



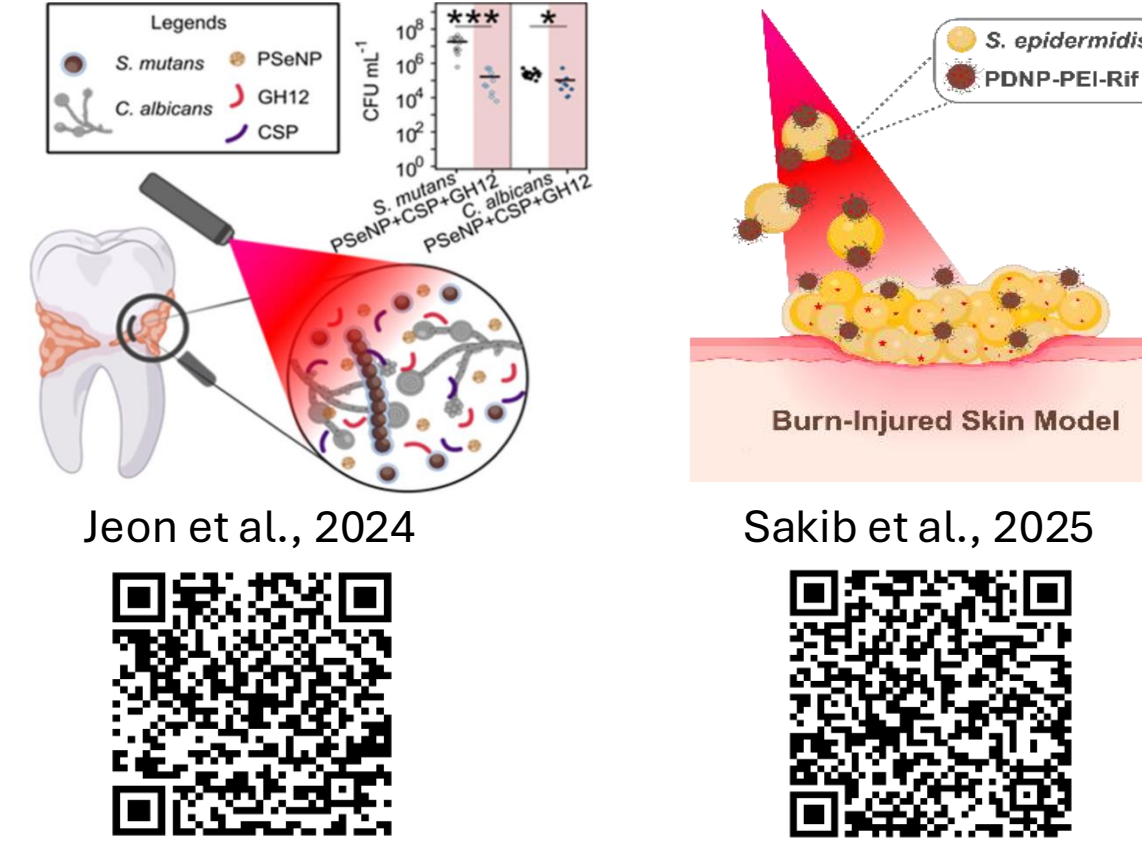
Introduction & Methods

Nanoparticles are versatile and multifunctional

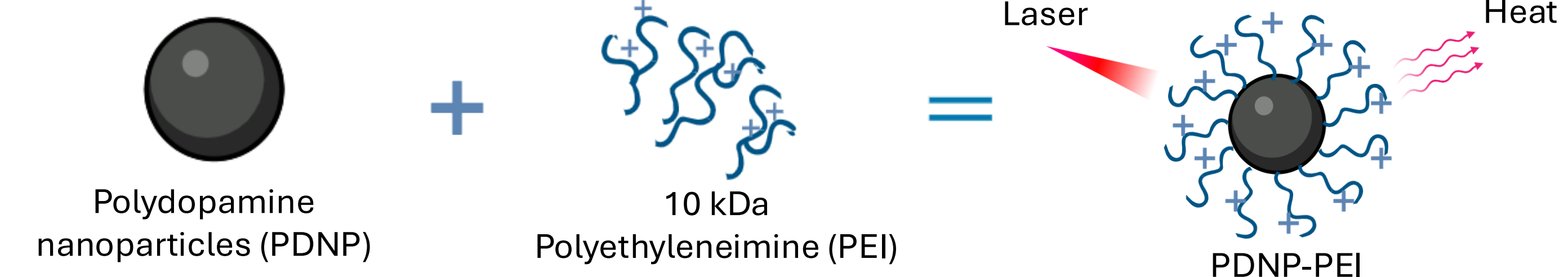
- Various applications in health and medicine, energy and environment, electronics, etc.

Our group develops bioinspired nanotherapeutic platforms against drug-resistant pathogens

- Polyserotonin nanoparticles (PSeNPs) and antimicrobial peptides in the treatment of dental caries pathogen¹
- Polyethyleneimine-modified polydopamine nanoparticles (PDNP-PEI) for treating burn-injured chronic wound skin model²



In this research, we focus on PDNP-PEI:

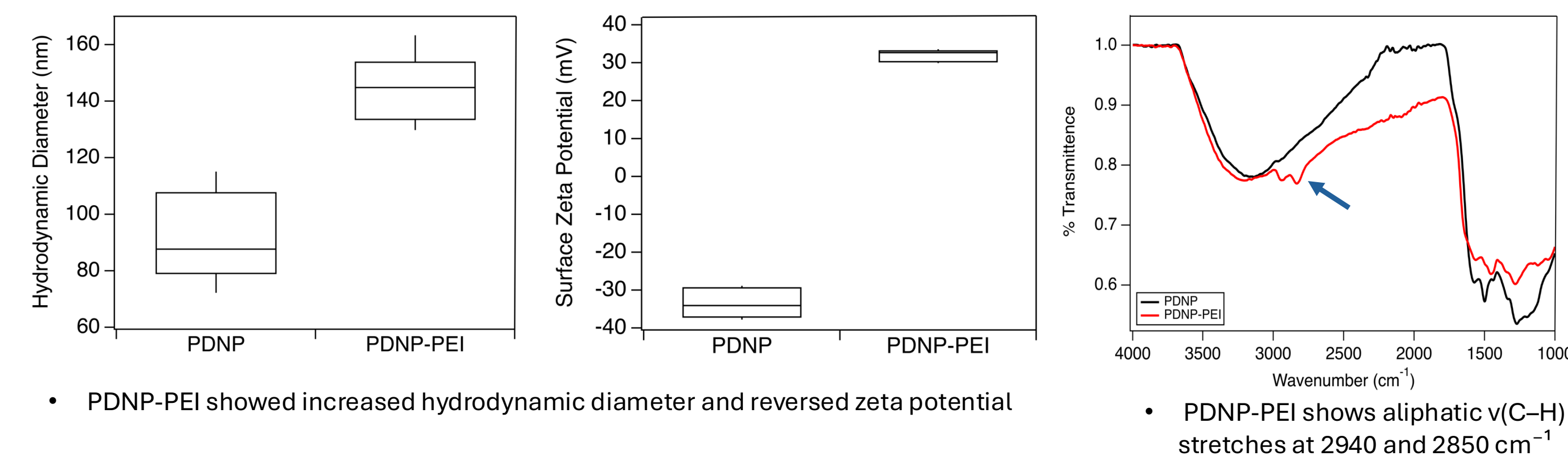


- Biocompatible³
- Drug carrier⁴
- ROS scavenging activity⁵
- Negatively charged²
- Positively charged⁶
- Targets bacteria⁶
- Antimicrobial activity⁶
- Disrupts biofilm⁶
- Cytotoxicity^{2,6}
- Positively charged²
- Targets bacteria surface²
- Delivers small drug molecules²
- Photothermal activity²
- Anti-inflammatory properties²

Purpose: Evaluate PDNP-PEI's antimicrobial and ROS scavenging activity, and applications

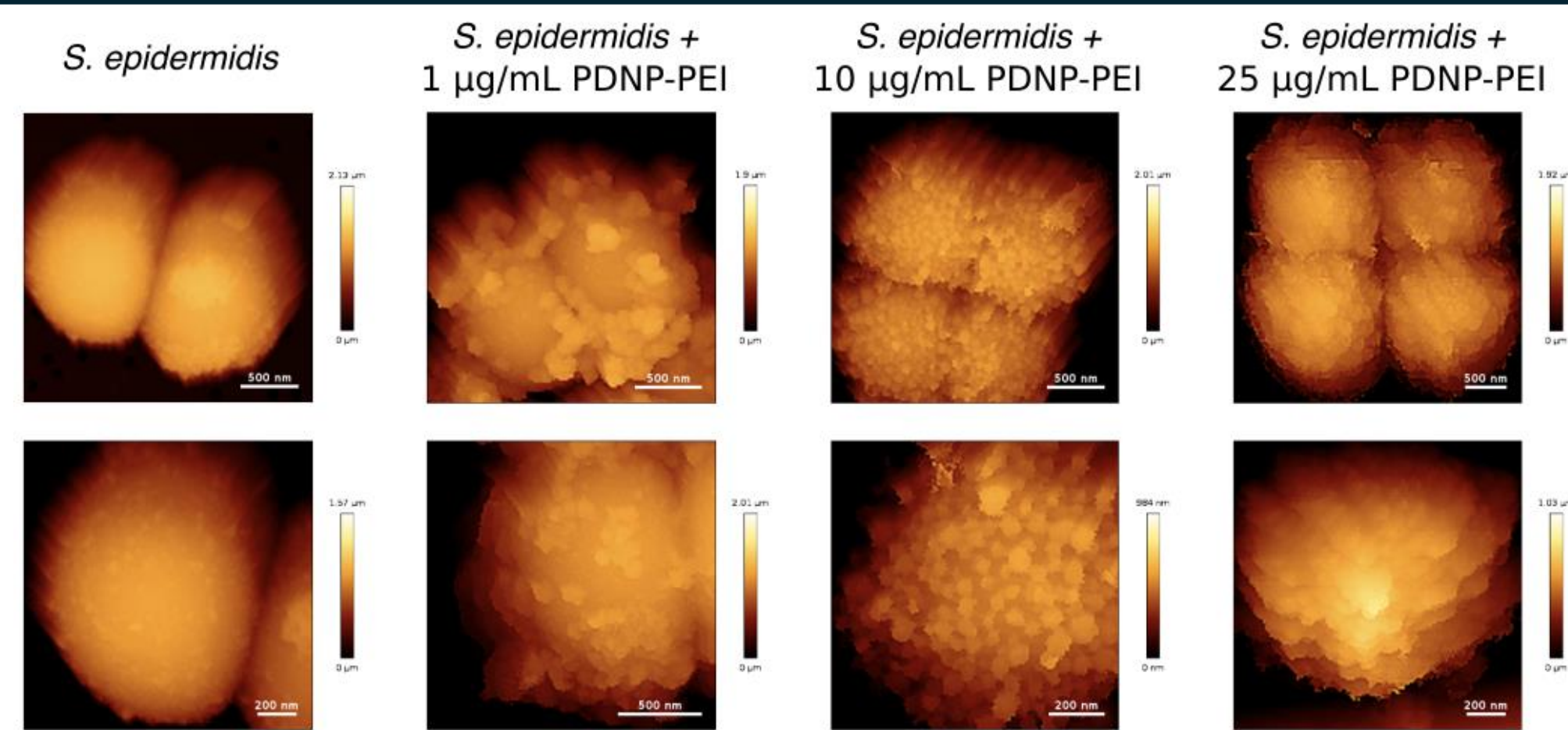
Methods: DLS/PALS, FT-IR, AFM, TEM, confocal fluorescence microscopy, microplate reader, etc.

DLS/PALS and FT-IR Confirms PEI on PDNP

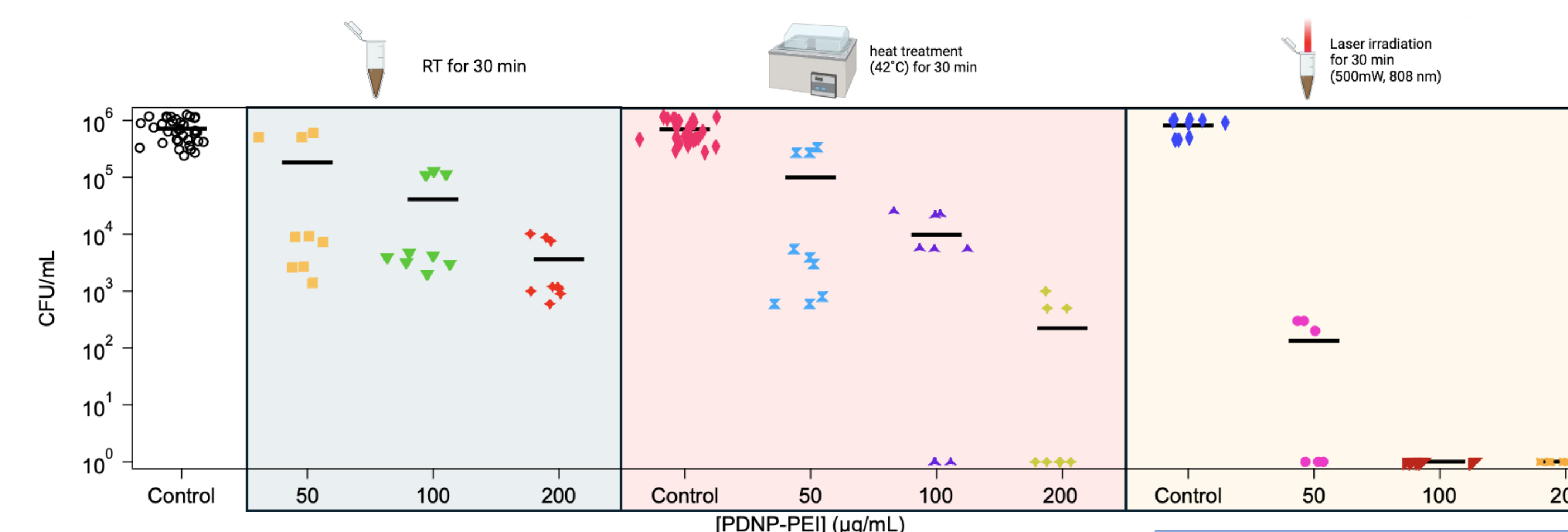


PDNP-PEI AFM Surface Coverage

- PDNP-PEI showed a concentration-dependent surface coverage on *S. epidermidis*
- Complete surface coverage was seen at 25 µg/mL

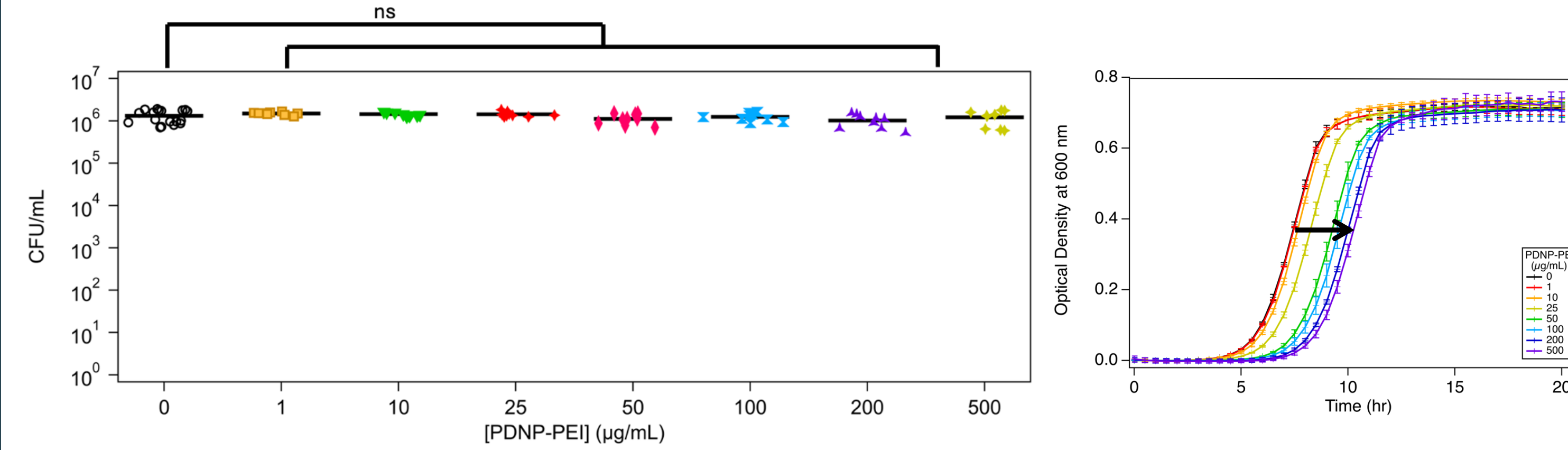


PDNP-PEI is Antimicrobial in Low-Salt Conditions



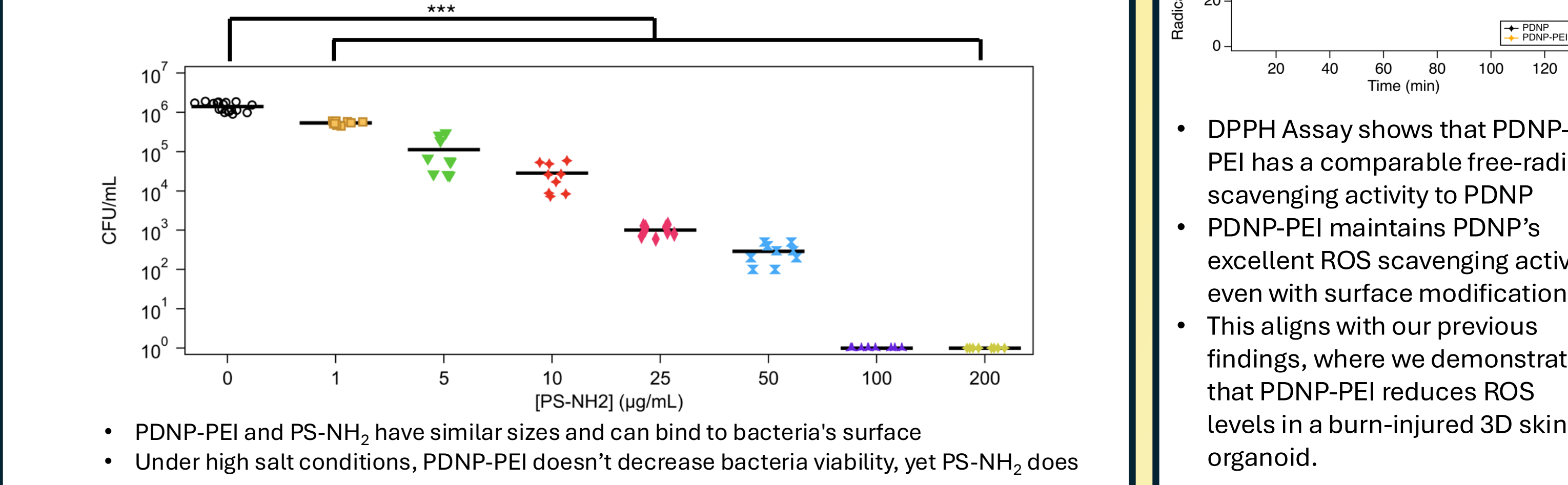
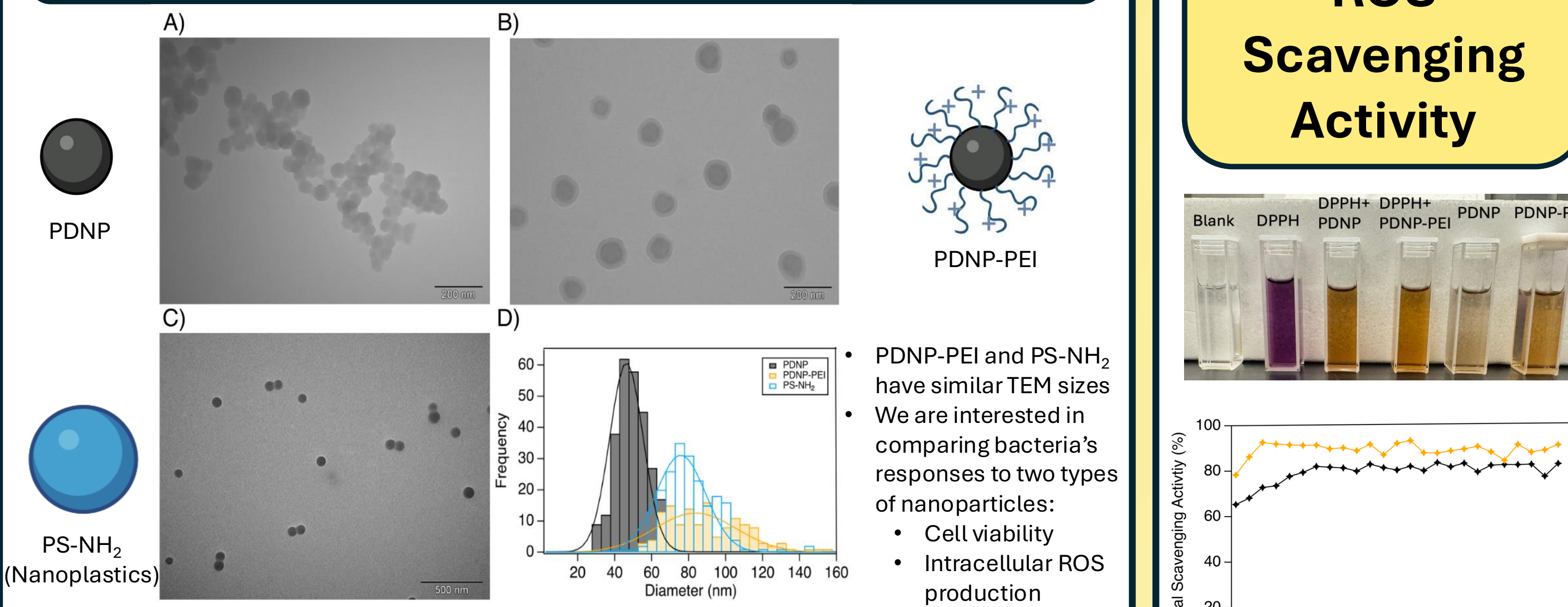
- Heat makes bacteria more susceptible to PDNP-PEI
- Laser-responsive antimicrobial activity
 - 4000-fold CFU/mL reduction at 50 µg/mL (localized "nano" heater⁷)

PDNP-PEI is NOT Killing in High-Salt Conditions

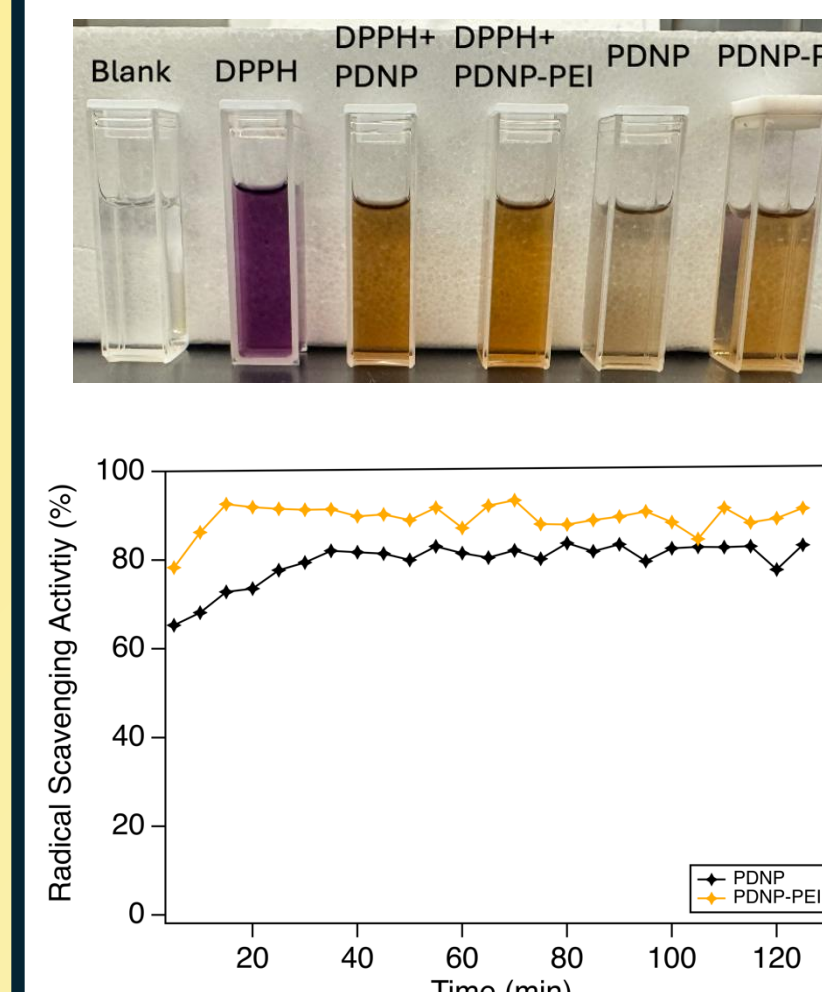


- The bacteria can survive even at 500 µg/mL PDNP-PEI (only showed an increase in lag phase)
- **Hypothesis:** PDNP-PEI retains PDNP's ROS scavenging activity and has limited antimicrobial action when bacteria are not under osmotic stress -> Evaluate bacteria's response to amine-modified polystyrene nanoparticles PS-NH₂ (nanoplastics), which is known to induce intracellular ROS⁸

TEM Images show PS-NH₂ has a similar size to PDNP-PEI but is antimicrobial

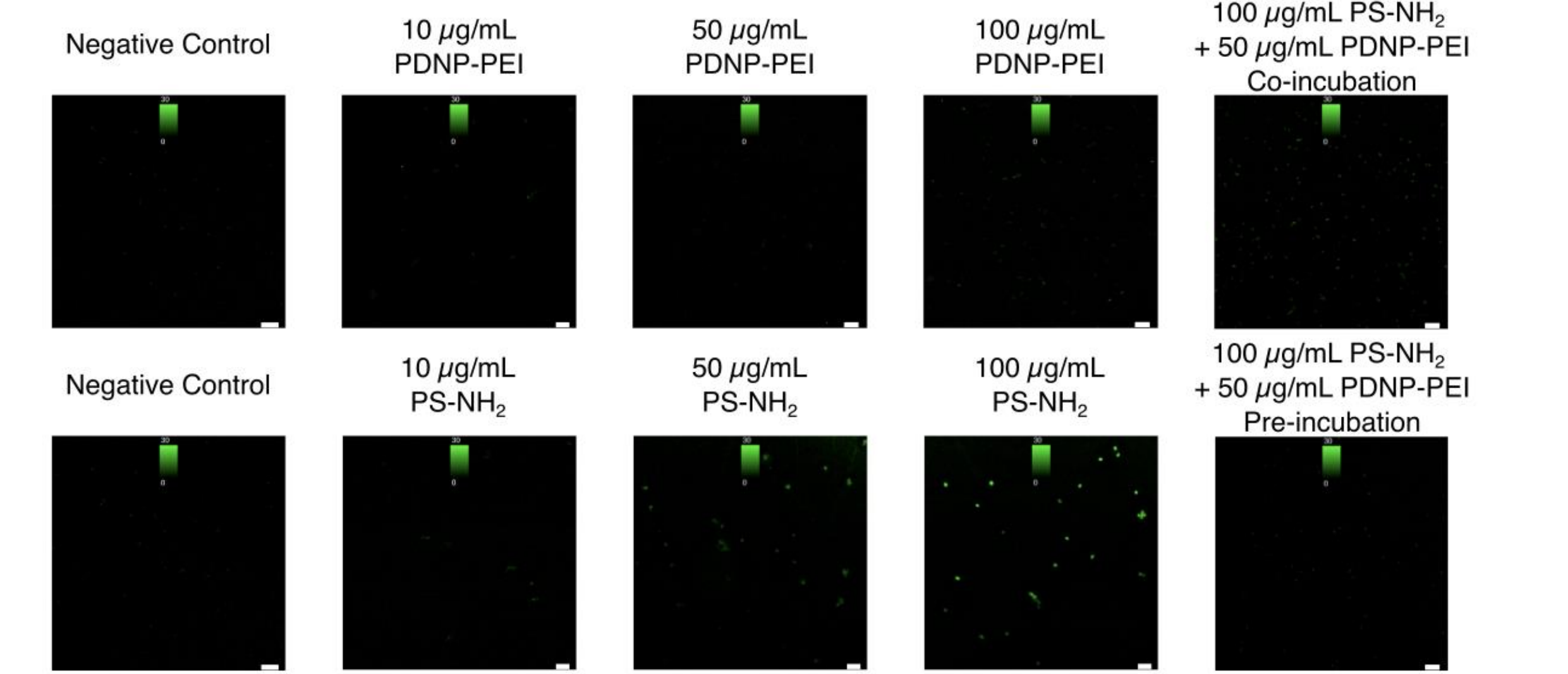


PDNP-PEI's ROS Scavenging Activity

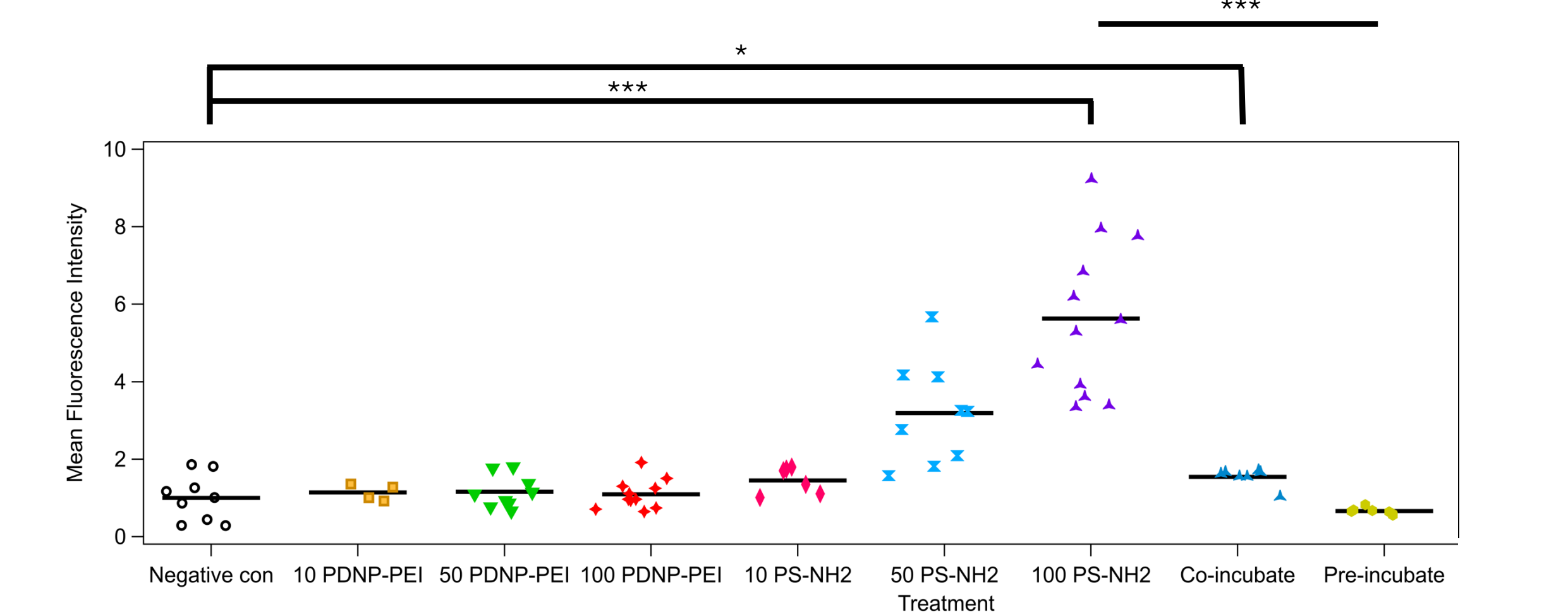


- DPPH Assay shows that PDNP-PEI has a comparable free-radical scavenging activity to PDNP
- PDNP-PEI maintains PDNP's excellent ROS scavenging activity, even with surface modification
- This aligns with our previous findings, where we demonstrated that PDNP-PEI reduces ROS levels in a burn-injured 3D skin organoid.

PDNP-PEI Decrease ROS caused by PS-NH₂

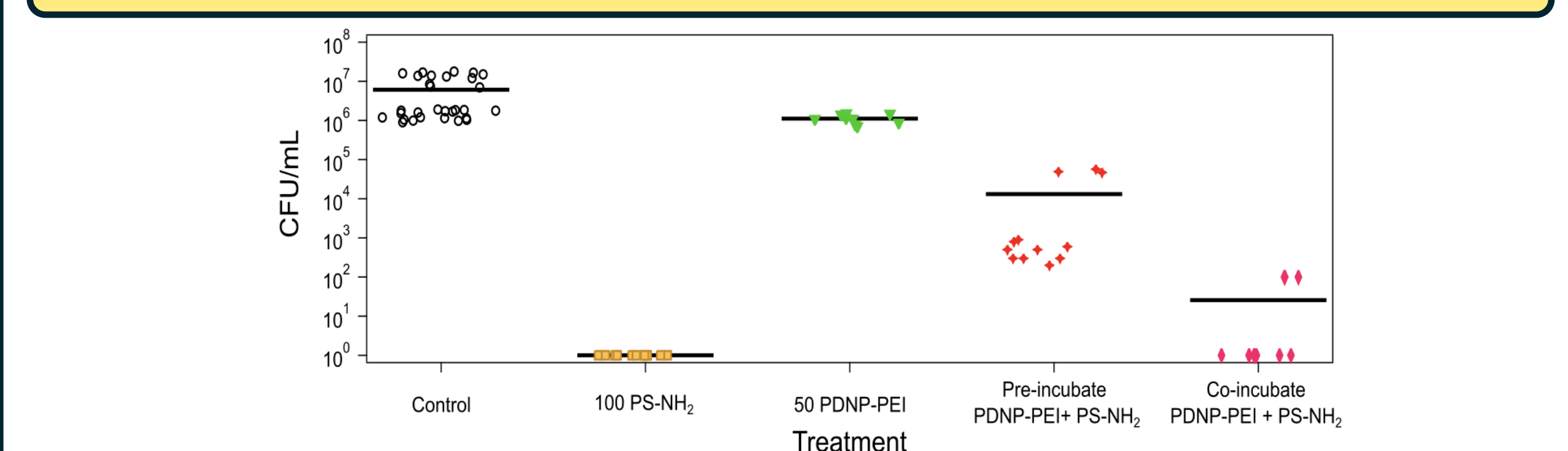


"Co-incubation": both types of NPs are added simultaneously. "Pre-incubation": PDNP-PEI was added first, then PS-NH₂

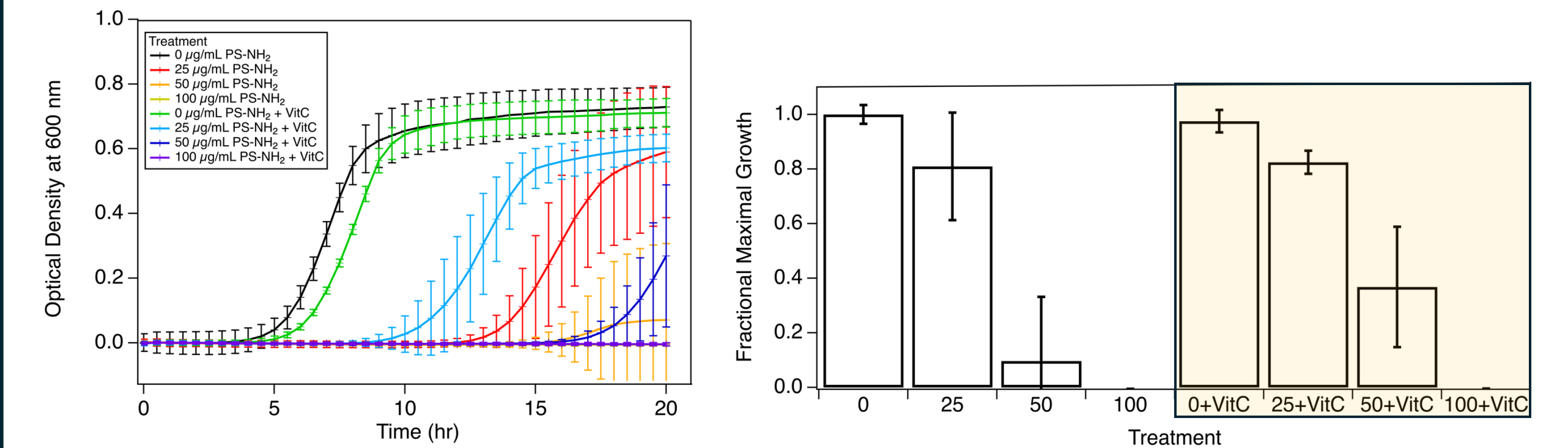


- Increasing [PDNP-PEI] showed similar ROS levels as -ive control; Increasing [PS-NH₂] showed an increase in ROS
- Both "pre-incubation" and "co-incubation" with two types of NPs showed a significant decrease in ROS levels
- **Hypothesis A:** PDNP-PEI's ROS scavenging activity can reduce PS-NH₂-induced intracellular ROS production
- **Hypothesis B:** PDNP-PEI's ability to compete with PS-NH₂ for binding to bacteria surface results in lower ROS levels
- Can PDNP-PEI increase bacteria viability when PS-NH₂ is present? How does it compare with Vitamin C?

PDNP-PEI and Vitamin C in Bacterial Protection

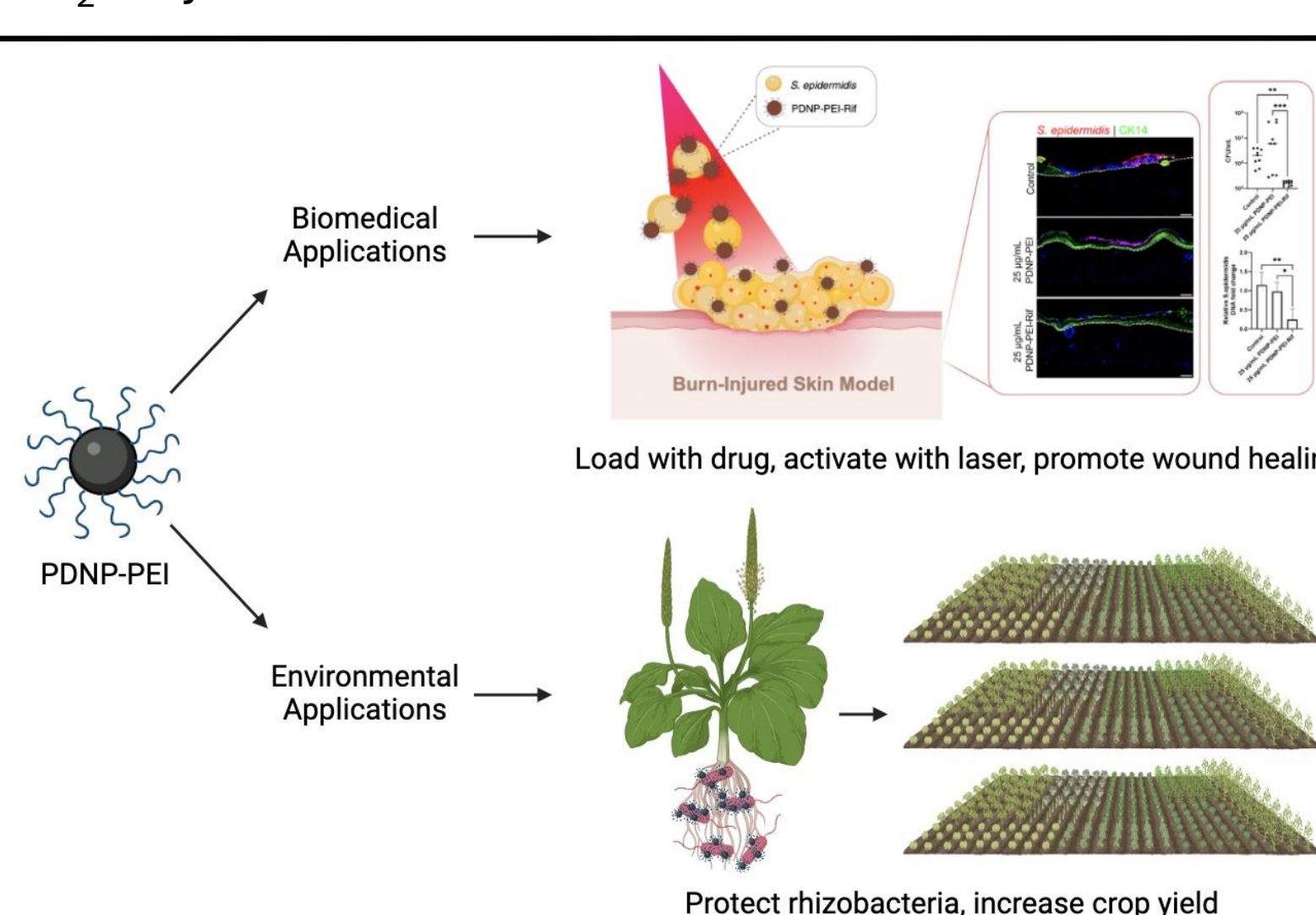


- With 50 µg/mL PDNP-PEI pre-incubation, bacteria were slightly rescued from nanoplastics' (100 µg/mL) toxic effect
- With 50 µg/mL PDNP-PEI co-incubation, most bacteria remain lost of cell viability
- Although PDNP-PEI can decrease intracellular ROS levels in bacteria, it can only provide limited protection



Conclusion & Future Directions

- PDNP-PEI shows stimuli-responsive antimicrobial activity against *S. epidermidis* under low-salt environment
- PDNP-PEI alone (without laser or heat) doesn't kill *S. epidermidis* under a high-salt environment, yet PS-NH₂ does
- PDNP-PEI has great ROS-scavenging activity and can reduce nanoplastic-induced intracellular ROS levels in bacteria
- PDNP-PEI can rescue bacteria from PS-NH₂ slightly but not entirely, similar to the antioxidant vitamin C
- PS-NH₂ may have other bactericidal mechanisms other than ROS



References

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Acknowledgements

