# Design and Development of Surface Modification and Synthesis Strategies to Reduce Toxicity of Nanoparticles

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# Outline

- Determination surface modifiers and surface modification strategies
- Surface modification process and characterization of the nanoparticles
- Toxicity assesment
- Conclusions

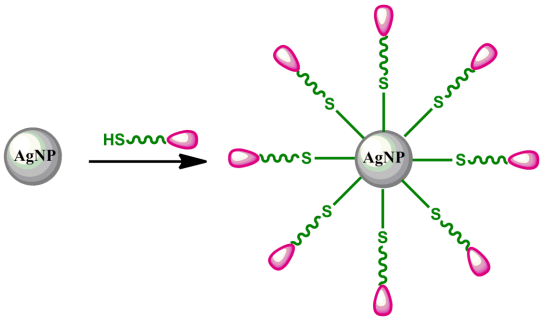
# Determination of The Best Surface Chemistry

The selection and design of the surface modifiers by considering

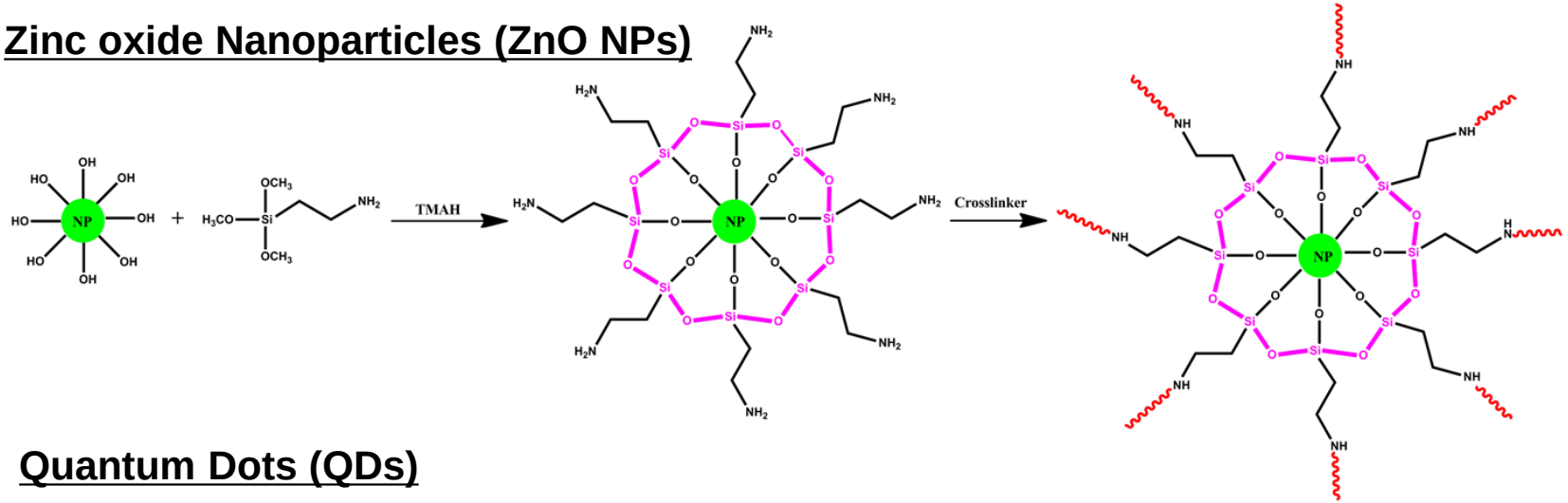
- Nontoxicity
- Stability
- Biocompatibility
- Cost and availability
- Compatibility with the physicochemical properties of the NMs and chemistry,

# Surface Modification Strategies

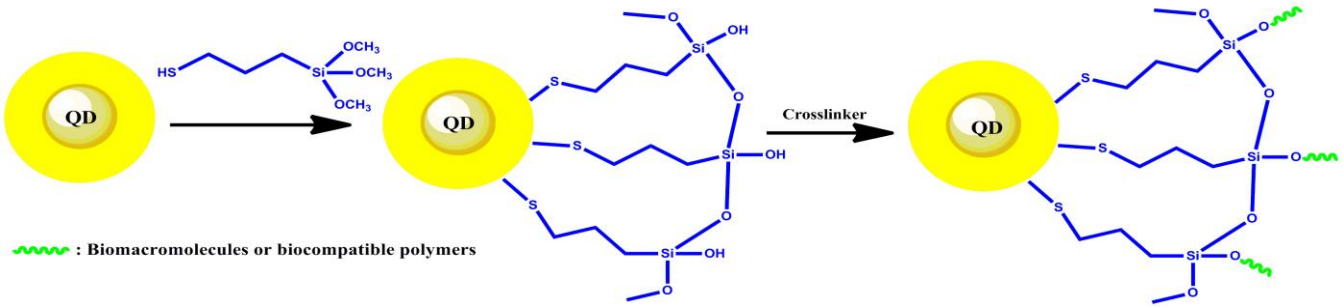
## Silver Nanoparticles (AgNPs)



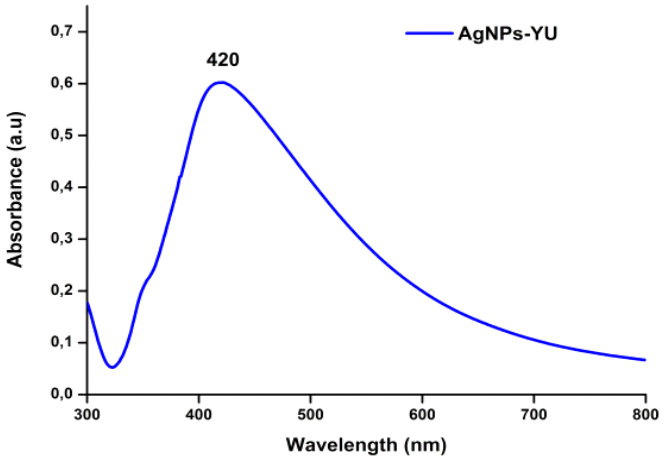

## Zinc oxide Nanoparticles (ZnO NPs)

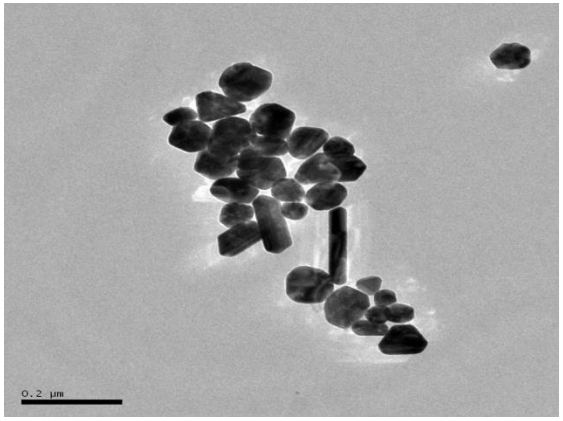



## Quantum Dots (QDs)

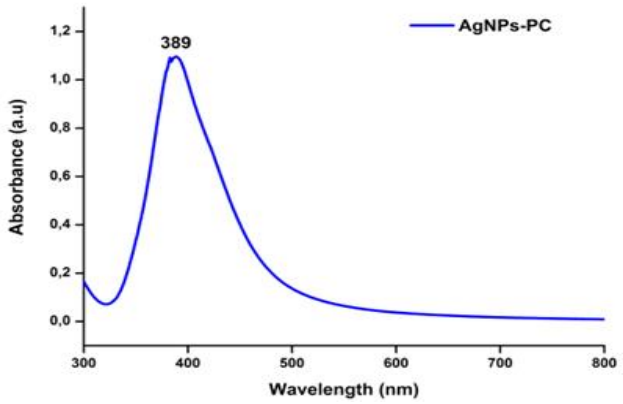


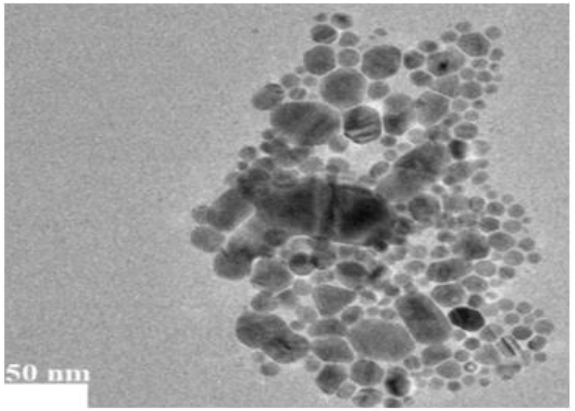
# Modification of AgNPs with thiolated carbohydrates and biomolecules



AgNPs synthesized in Yeditepe University



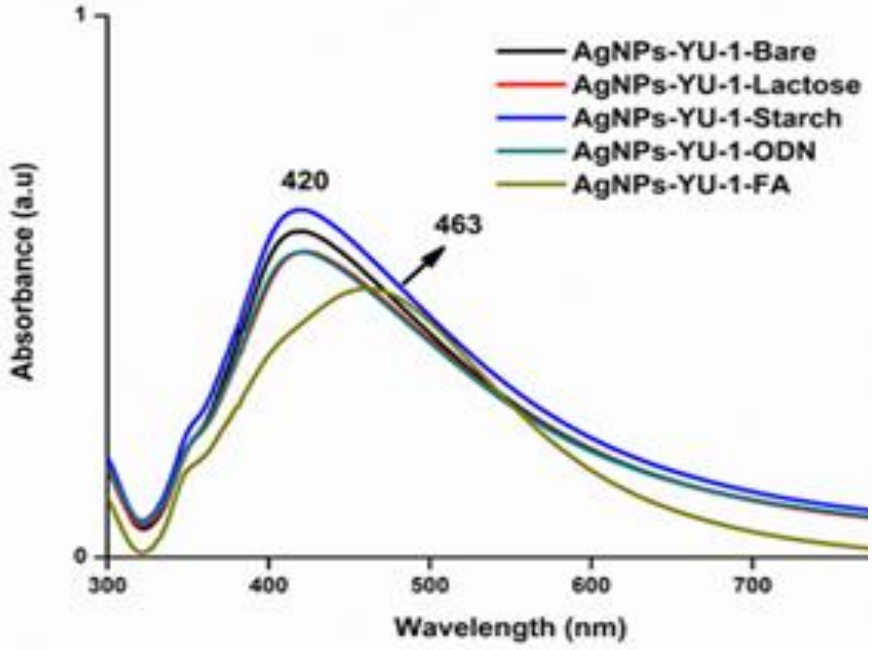



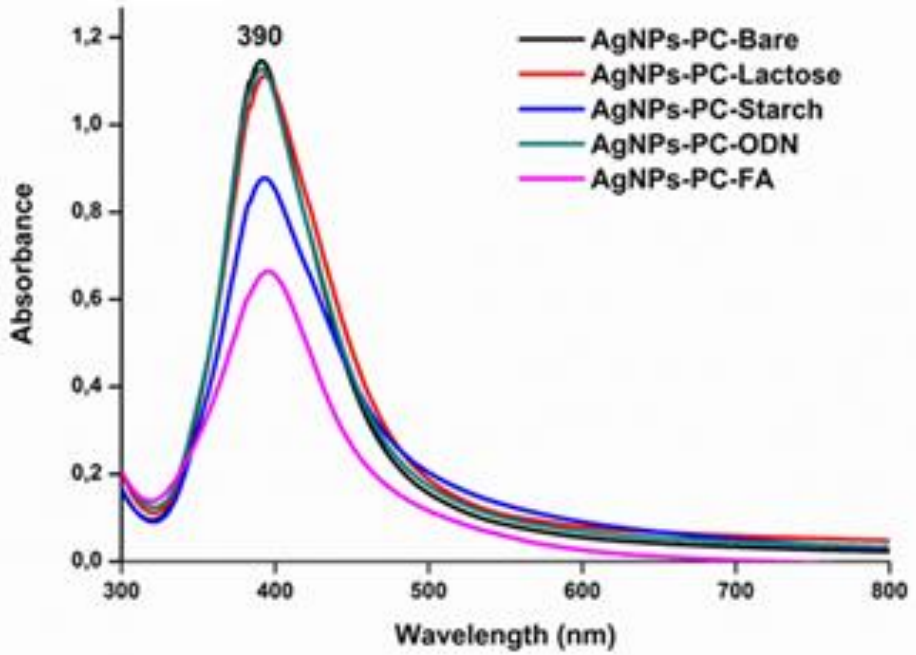

AgNPs obtained from PlasmaChem

Selected Surface Modifiers;

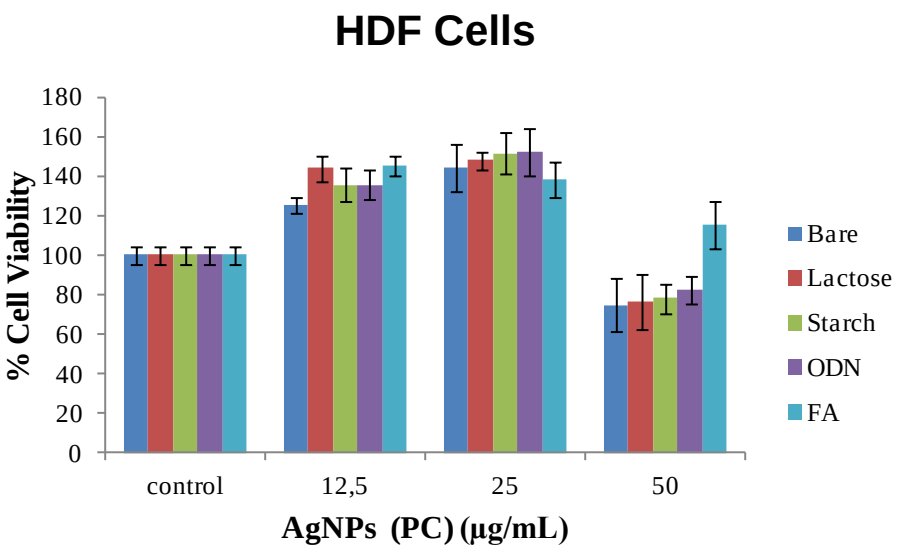
- Lactose
- Starch
- Oligonucleotide
- Folic acid

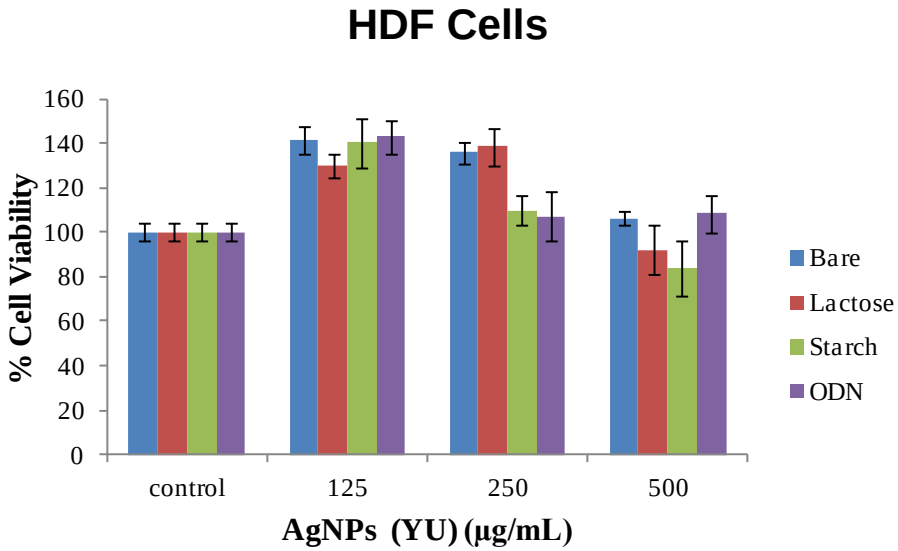
# Characterization of AgNPs with thiolated carbohydrates and biomolecules

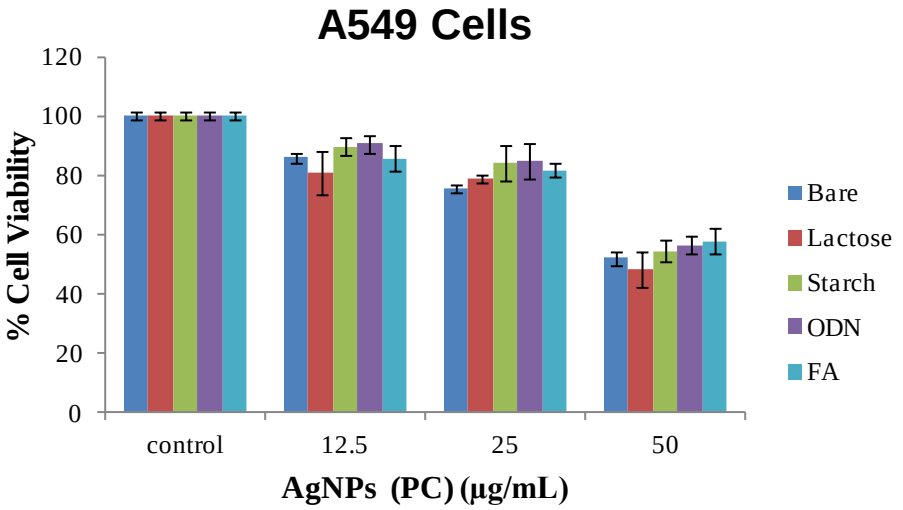


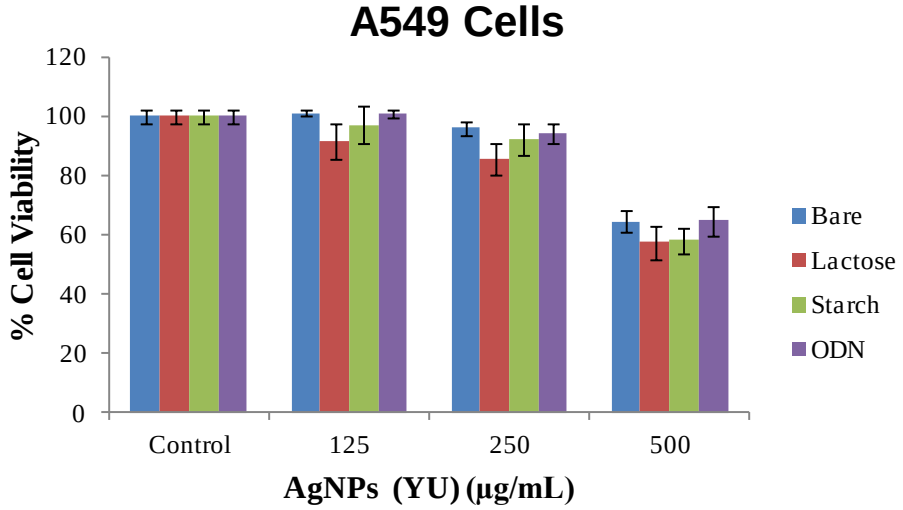



# Cytotoxicity of modified AgNPs



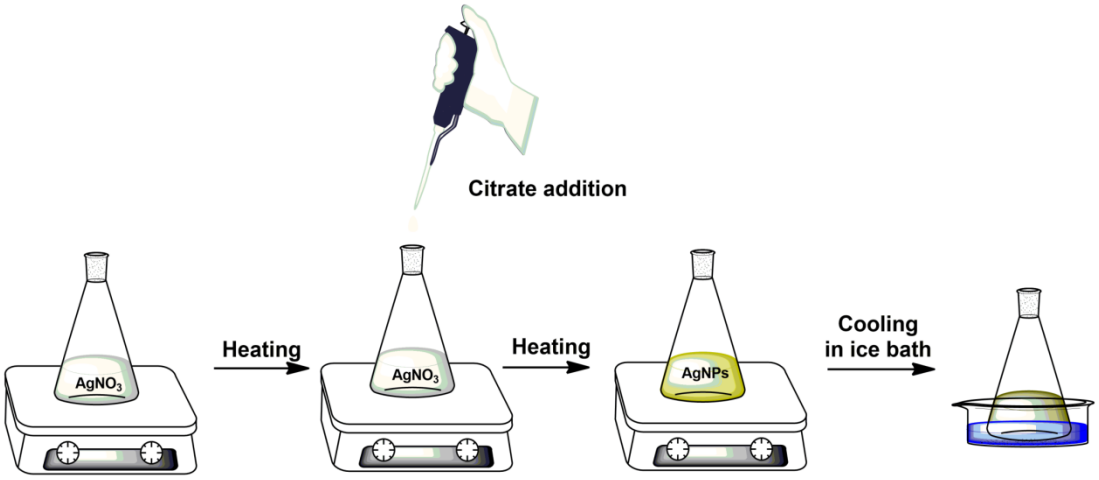



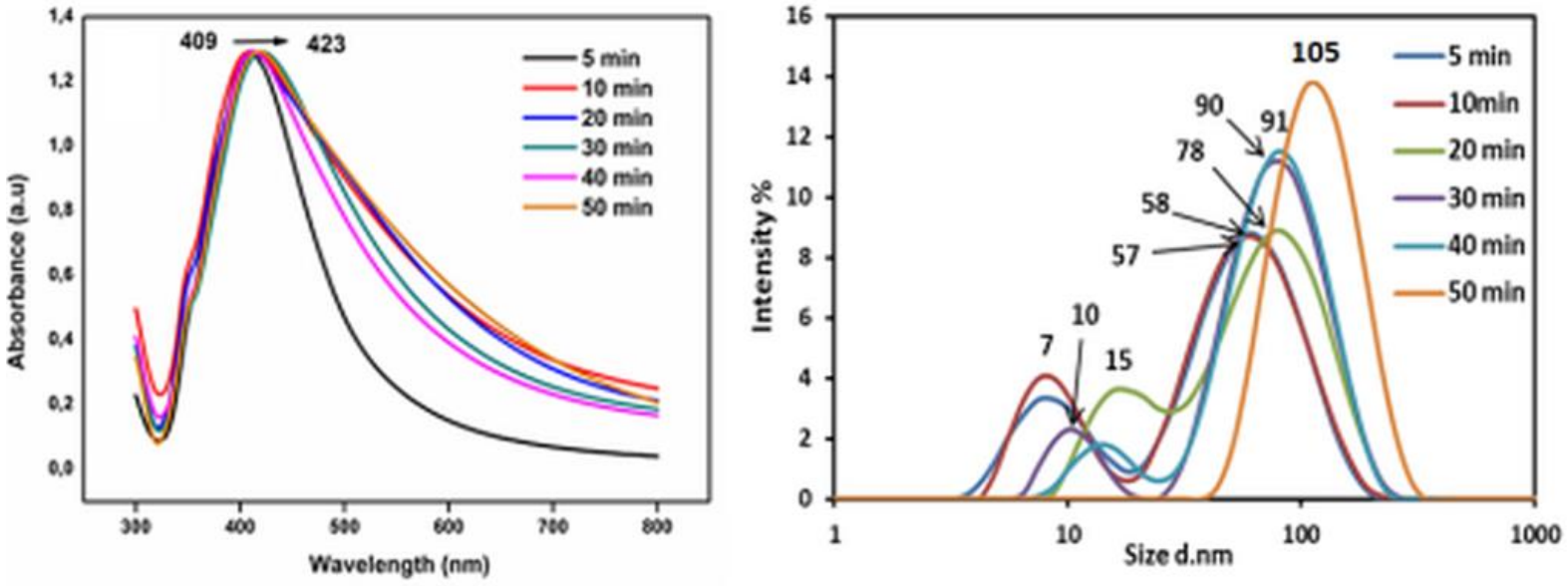
# A Safety by Design Approach for AgNPs

Modification the Lee and Meisel Method by varying;

- The reaction time
- The reducing agent concentration

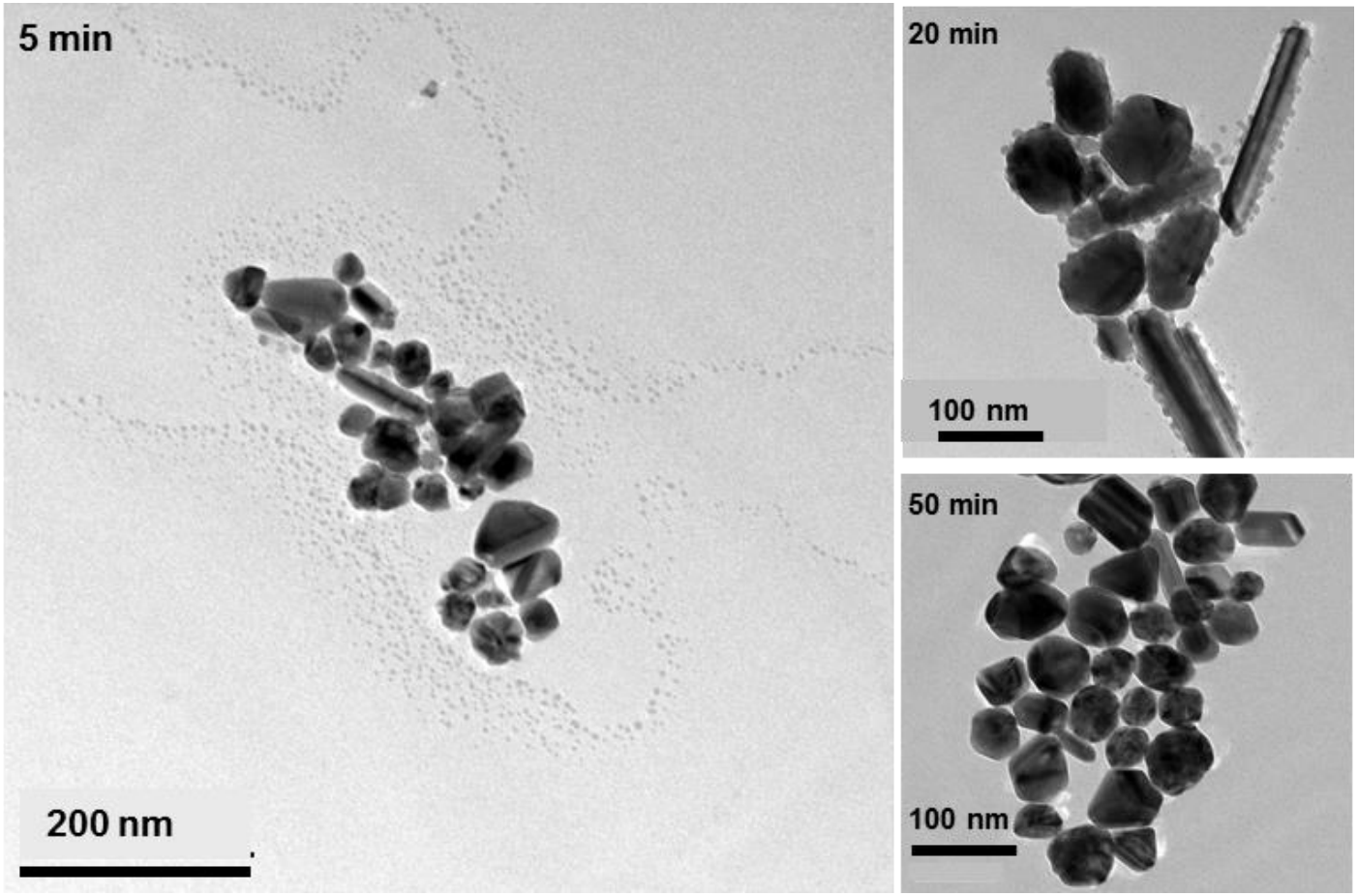


# Characterization of AgNPs synthesized by varying reaction time

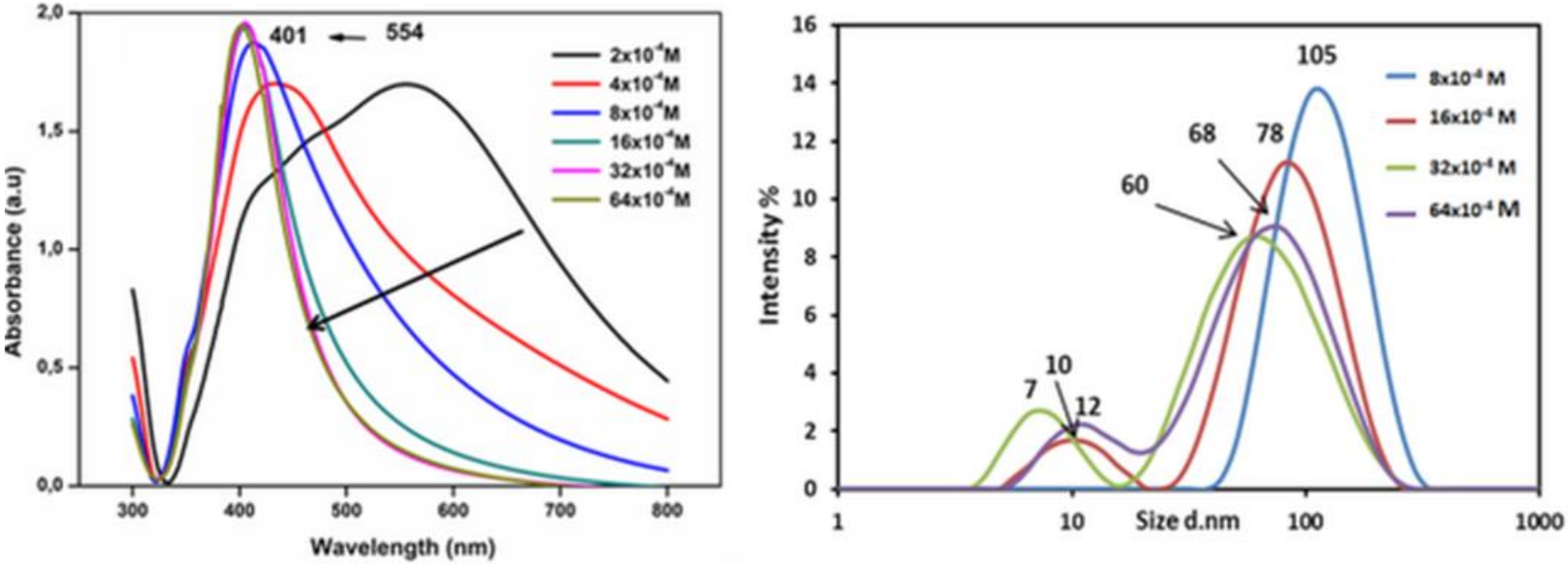



UV-Vis and DLS spectra of AgNPs prepared with increasing reaction time from 5 min to 50 min.

# Characterization of AgNPs synthesized by varying reaction time

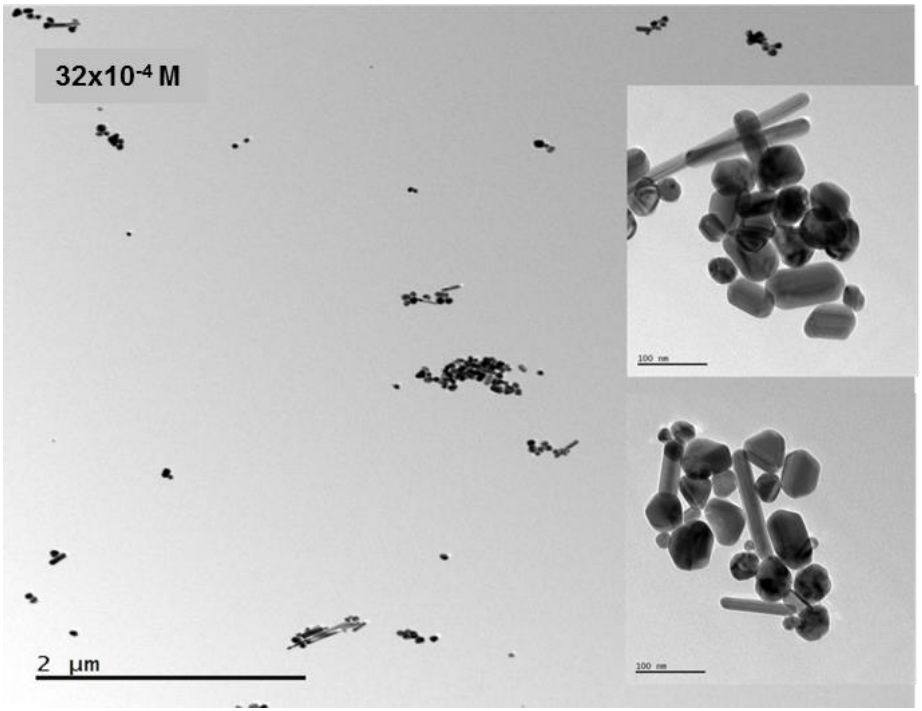


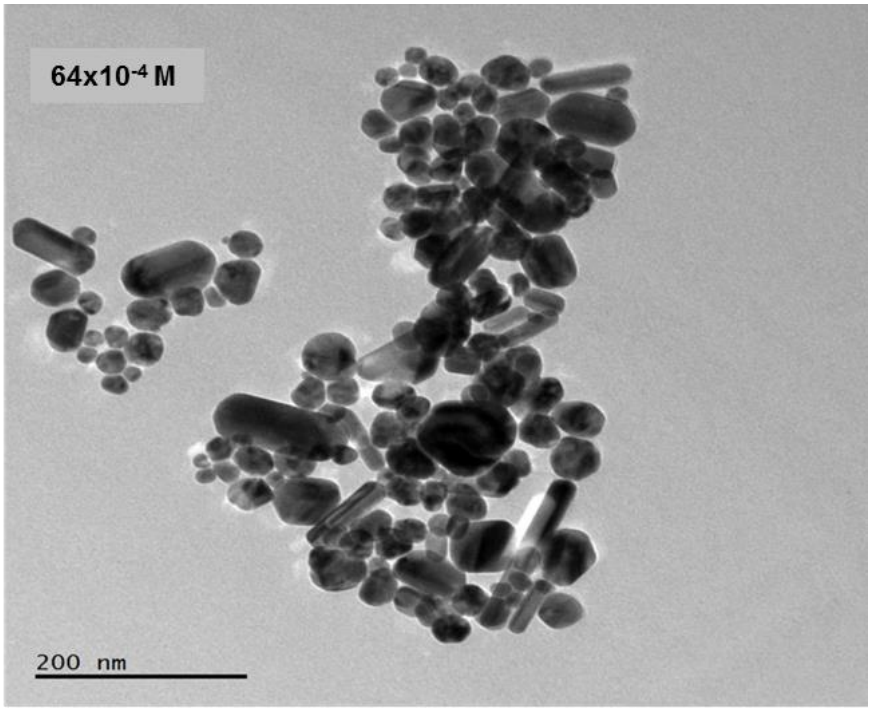
# Characterization of AgNPs synthesized by varying citrate concentration



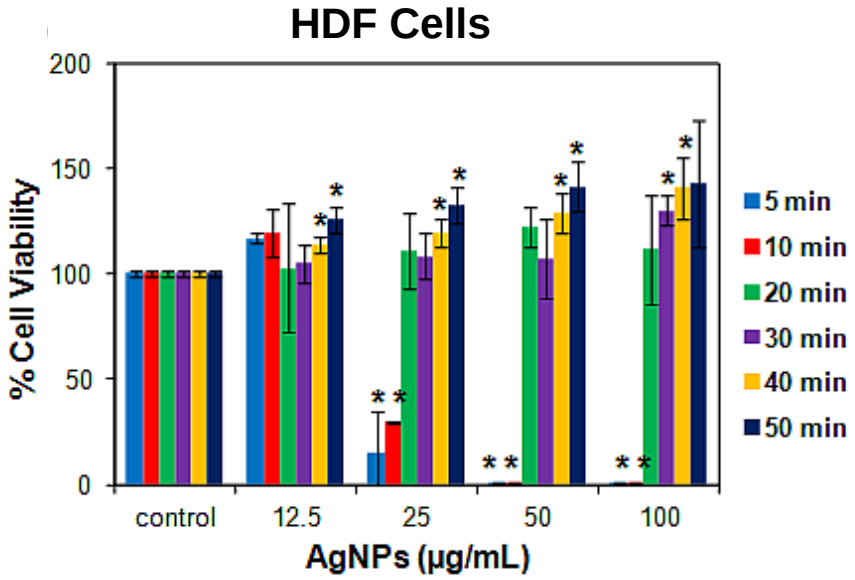

UV-Vis and DLS spectra of AgNPs prepared at different citrate concentrations.

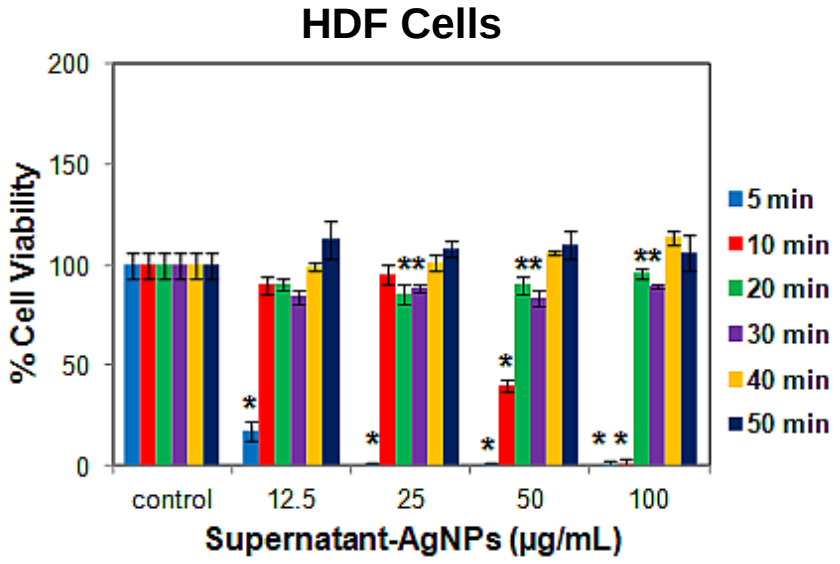
# Characterization of AgNPs synthesized by varying citrate concentration

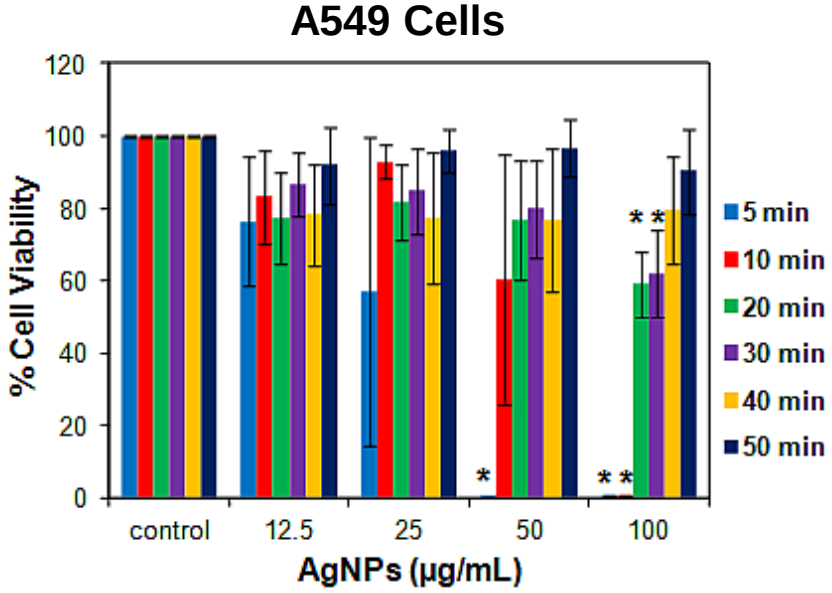


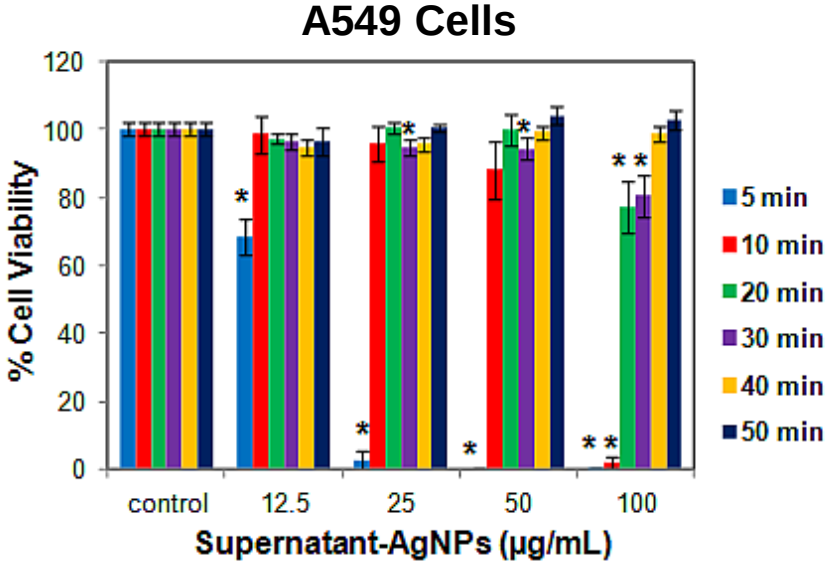



# Cytotoxicity of AgNPs synthesized by varying reaction time and their supernatants

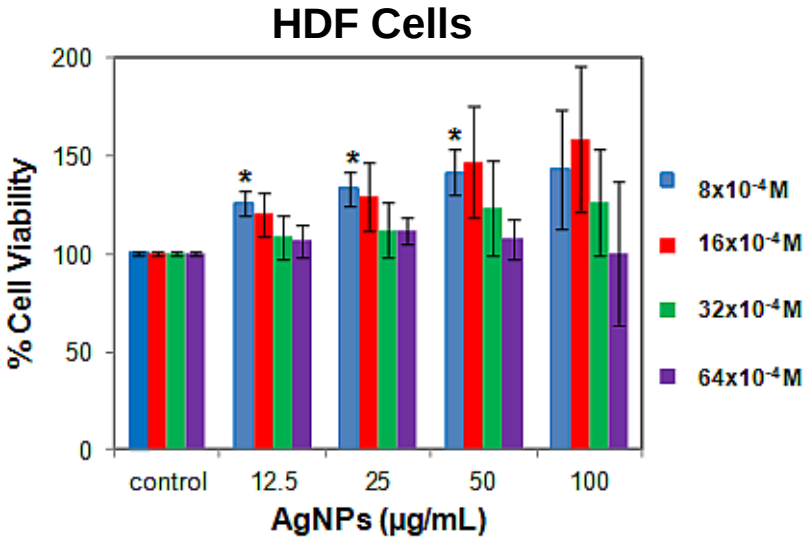


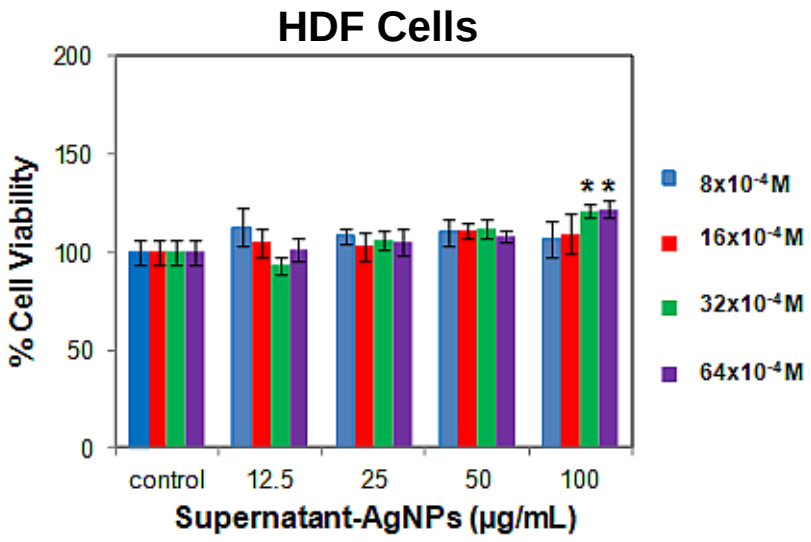



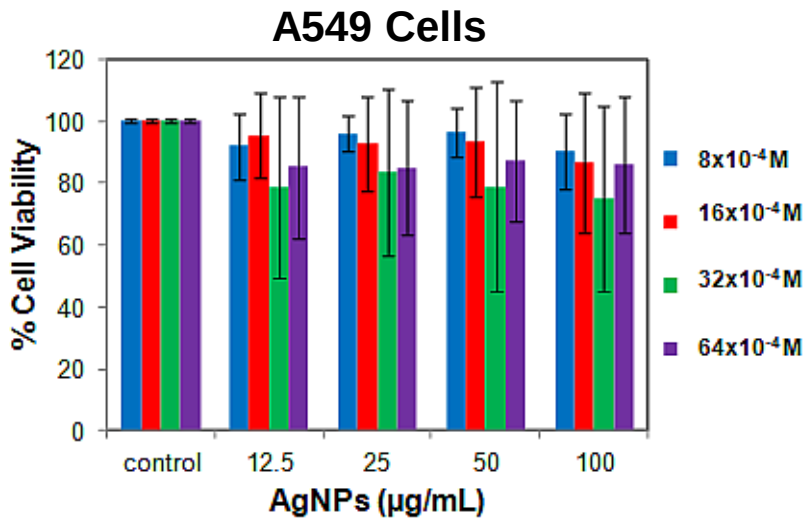



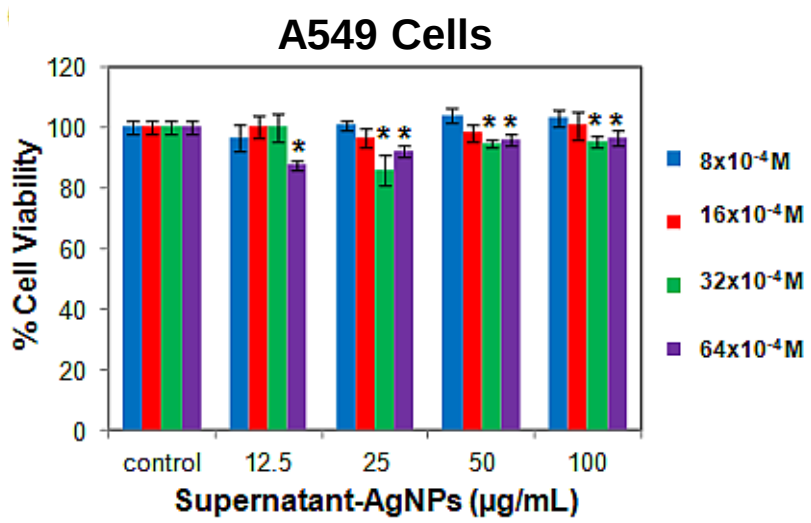



# Cytotoxicity of AgNPs synthesized by varying citrate concentration and their supernatants



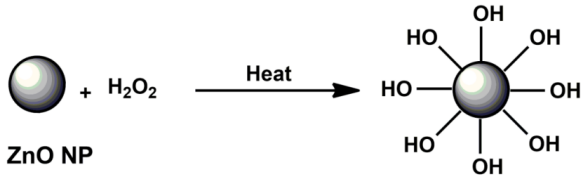



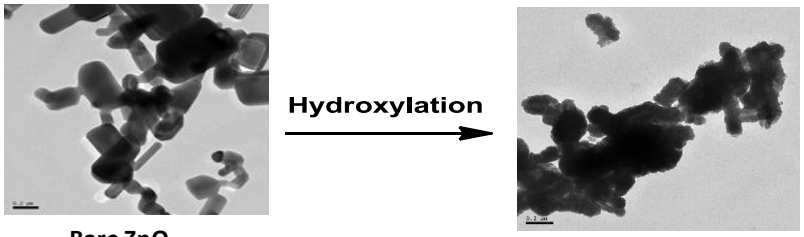



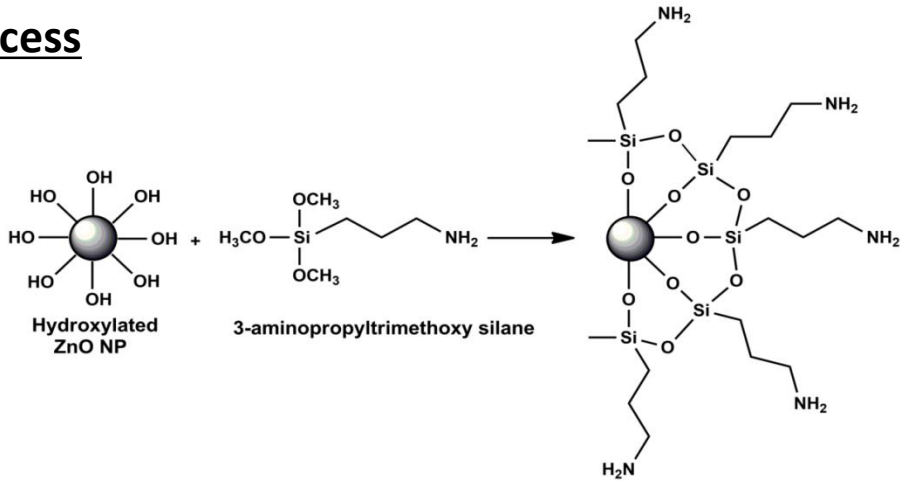
# Surface Modification Strategies for ZnO NPs

## Hydroxylation Process

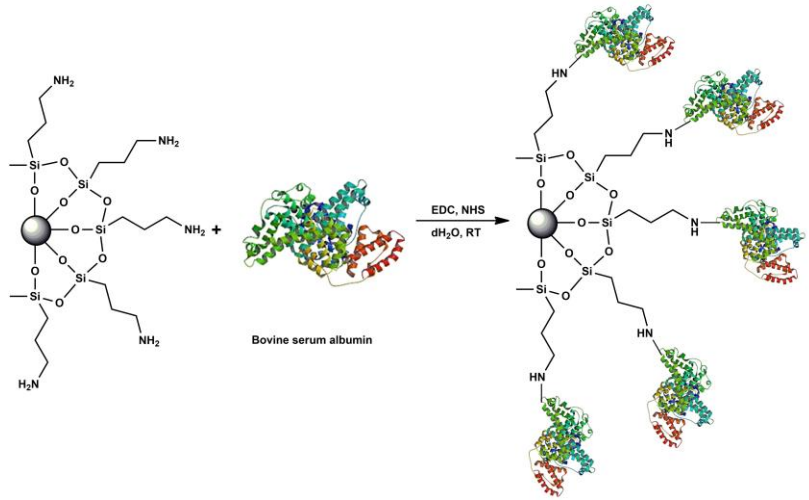


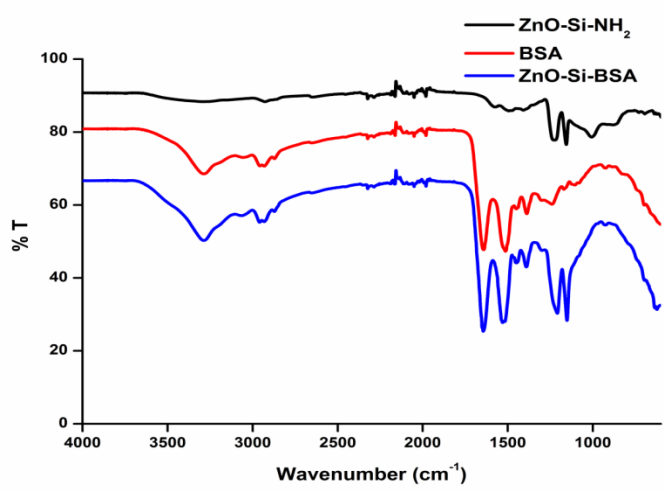



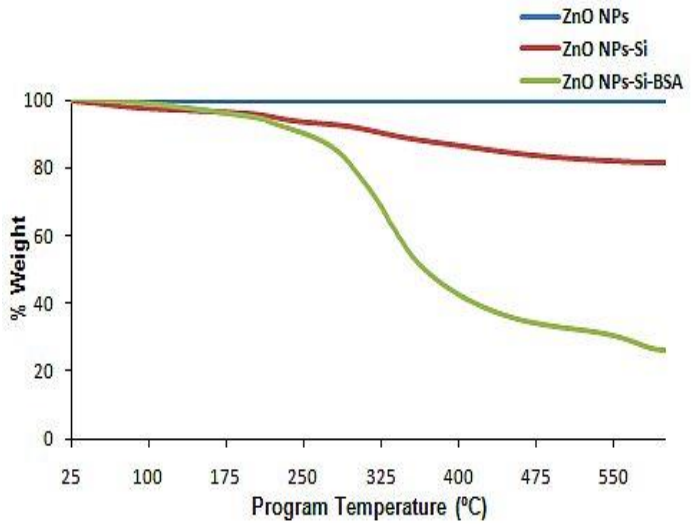

## Silica Coating Process



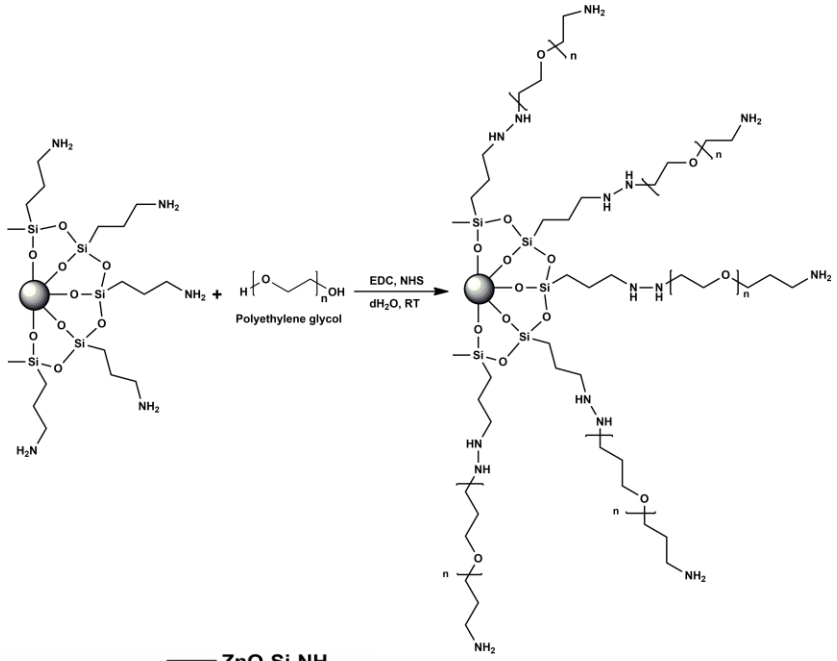
# Bovine serum albumin (BSA) attachment onto silica coated ZnO NPs

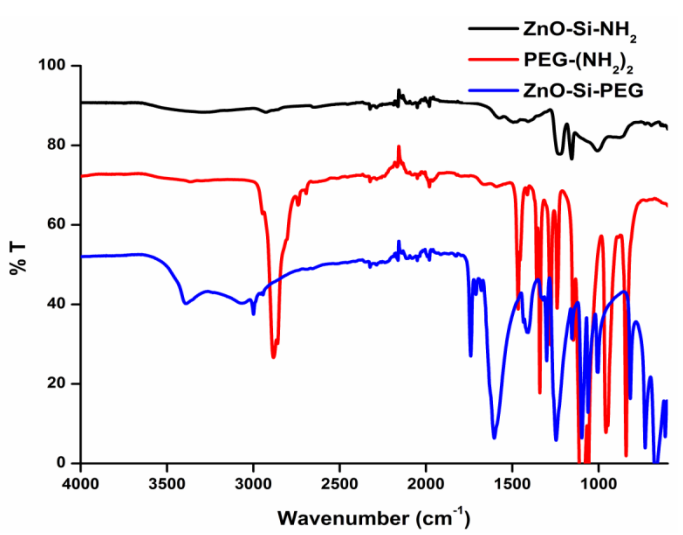


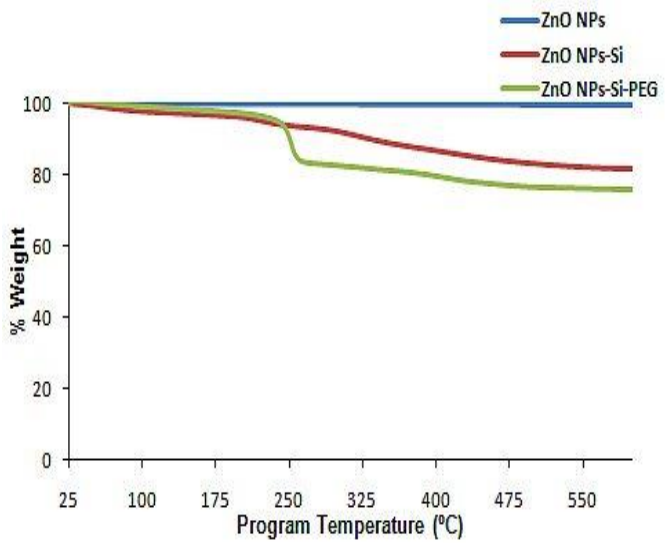



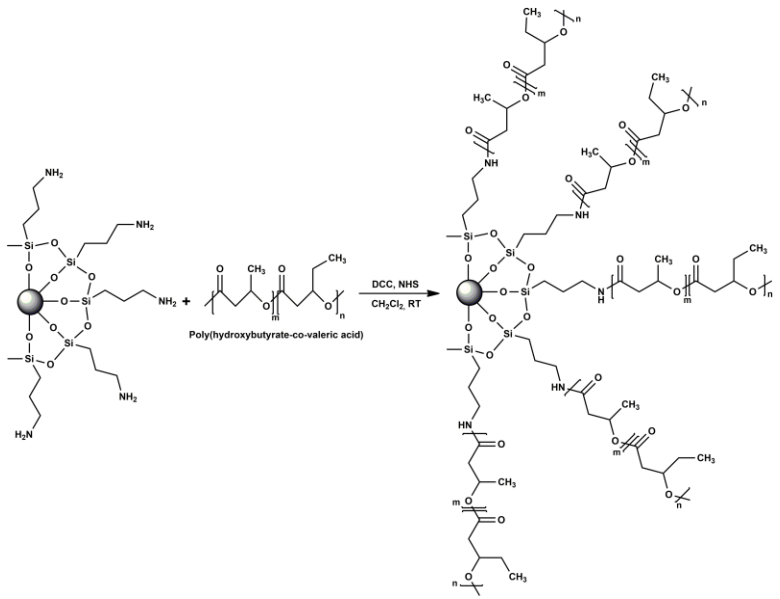
# Amine terminated poly(ethylene glycol) $(PEG\text{-}NH_2)_2$ attachment onto silica coated ZnO NPs

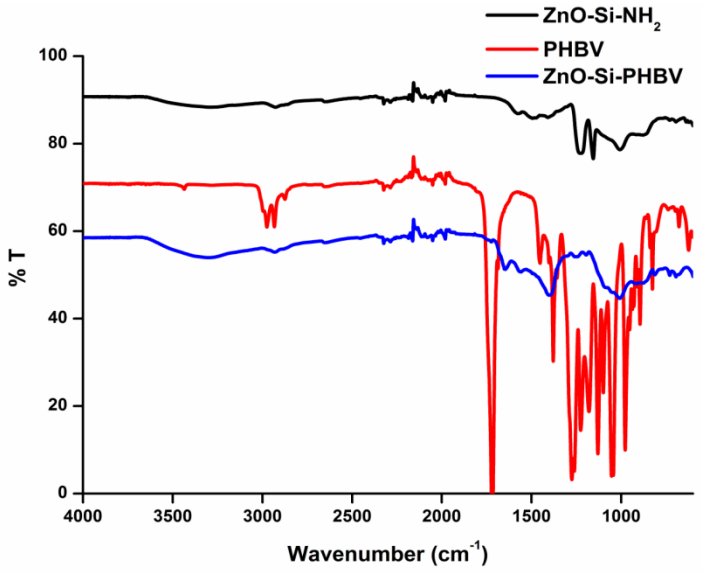


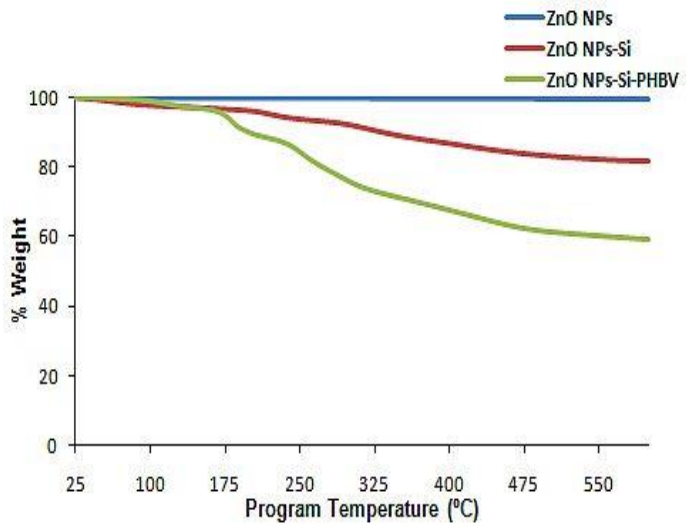



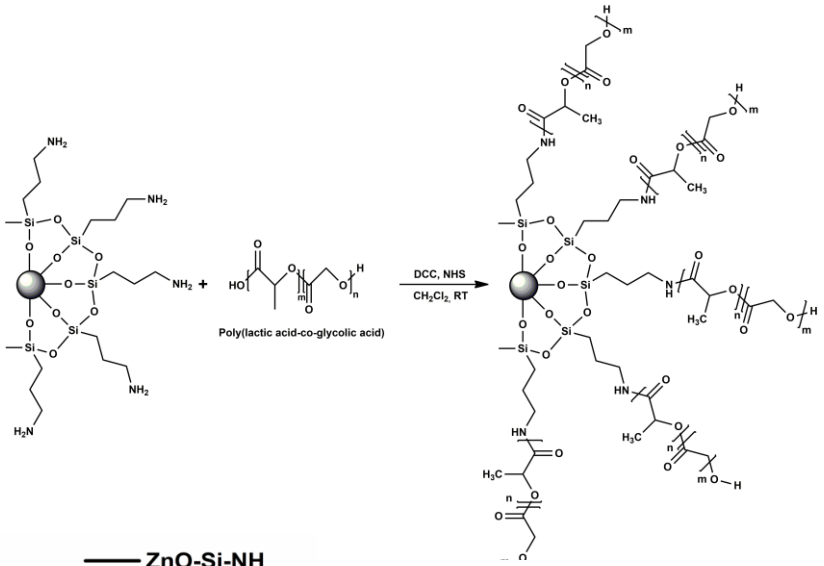
# Poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) attachment onto silica coated ZnO NPs

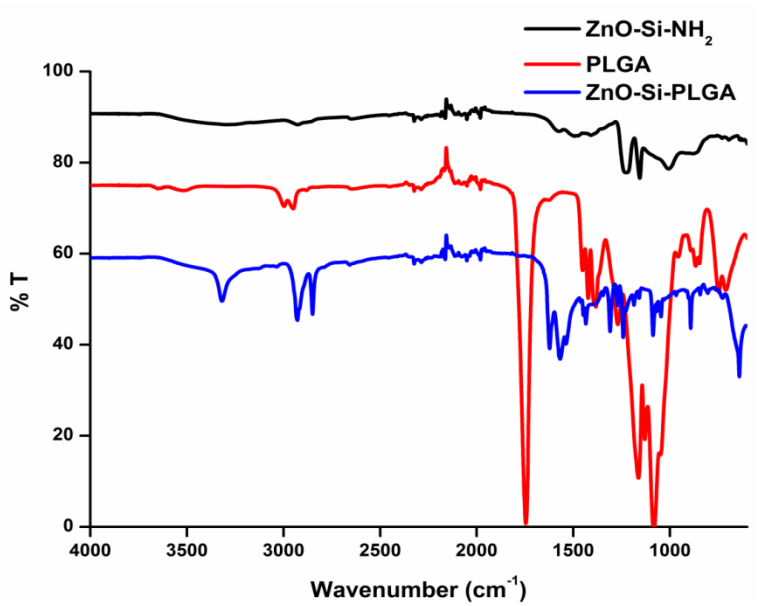


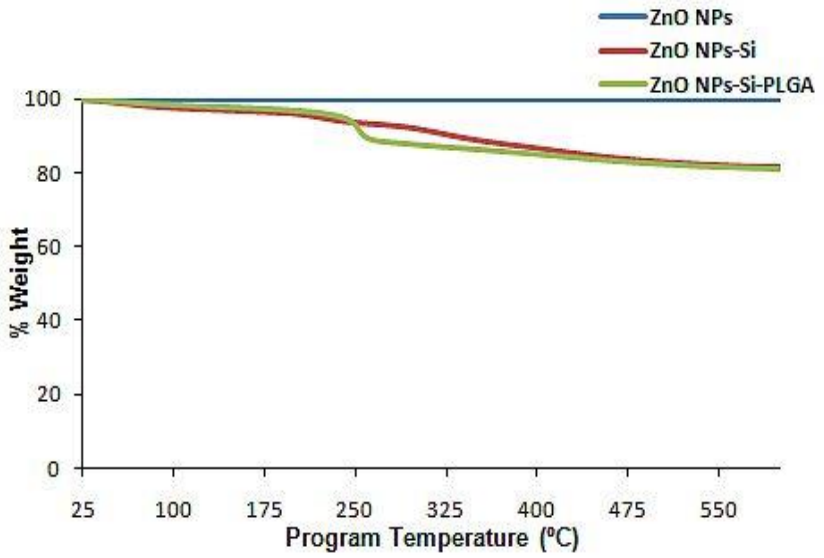



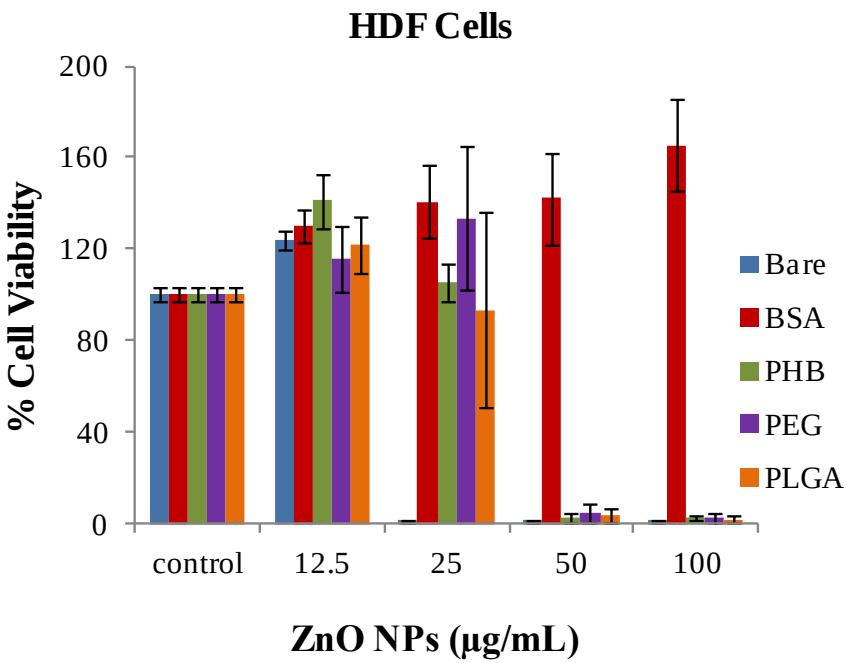
# Poly(lactide-co-glycolide) (PLGA) attachment onto silica coated ZnO NPs

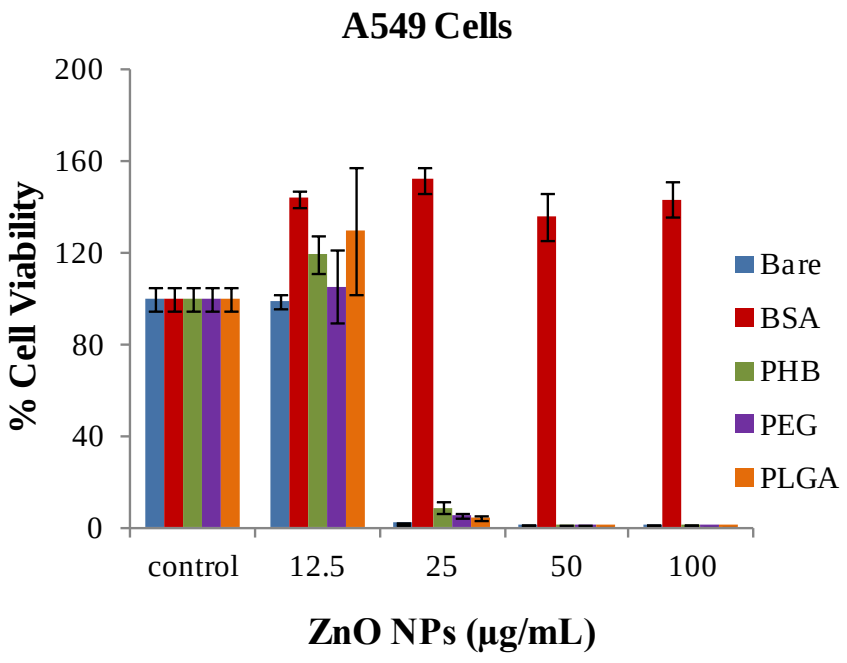


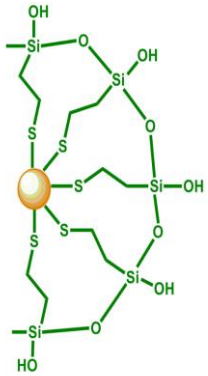
# Cytotoxicity of Modified ZnO NPs



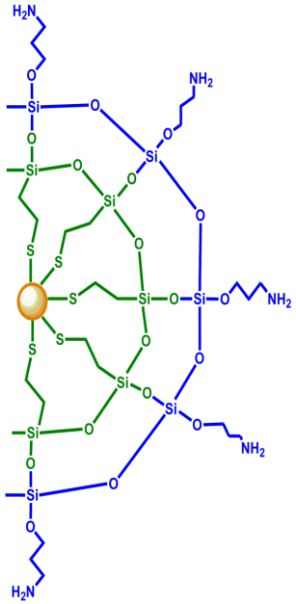
# Quantum Dots (QDs)

**QD-Si-OH**

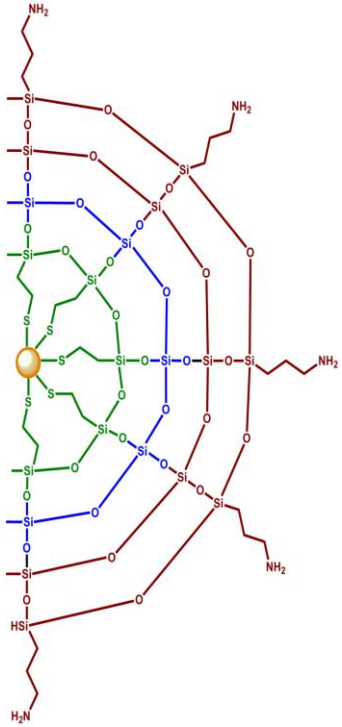


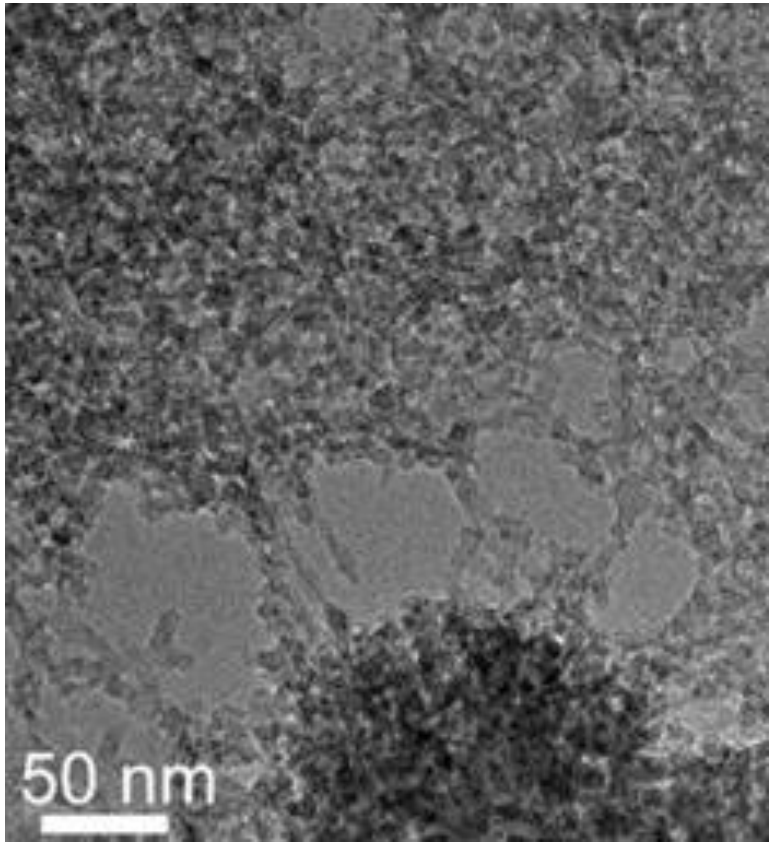

: CdSe/ZnS

**QD-Si(2)-$NH_2$**

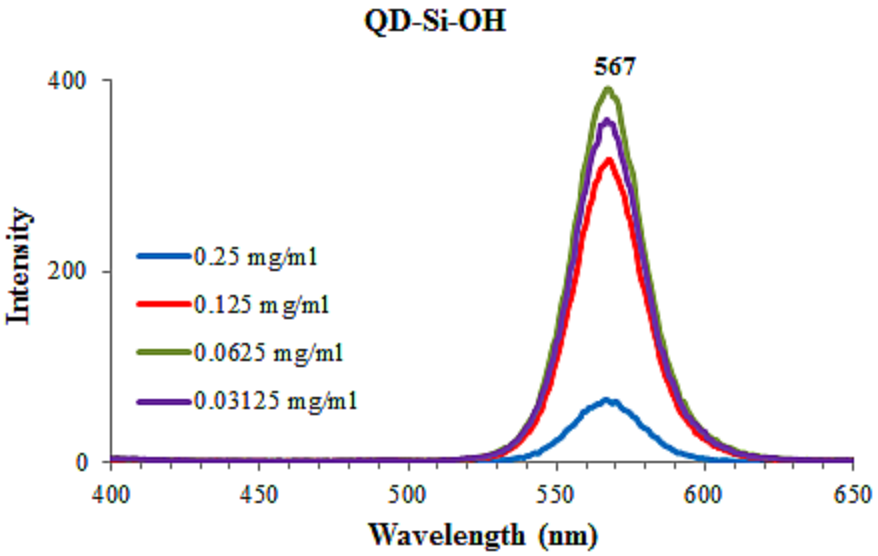


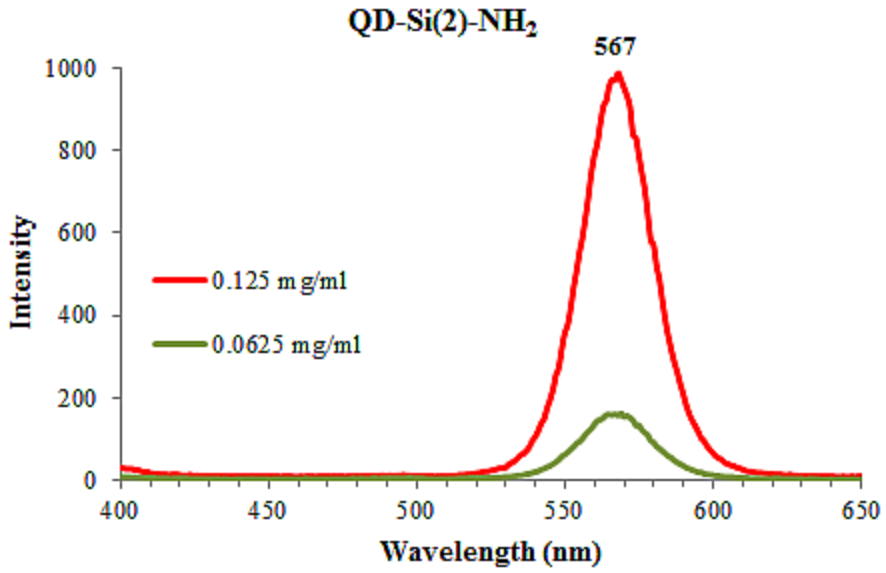

**QD-Si(4)-$NH_2$**

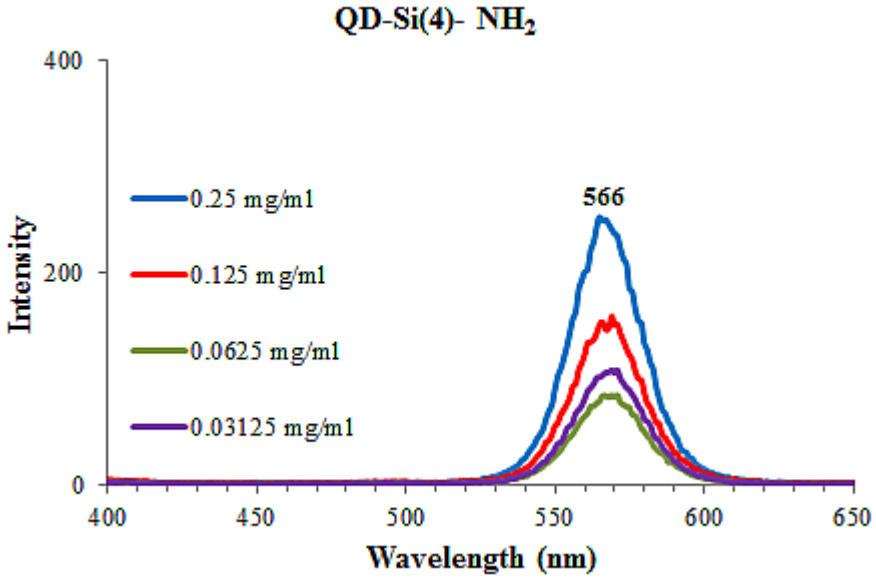


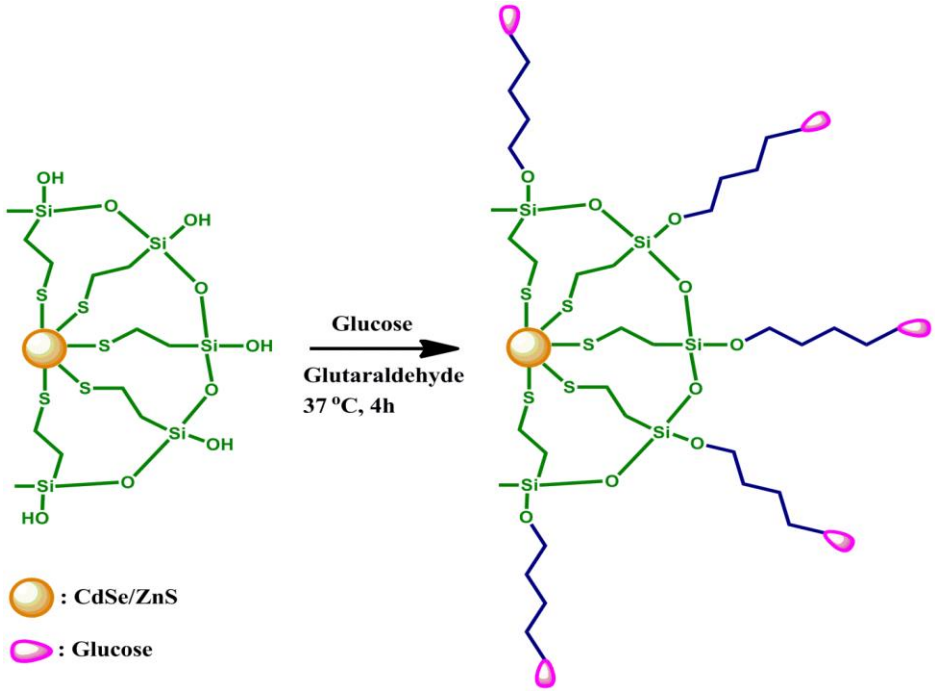
# Initial Characterization of QDs

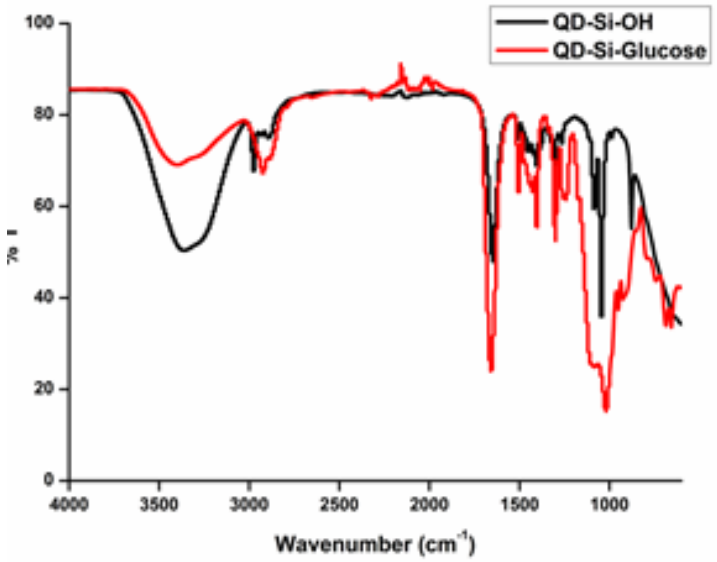


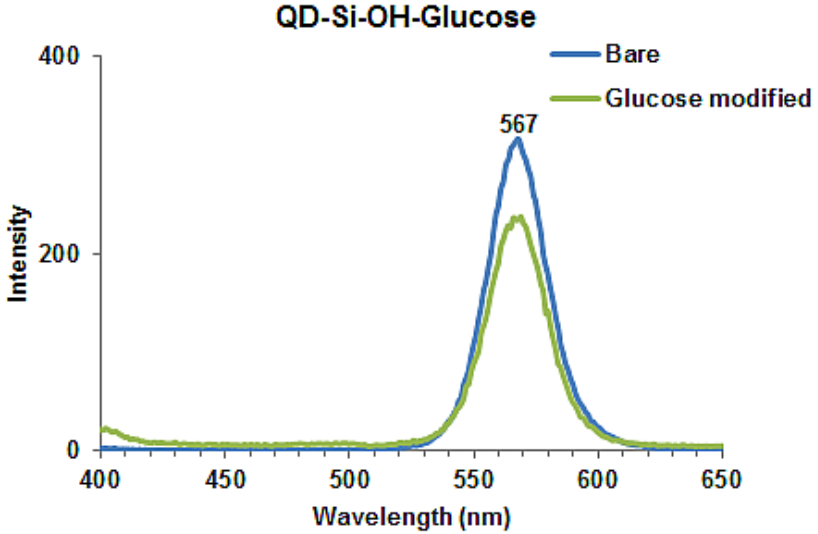



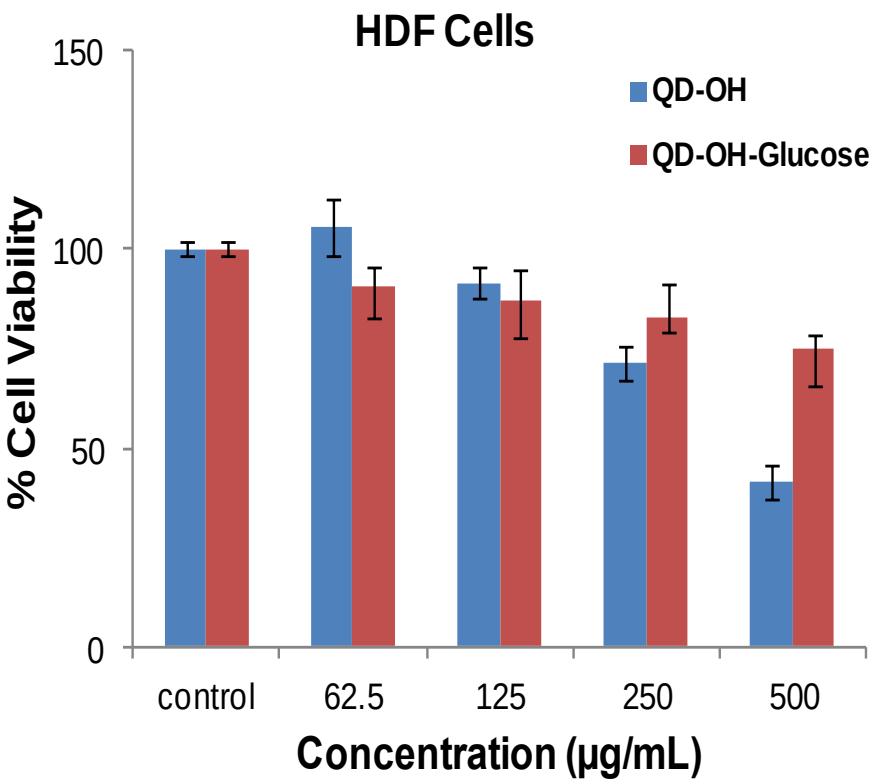
# Glucose Modification of QDs-Si-OH

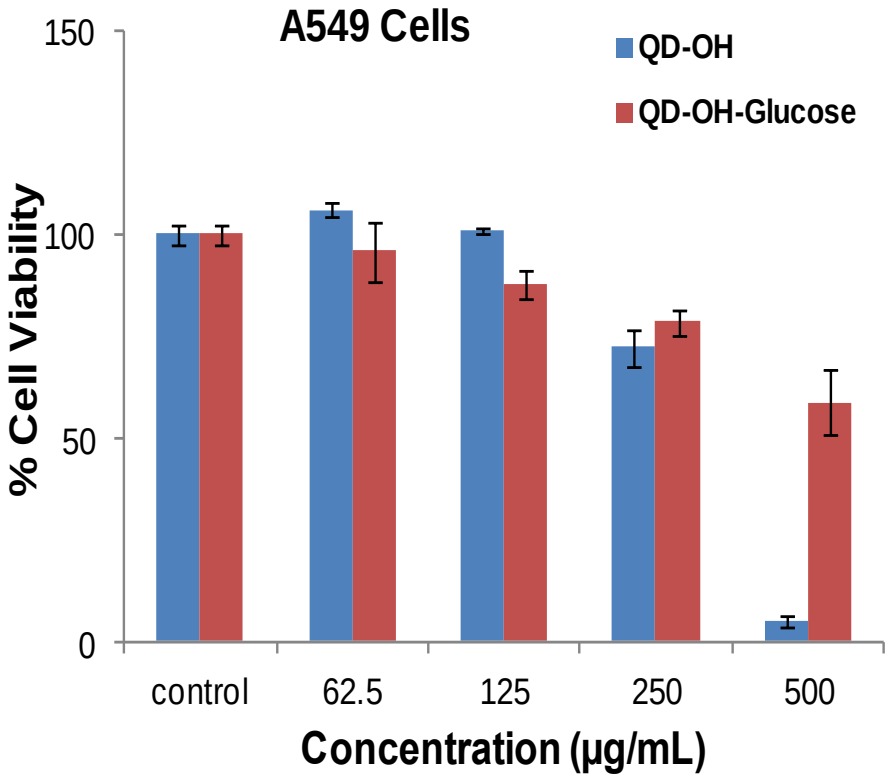


# QDs-Si-OH-Glucose Cytotoxicity Assessments



# Overall Conclusions

**AgNPs**

- All attempts to reduce the toxicity with surface modifications were failed while the citrate reduced AgNPs synthesized through Lee and Meisel method were nontoxic.
- The few nanometers of AgNP seeds were the main source of toxicity in a AgNP colloidal suspension.
- Surface modification may increase lifetime of the AgNPs in the media by decreasing the dissolution of the AgNPs.

**ZnO NPs**

- The initial characterization of the modified ZnO NPs suggests that all surface modifications are successful.
- Both polymers and BSA modifications hepled to decrease cellular toxicity according to pristine ZnO NPs.
- The most important outcome is the surface modifications must be performed in extremely diluted suspensions by using excess amount of modifier to cover the whole surface area of ZnO NPs.

**QDs**

- It is necessary to coat the surface of QDs with a silica layer to prevent the Cd ion release into the medium.
- The strategy of glucose modification helped to reduce the cytotoxicity without altering the fluorescence properties of QDs.

# NANOBIOTECHNOLOGY AND MOLECULAR ENGINEERING GROUP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