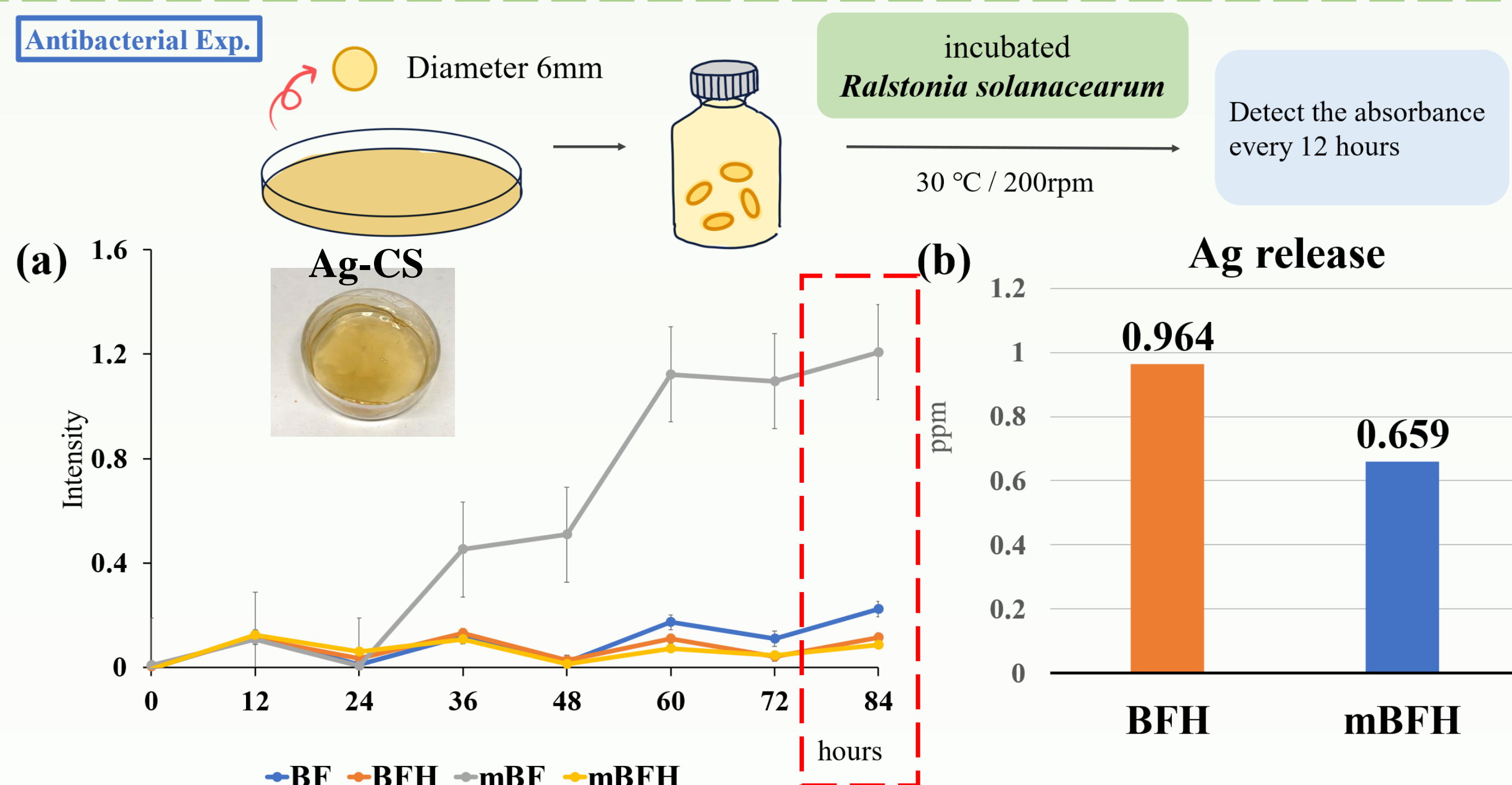


Figure 5. (a) Comparison of the absorbance of different concentrations of chitosan hydrogel, bacteria + commercial fertilizer solution (BF), bacteria + commercial fertilizer + Ag-CS solution (BFH), bacteria + ratio of fertilizer and NB medium was 9:1 solution (mBF), bacterial + ratio of fertilizer and NB medium was 9:1 + Ag-CS solution (mBFH) (b) Comparison of the release of Ag⁺.

Conclusion

In the planting experiment, we used nHA as the main phosphate fertilizer in *Ipomoea aquatica* resulting improved the growth performance on root and shoot at 15 ppm nHA. Next, the biodegradable Ag-CS was treated into *Ralstonia solanacearum* mixture. The UV-Vis absorbance result of anti-bacterial presented the mixture containing Ag-CS did not significantly increase in OD_{600nm} within 84 hours due to the Ag⁺ release with 0.964ppm (BFH) and 0.659ppm (mBFH), respectively. In the future, we expected that combination of the nHA and Ag-CS nanocomposites to simultaneously achieve higher crop-yield and lower crop-protection toxicity in agricultural applications.

References

1. S. Thakur, P. Kumar, M. V. Reddy, D. Siddavattam, A. Paul, Enhancement in sensitivity of fluorescence based assay for organophosphates detection by silica coated silver nanoparticles using organophosphate hydrolase. *Sensors and Actuators B: Chemical* **178**, 458-464 (2013).
2. P. L. Kashyap, X. Xiang, P. Heiden, Chitosan nanoparticle based delivery systems for sustainable agriculture. *International journal of biological macromolecules* **77**, 36-51 (2015).