

# Sono-photodynamic Therapy on Cancer and Bacteria

Literature Seminar

2023/9/14

Keiichi Kawabata (M2)

# Contents

- Introduction
- Sono-photodynamic Therapy on Cancer
- Sono-photodynamic Therapy against Bacteria
- Summary

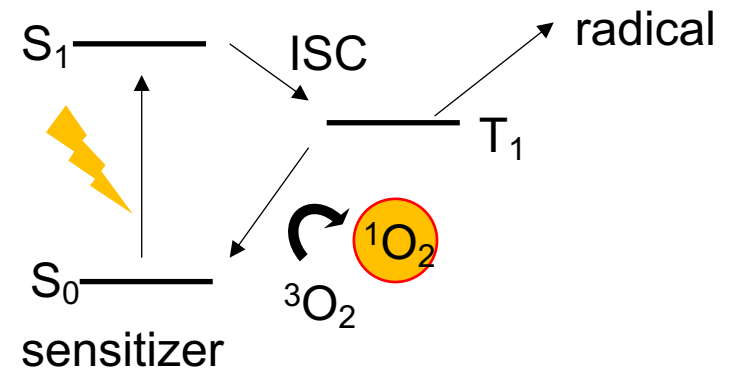
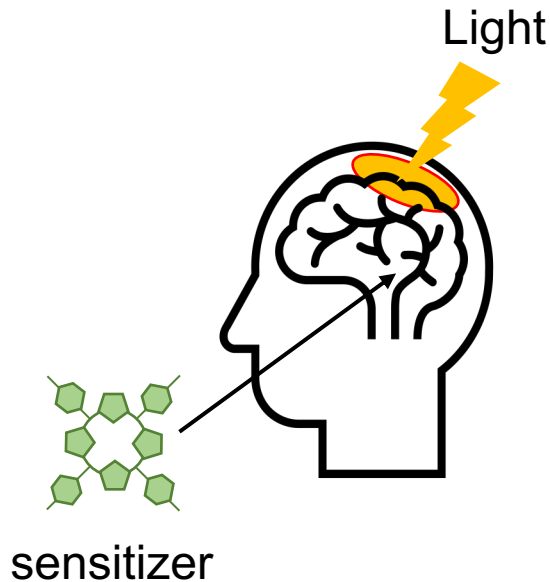
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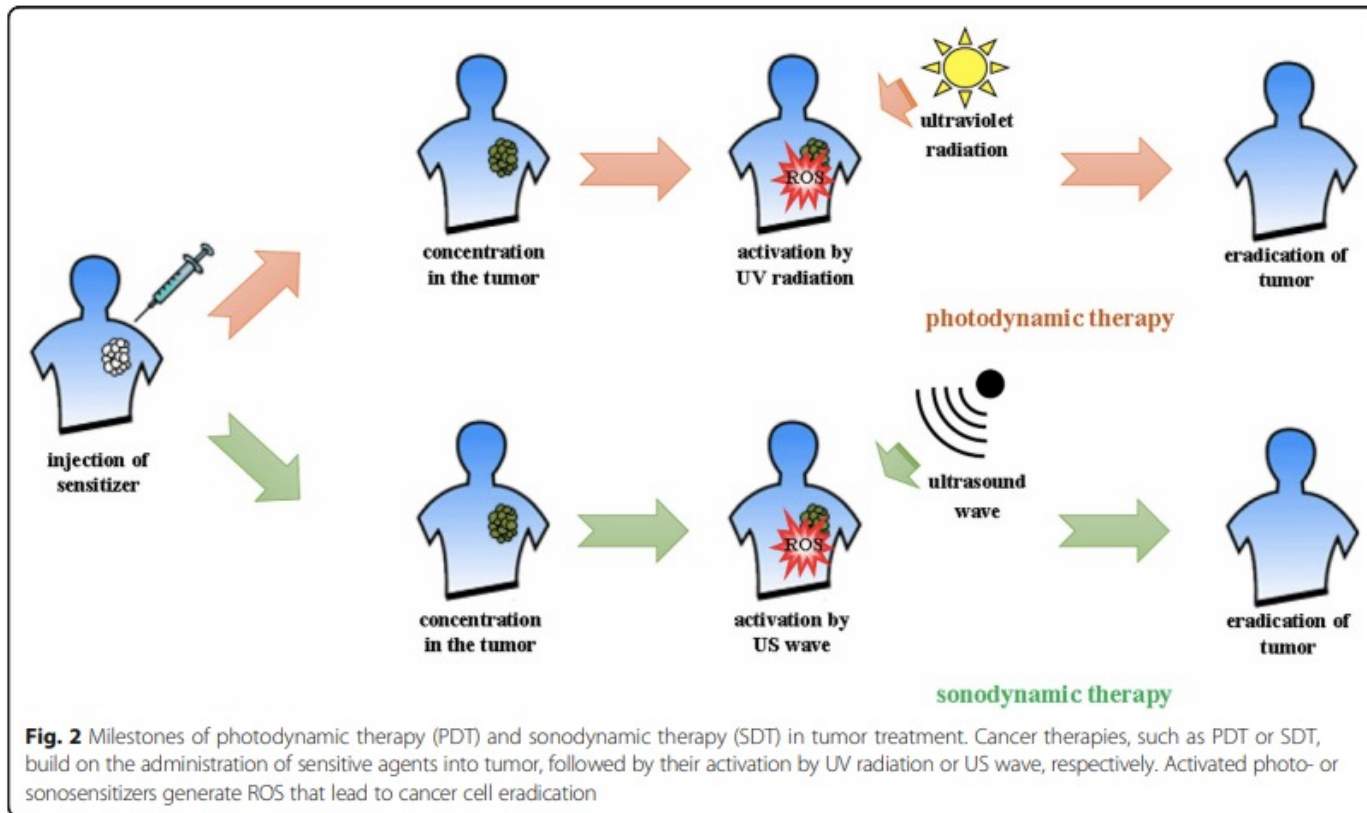
# Photodynamic Therapy

## PDT

- ✓ High selectivity
- ✓ Low risk of side effects
- ✗ Low permeability



# Sonodynamic Therapy



SDT

- ✓ Non-invasive
- ✓ High permeability

Bogdan, *et al.*, *Nanoscale Res. Lett.*, **2017**, *12*, 225

# Cavitation

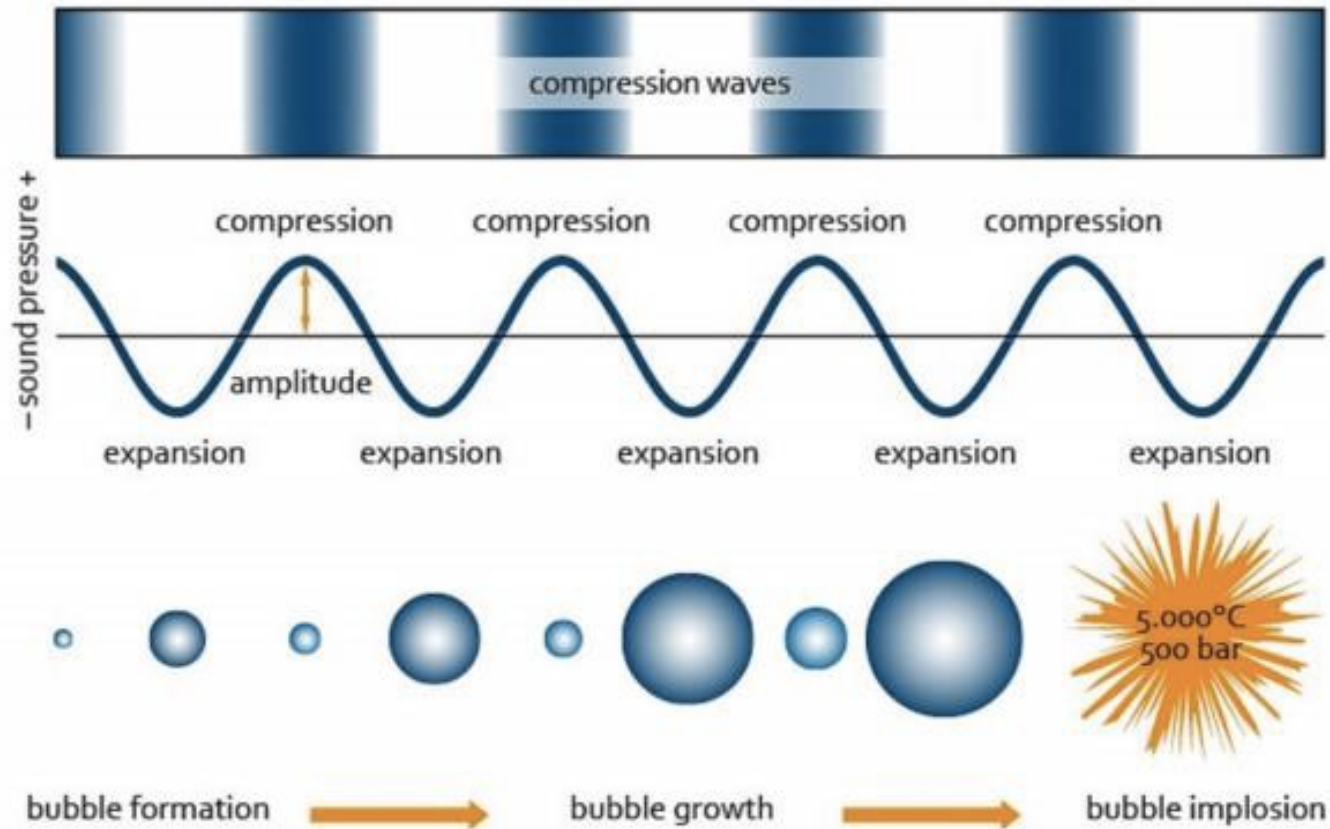
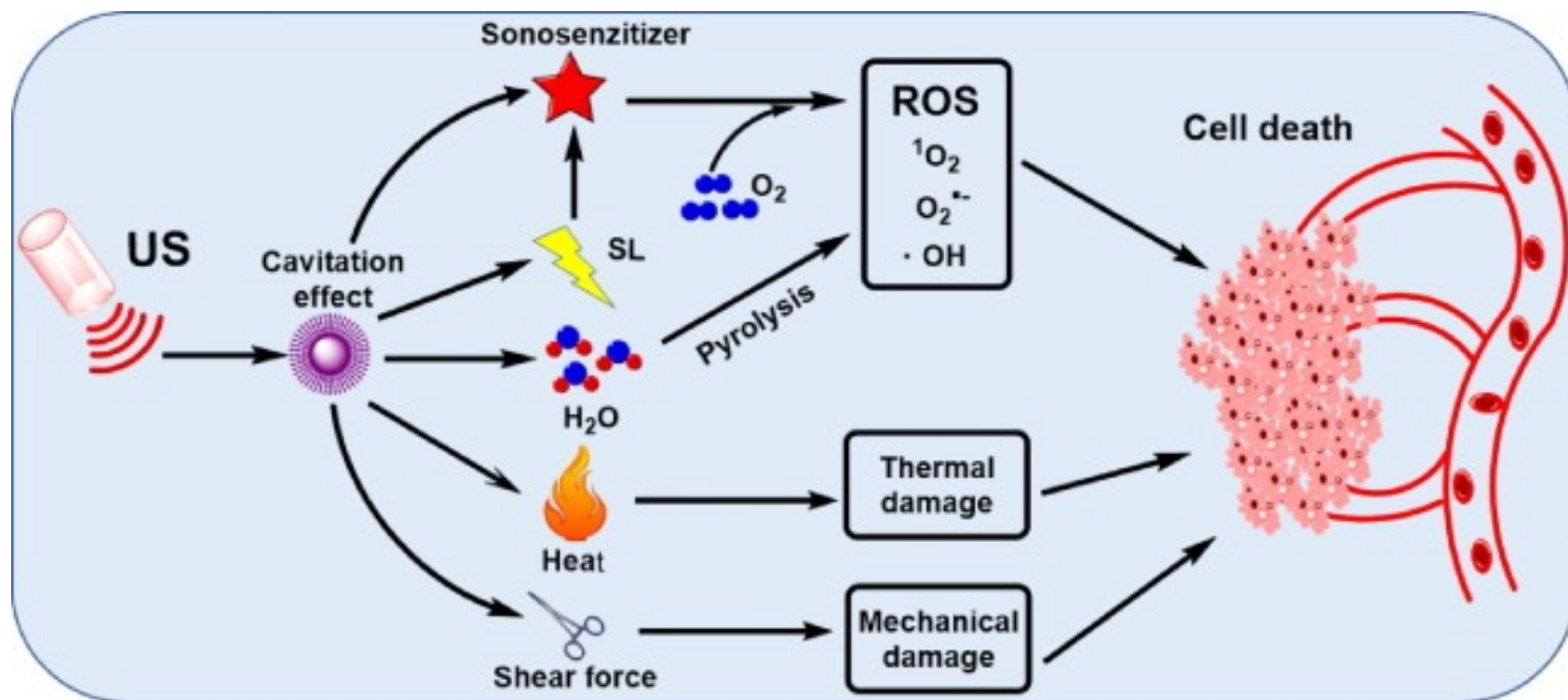


Figure 1. Principle of ultrasound cavitation [16]. The initiated bubbles grow due to evaporation and finally reach critical size (resonant) when it grows quickly and collapse violently.

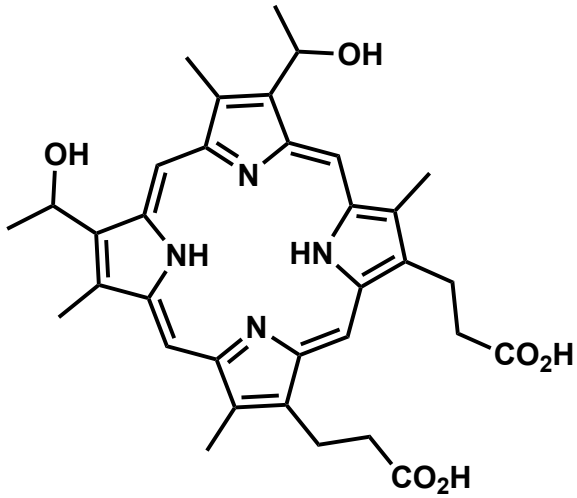
J, Ö., et al., *Sustainable and energy efficient leaching of tungsten (W) by ultrasound controlled cavitation*, 2017, p8<sup>6</sup>

# Mechanism of SDT

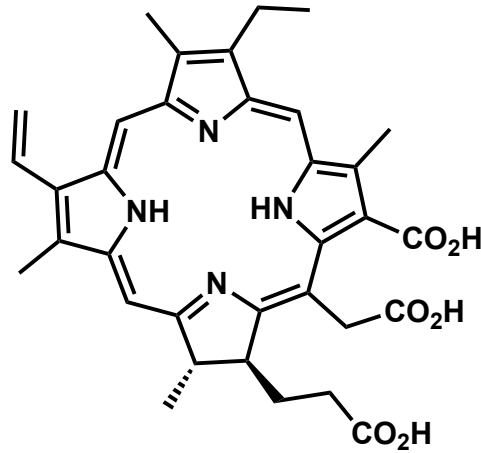


Xing, X. *et al.*, *Coordination Chemistry Reviews*, **2021**, 445, 214087

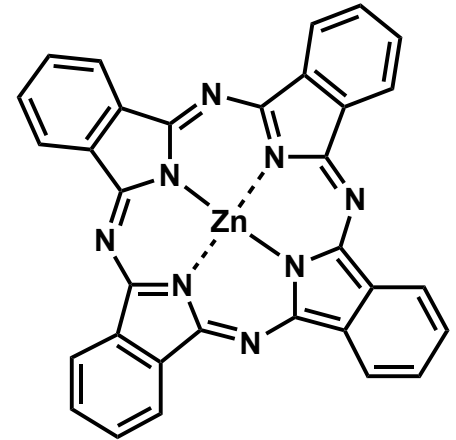
# Sensitizers



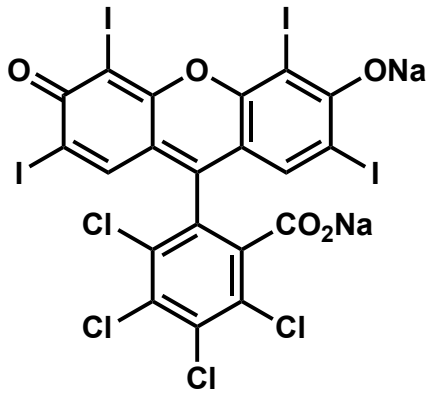
Hematoporphyrin



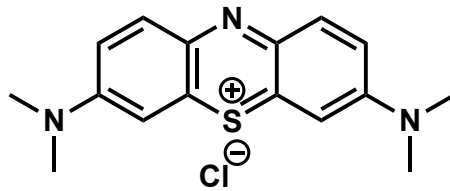
Chlorin e6



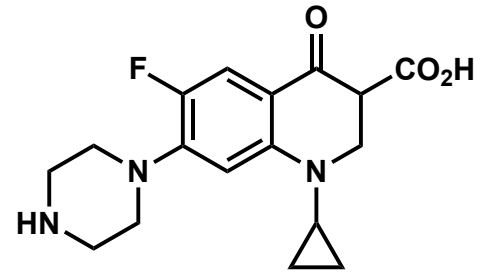
Zinc Phthalocyanine



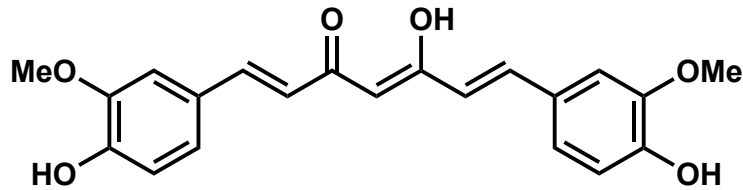
Rose Bengal



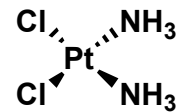
Methylene Blue



Ciprofloxacin



Curcumin



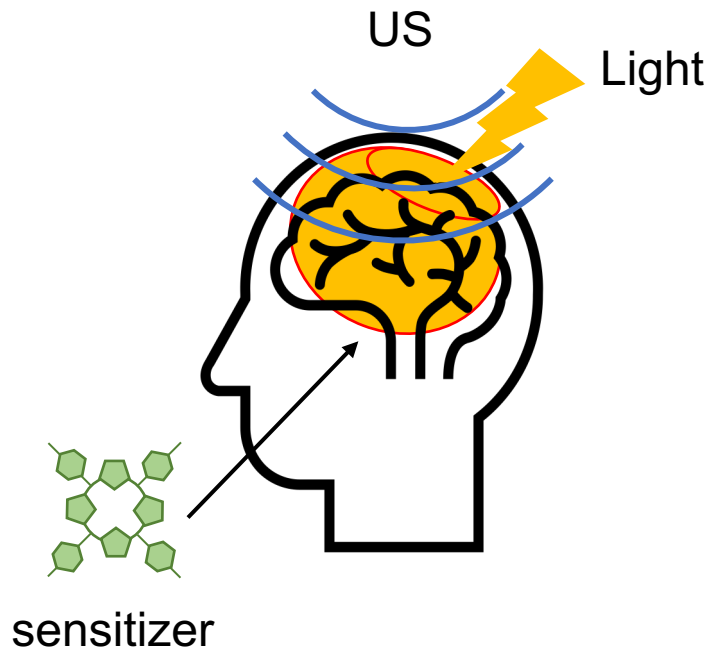
Cisplatin 8



# Sono-photodynamic Therapy

## SPDT

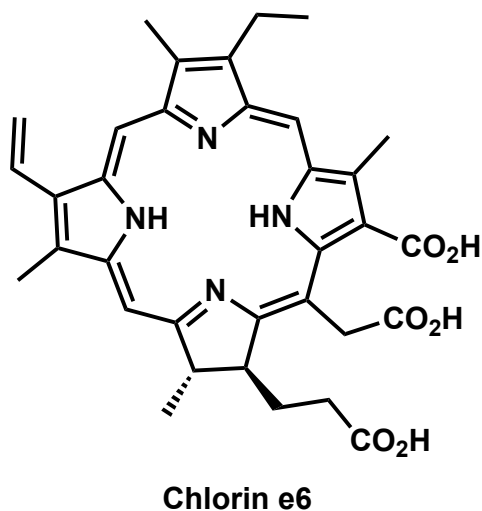
- ✓ High selectivity
- ✓ Low risk of side effects
- ✓ Low permeability
- ✓ High efficiency



# Contents

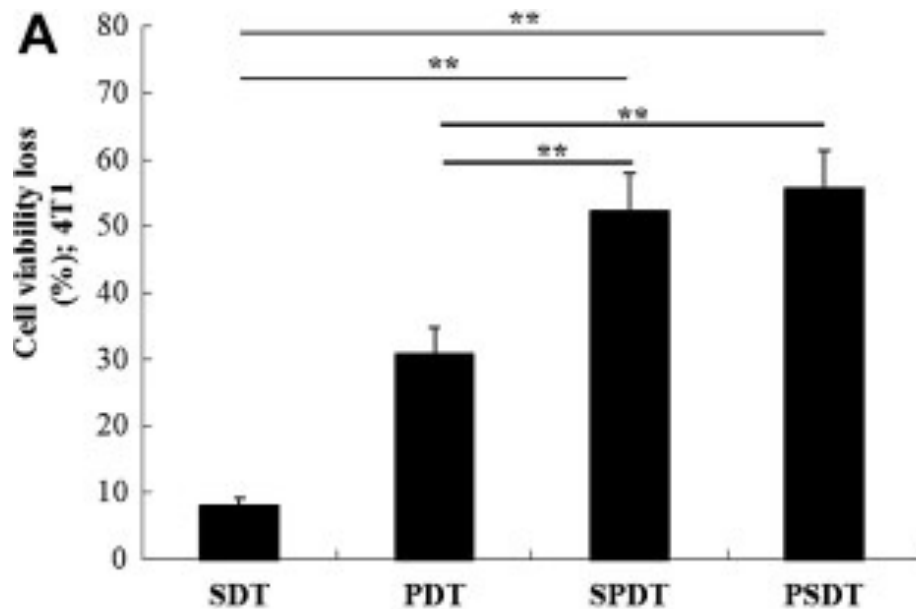
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# Cytotoxicity of Ce6

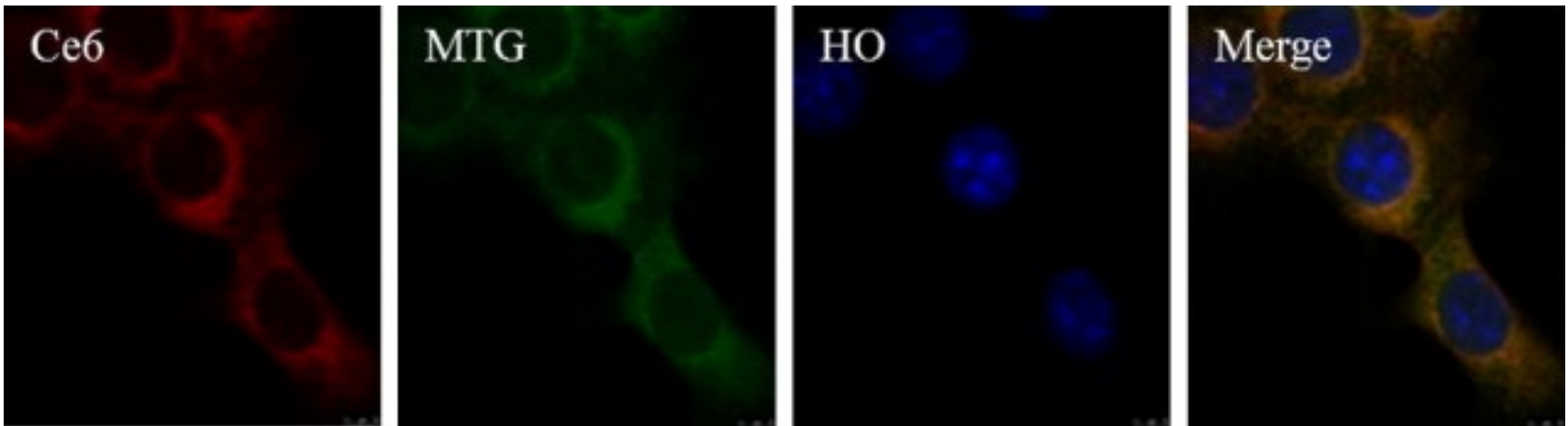


PDT: light only  
 SDT: US only  
 SPDT: light → US  
 PSDT: US → light

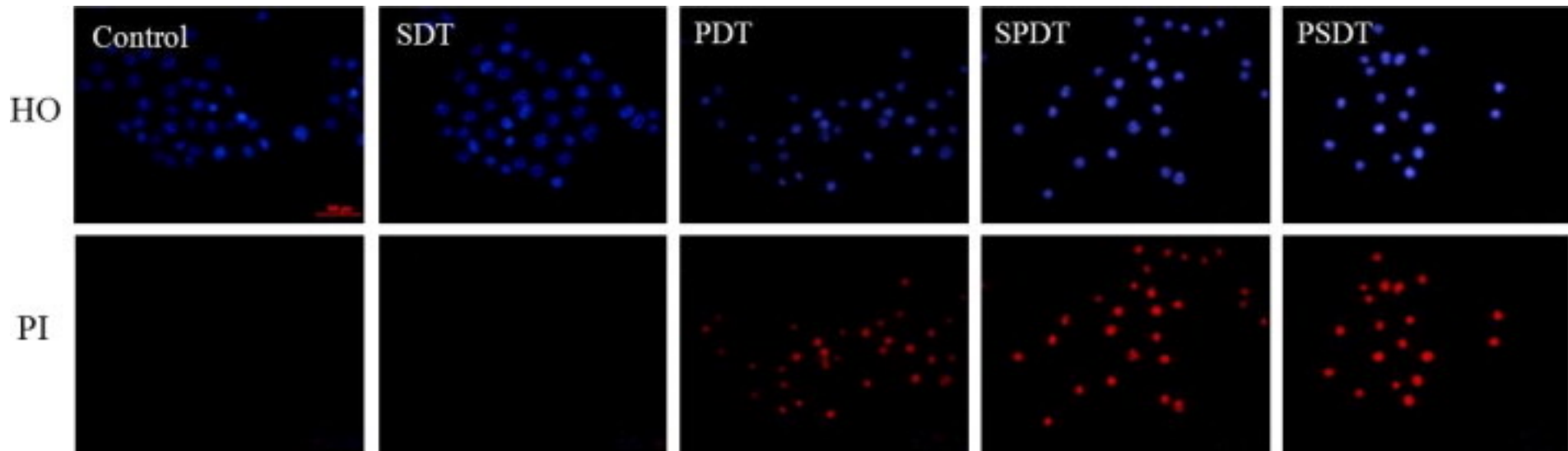
Light: 650 nm, 1.2 J/cm<sup>2</sup>  
 US: 0.36 W/cm<sup>2</sup>



# Localization



# Morphological Analysis

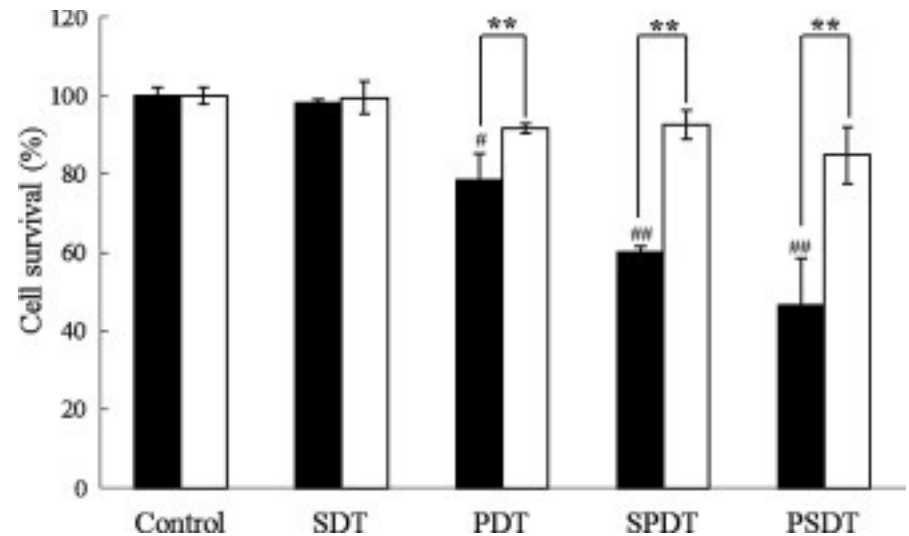
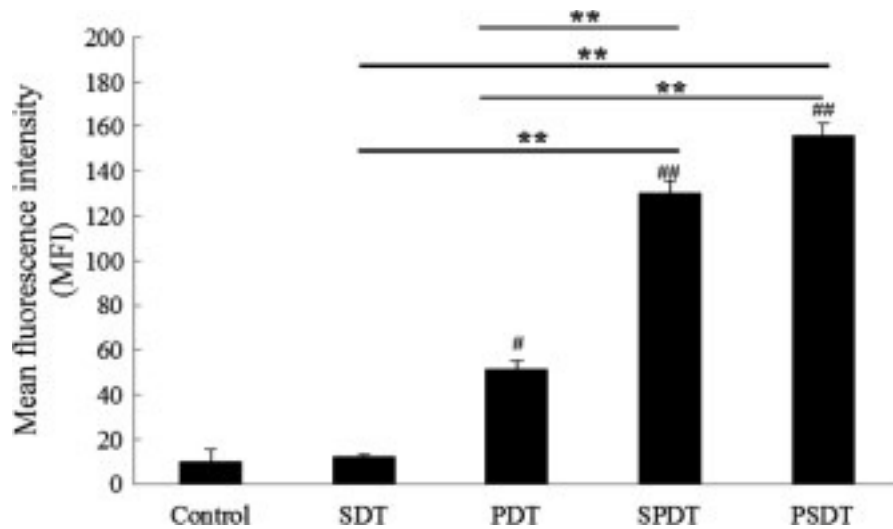


# ROS Detection

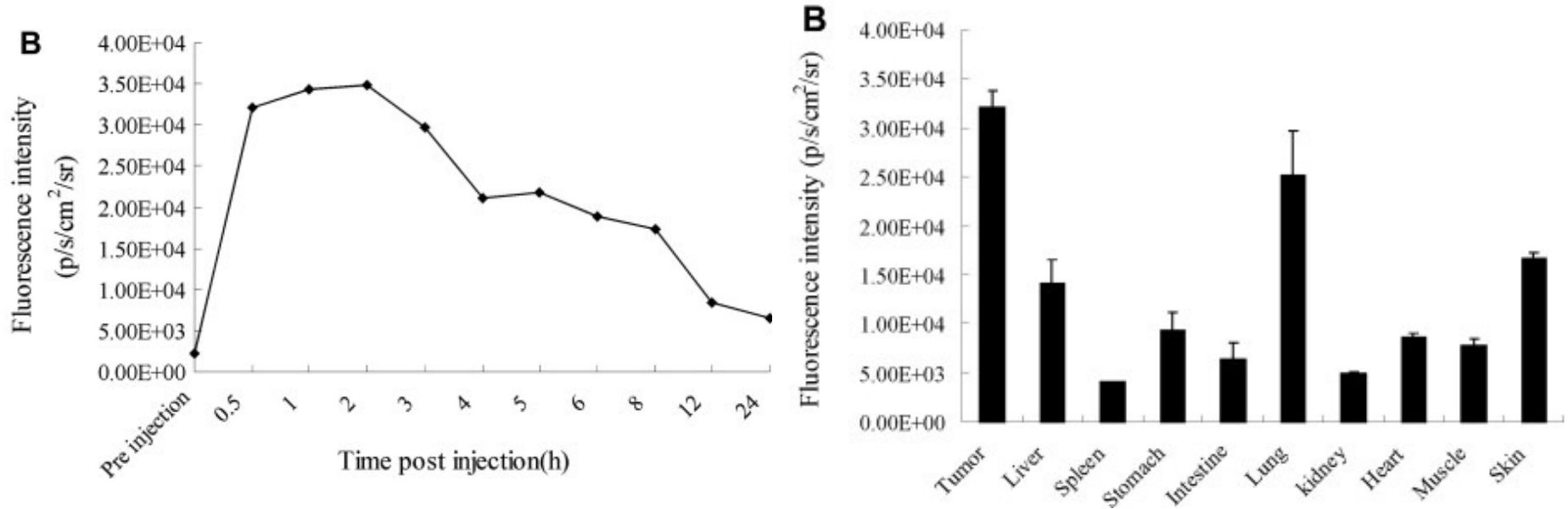


Rescue experiment

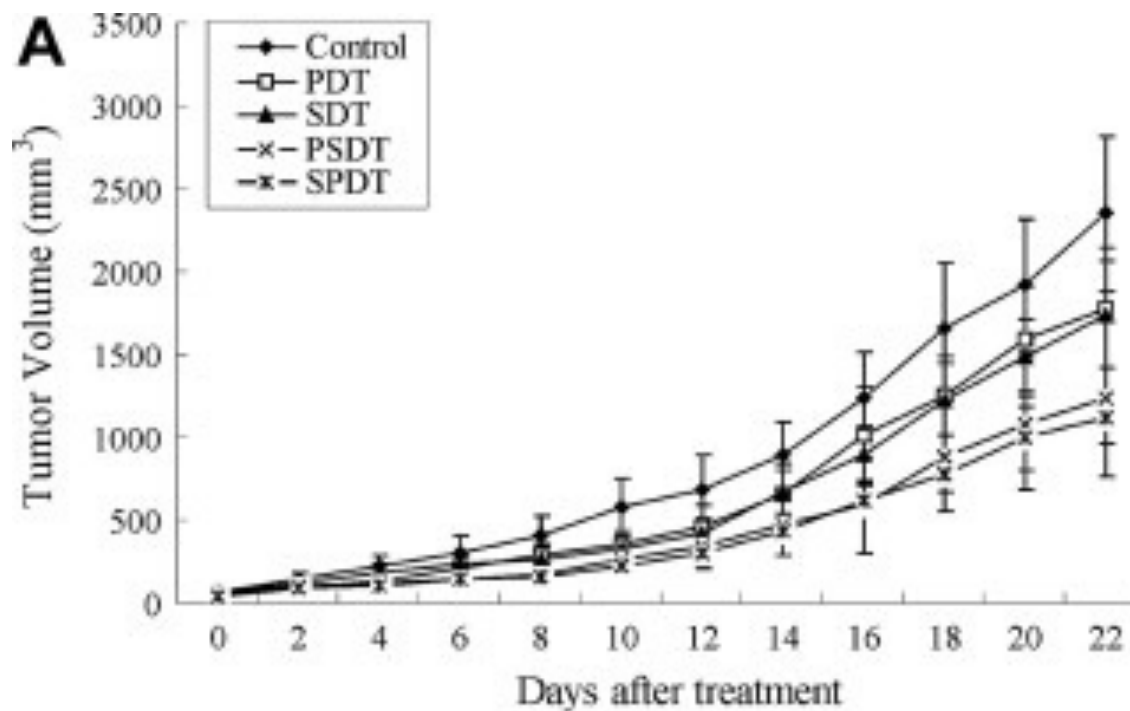
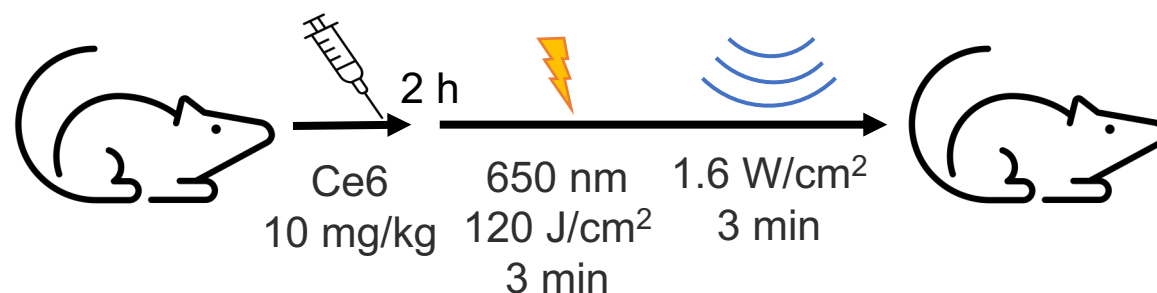
Black: NAC-  
White: NAC+



# Distribution of Ce6



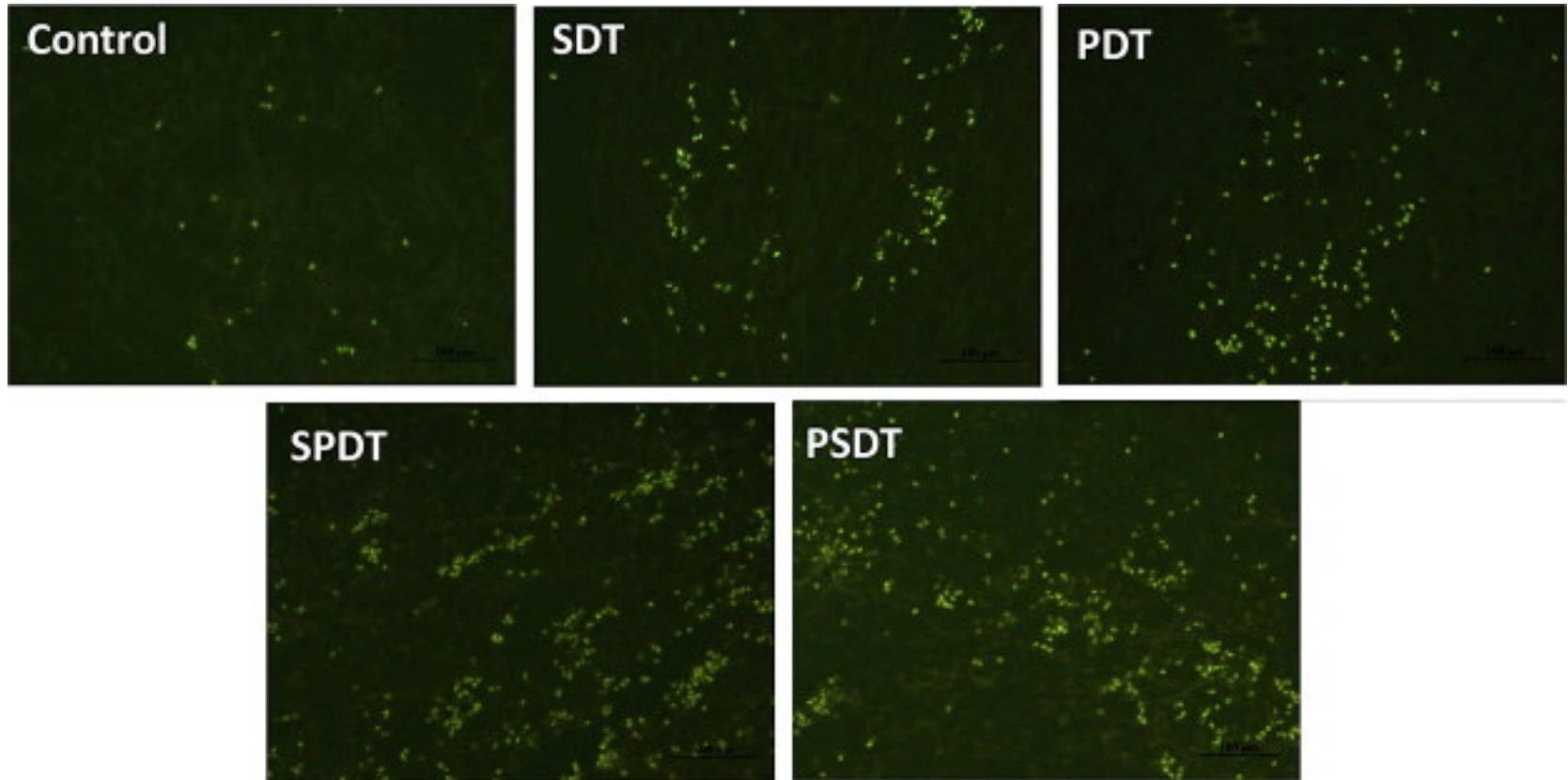
# Inhibition of Tumor Growth





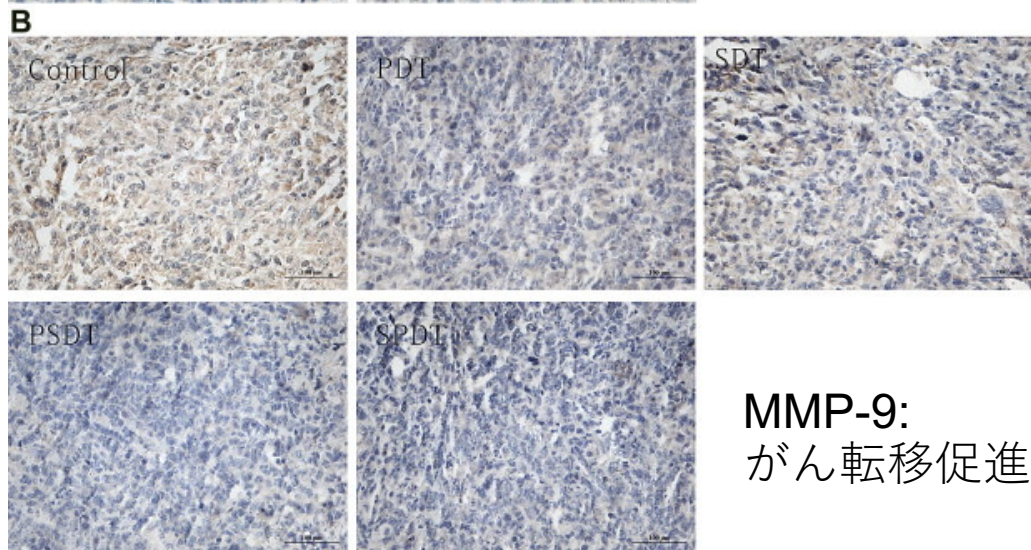
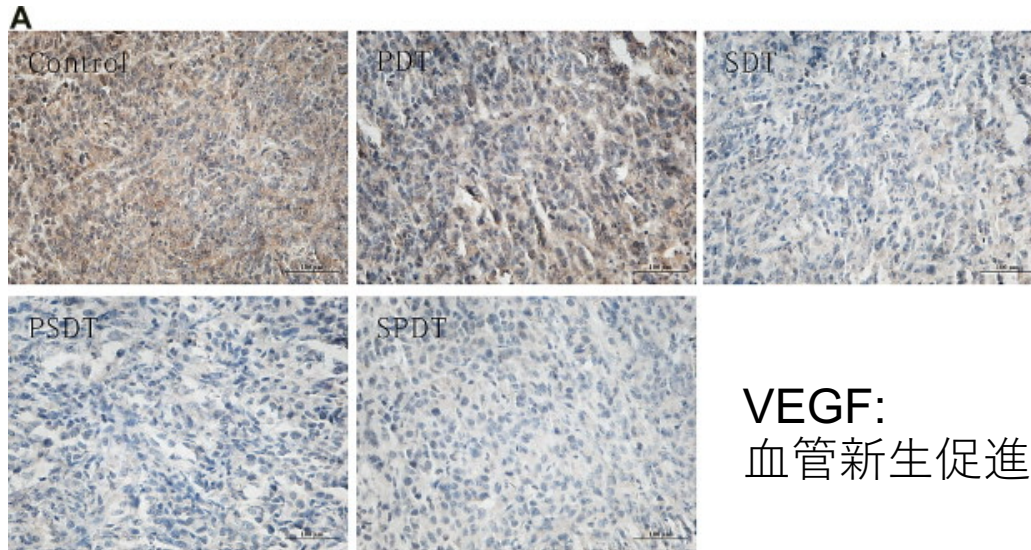
# Apoptosis In Vivo

TUNEL assay



# Decrease of VEGF & MMP-9

IHC assay



# Short Summary

- SPDT is a promising cancer therapy combining PDT and SDT.
- SPDT is more effective than PDT or SDT alone.
- ROS damage → mitochondria → apoptosis
- Decrease in expression level of VEGF and MMP-9

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# Antibacterial Strategies

- Antibiotics

  - ✗ Drug resistance



- PDT

  - ✓ High selectivity

  - ✓ Low risk of side effects

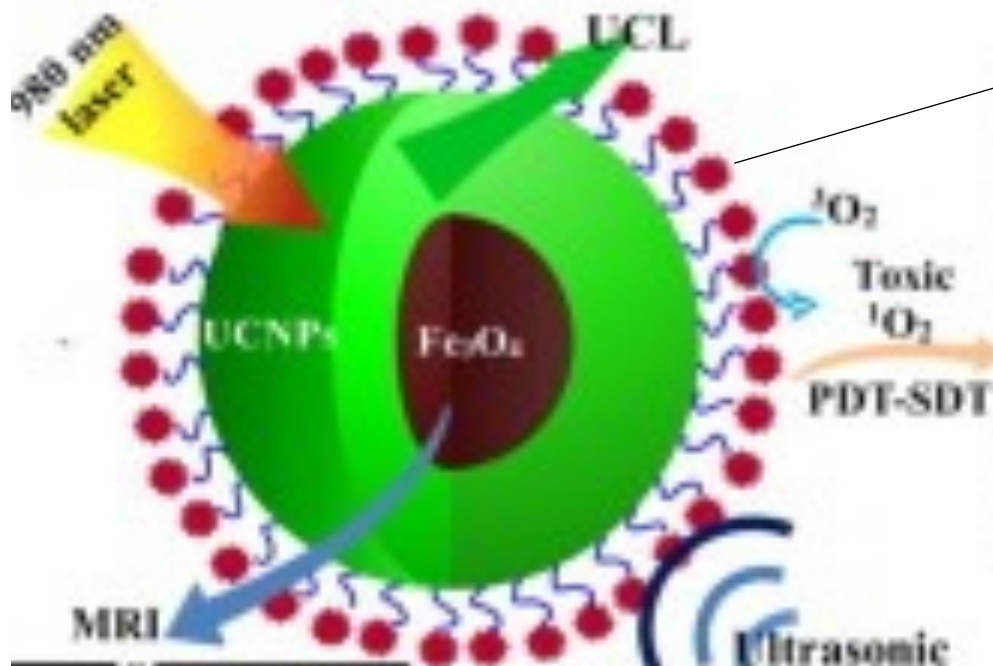
  - ✓ Low potential of drug resistance



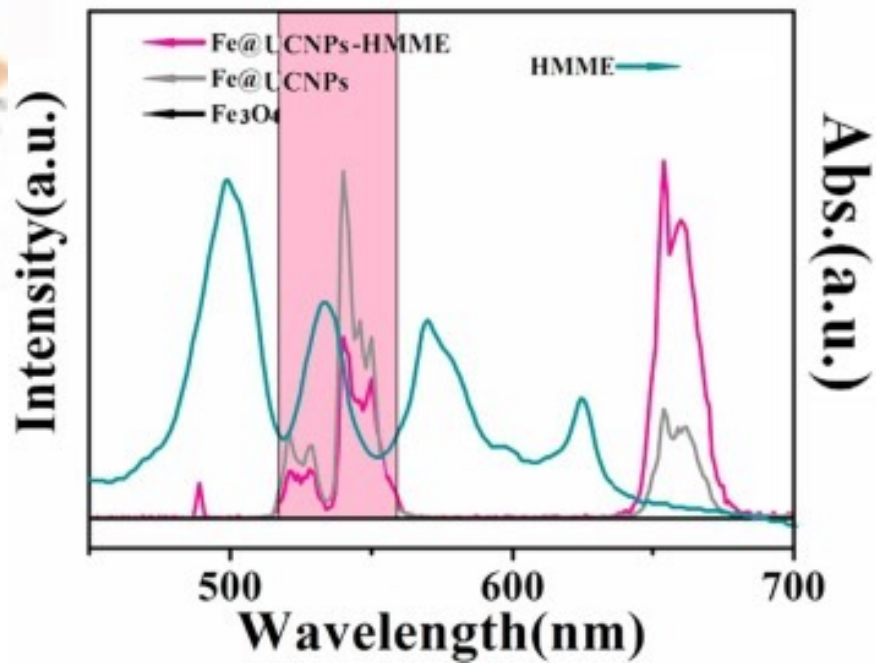
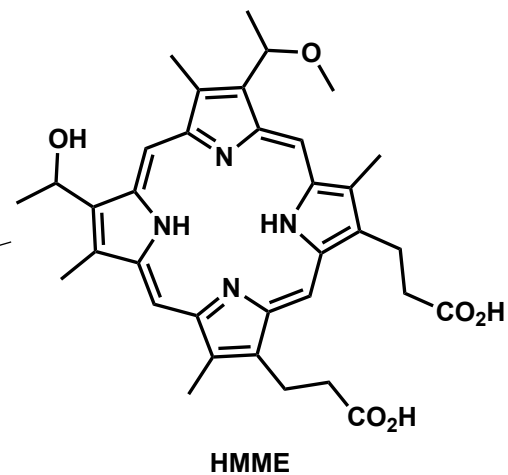
- SDT/SPDT

  - ✓ Permeability

# Nanoparticle

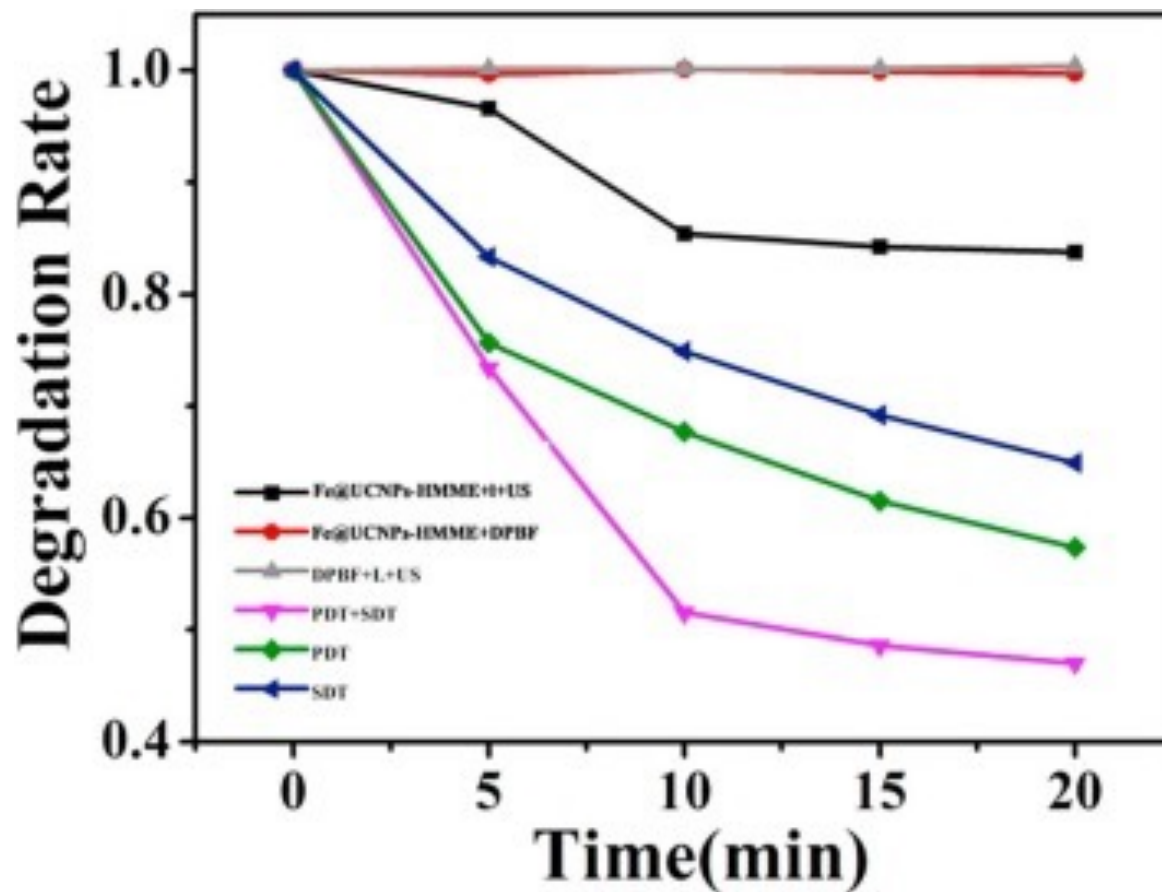


Fe@UCNP-HMME

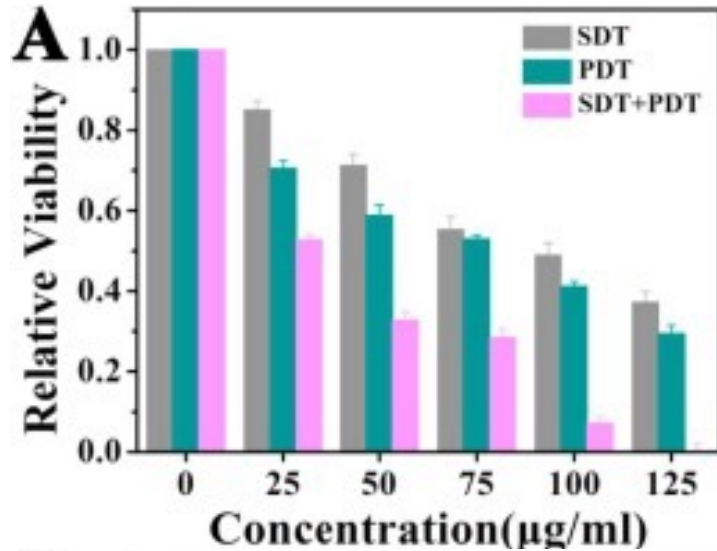


# $^1\text{O}_2$ Generation

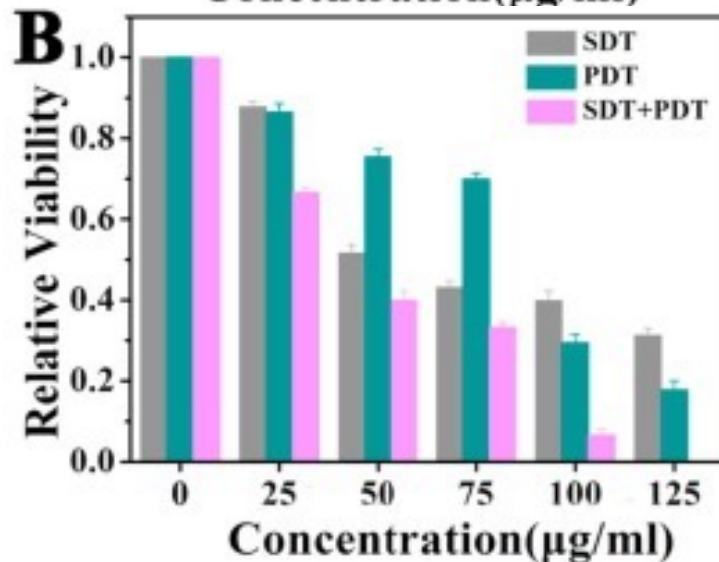
Light: 980 nm, 1 W/cm<sup>2</sup>  
US: 2 W/cm<sup>2</sup>



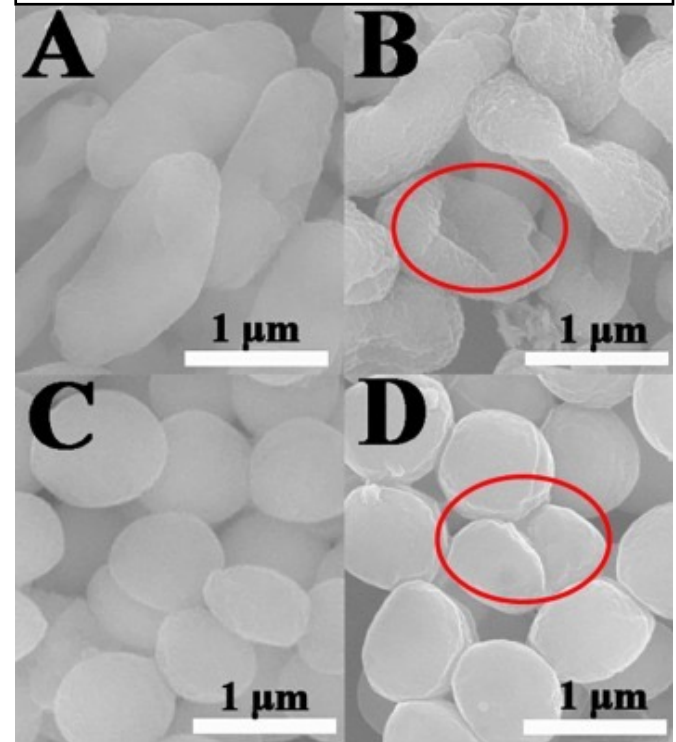
# Bacterial Viability



A: ESBL-producing *E. coli*  
B: MRSA



A, B: ESBL-producing *E. coli*  
C, D: MRSA





# Contents

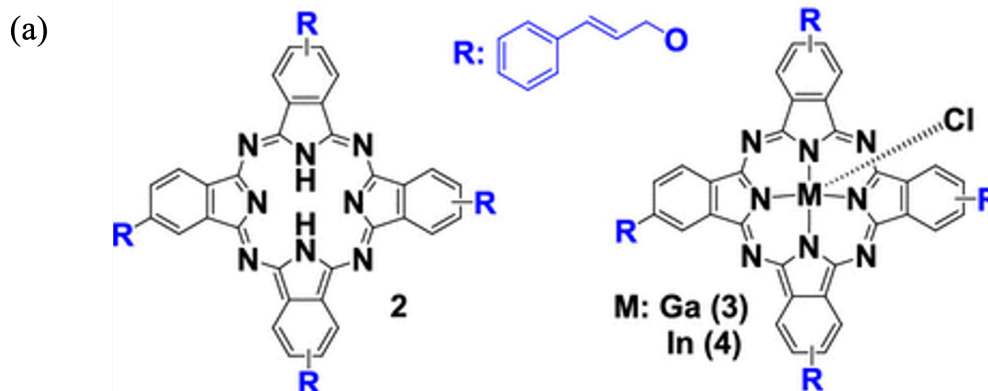
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# Summary

- SPDT is applied to cancer and bacteria treatment.
- SPDT is more effective than PDT and SDT.
- Mechanism of SPDT remains unclear.

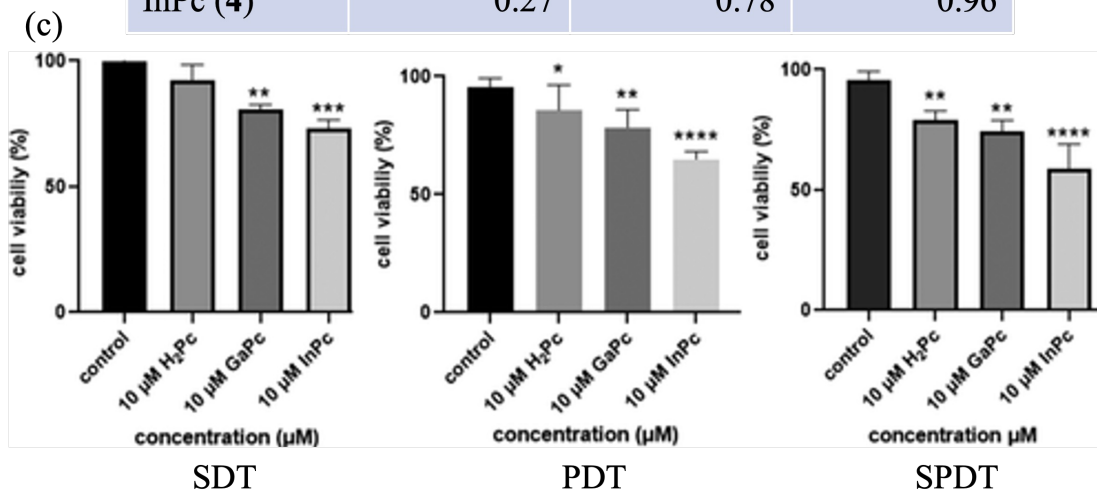
# APPENDIX

# $^1\text{O}_2$ Quantum Yield

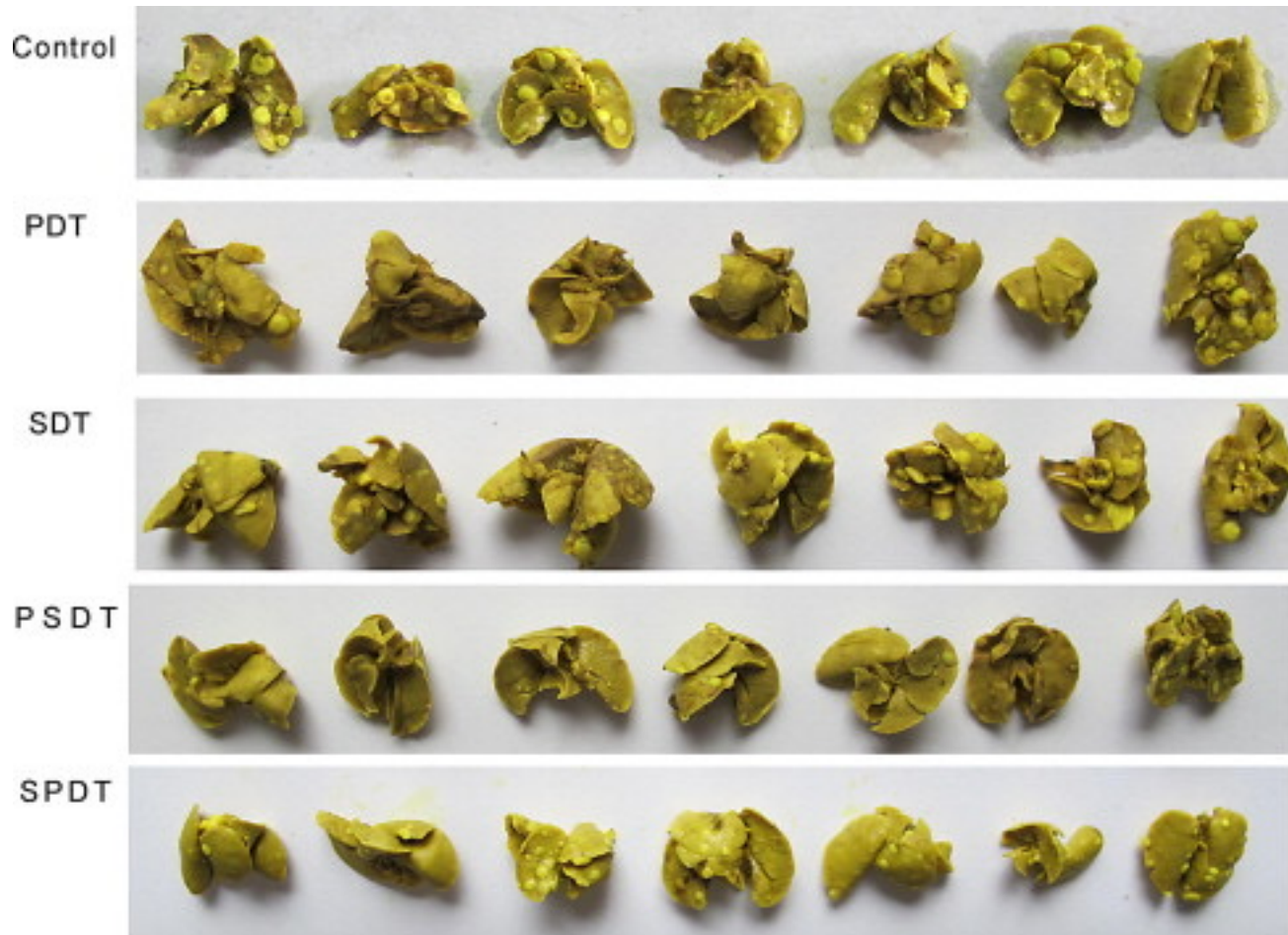


(b)

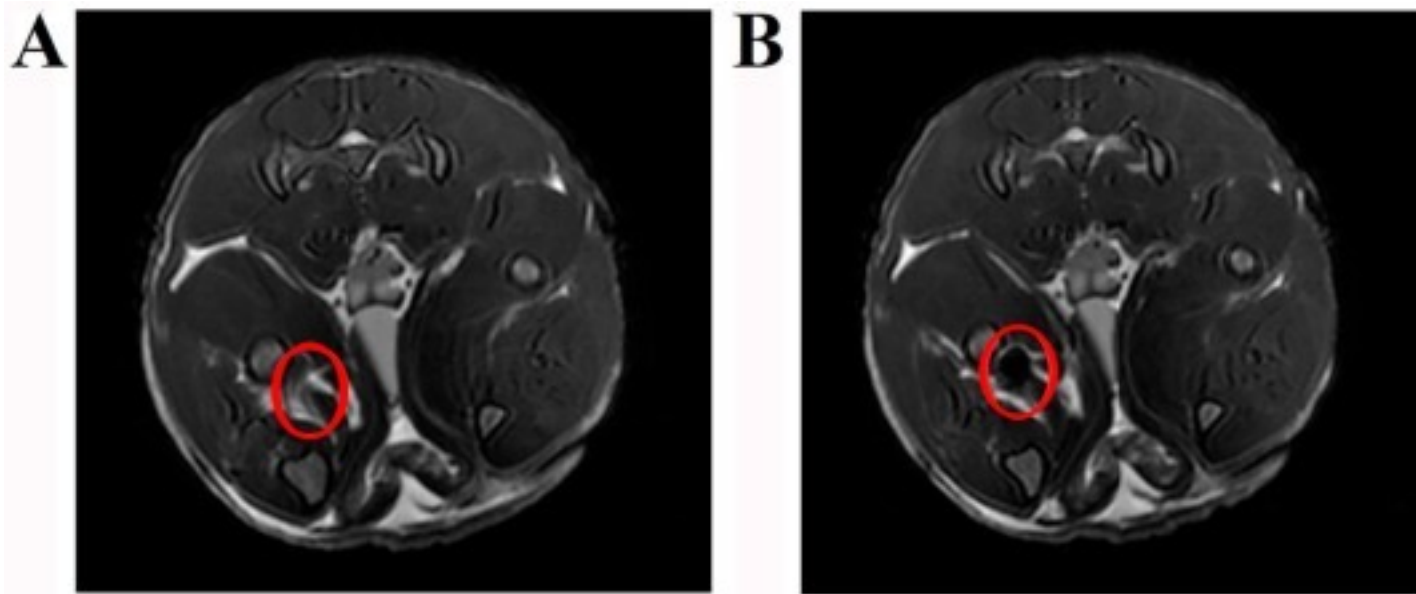
Pcs	$\Phi_F$ ( $10^{-2}$ )	$\Phi_{\Delta}(\text{PDT})$	$\Phi_{\Delta}(\text{SPDT})$
$\text{H}_2\text{Pc}$ (2)	8.60	0.22	0.55
GaPc (3)	0.13	0.61	0.85
InPc (4)	0.27	0.78	0.96



# Metastasis to Lung

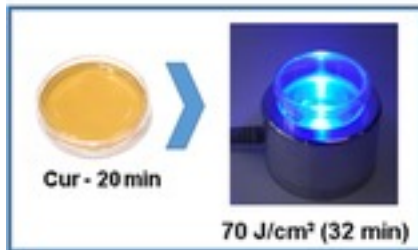


# Imaging

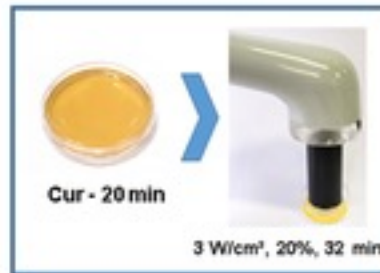


# Biofilm

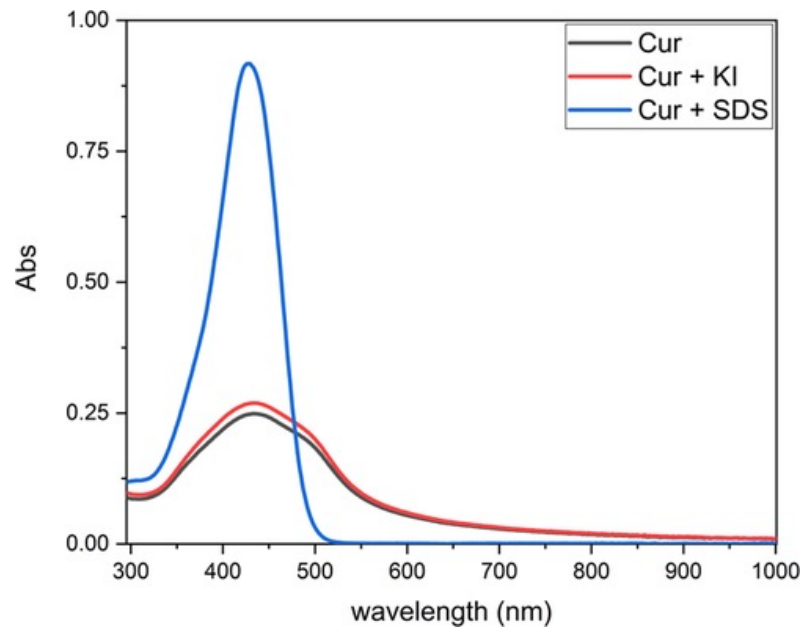
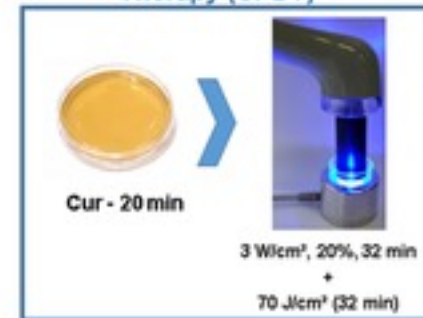
Photodynamic Therapy (PDT)



Sonodynamic Therapy (SDT)



Sonophotodynamic Therapy (SPDT)



# Biofilm

