

Porphyrin-functionalized additives to enhance the thermal conductivity of polymer-GNP composites

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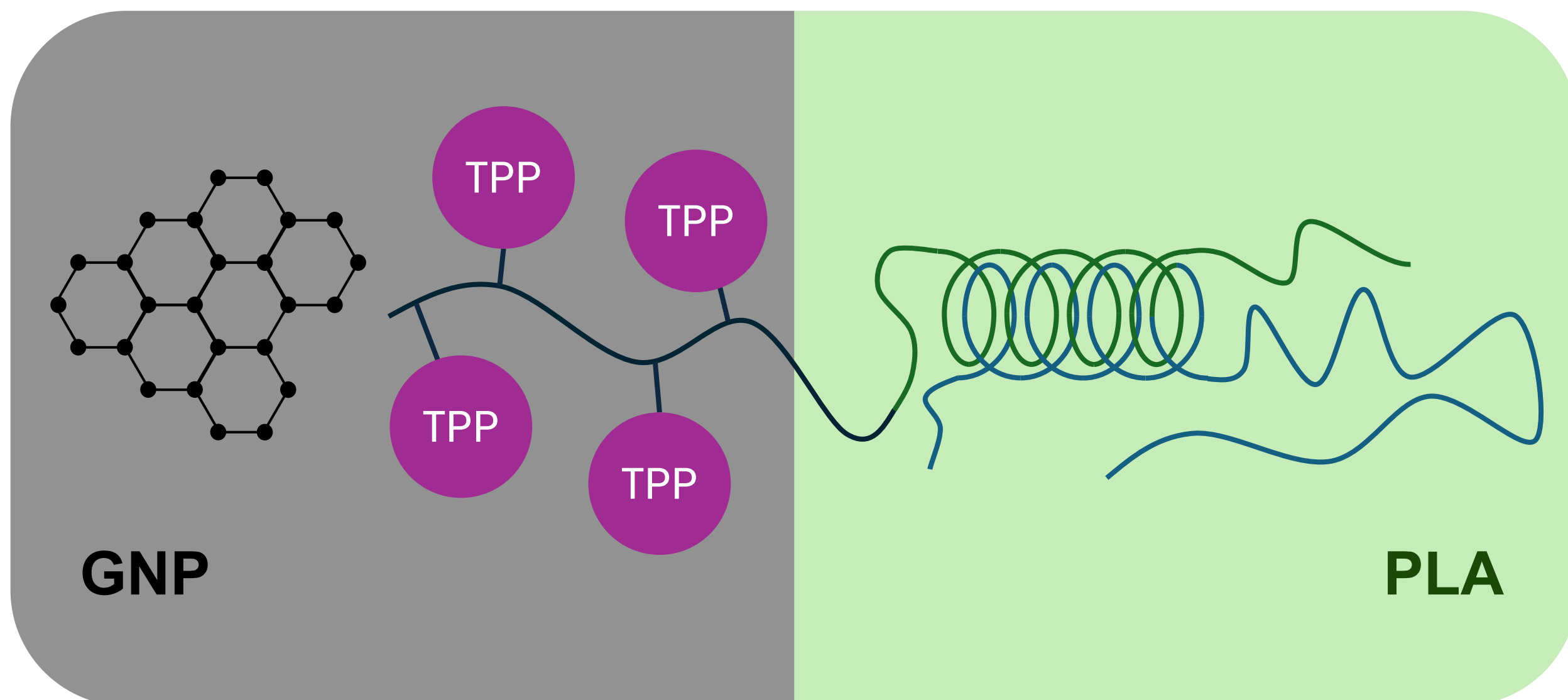
Aim

With the continued miniaturization of electronic devices, effective **thermal management** has become a critical challenge. The excessive heat generated during device operation must be effectively dissipated from the sensitive components to ensure reliable performance [1].

In many applications, thermal management components are made of **polymer composites** containing thermally conductive fillers. However, a major limitation in such systems is **weak filler-matrix interaction**, which leads to filler agglomeration and high interfacial thermal resistance [2].

In this work, we aim to tackle the problem by introducing **an additive** that provides additional **non-covalent interactions** between the organic phase and the filler.

The concept



Why graphene nanoplatelets (GNP)?

- High thermal conductivity
- Lightweight
- Non-toxic

Why tetraphenylporphyrin (TPP)?

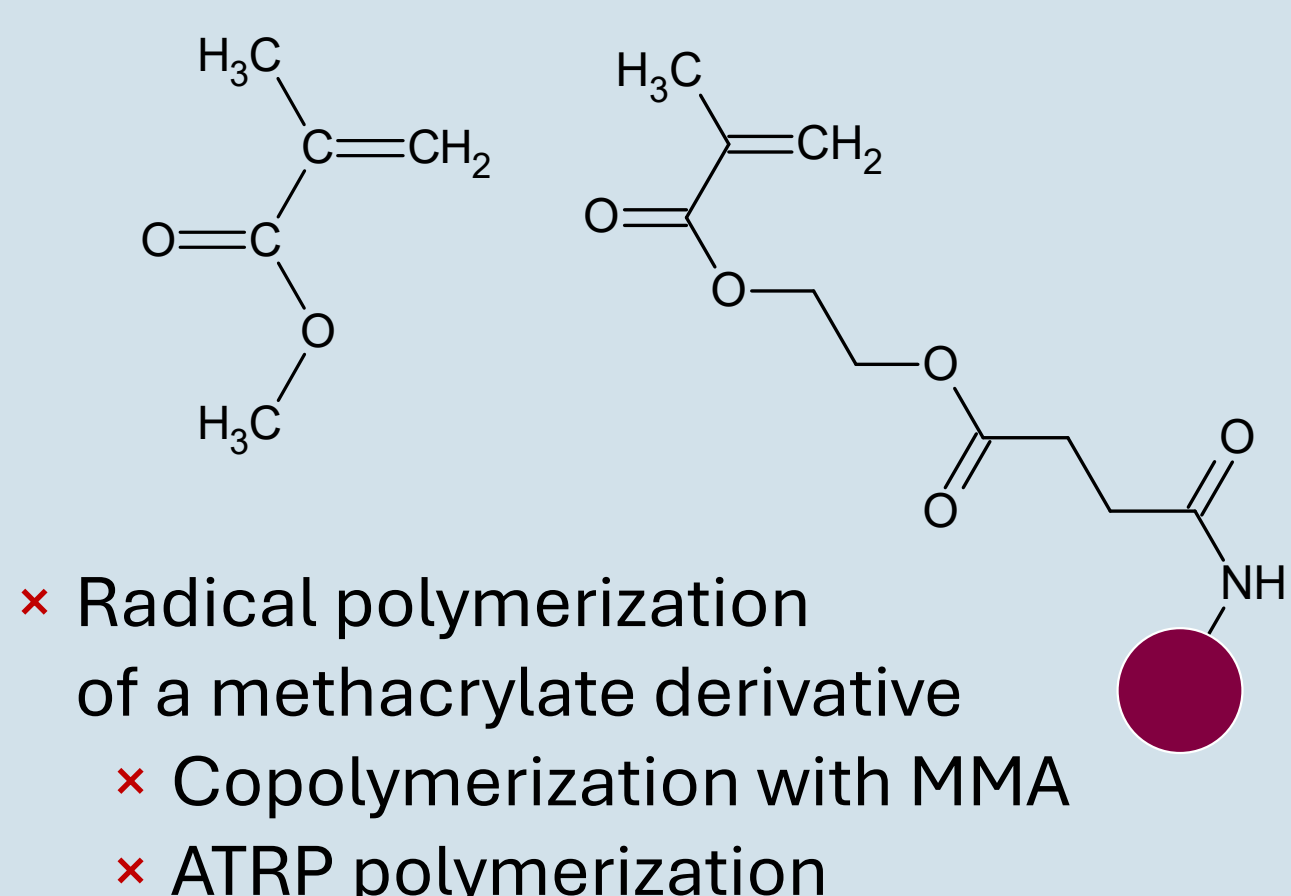
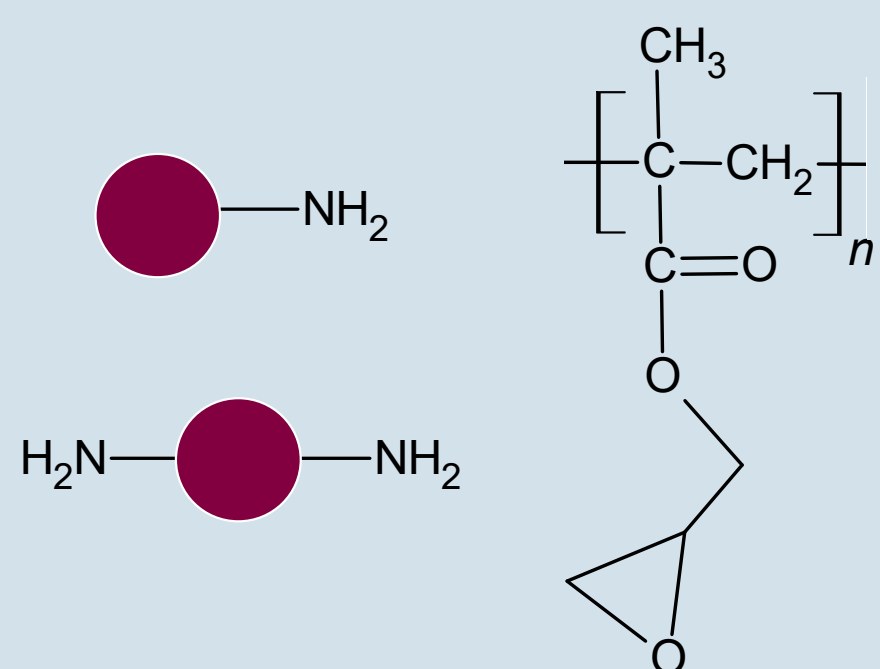
- Reported to adsorb on carbon nanomaterials
- Should provide spectroscopic evidence of interactions with GNP
- Not used in composites with GNP yet

Why built into a polymer?

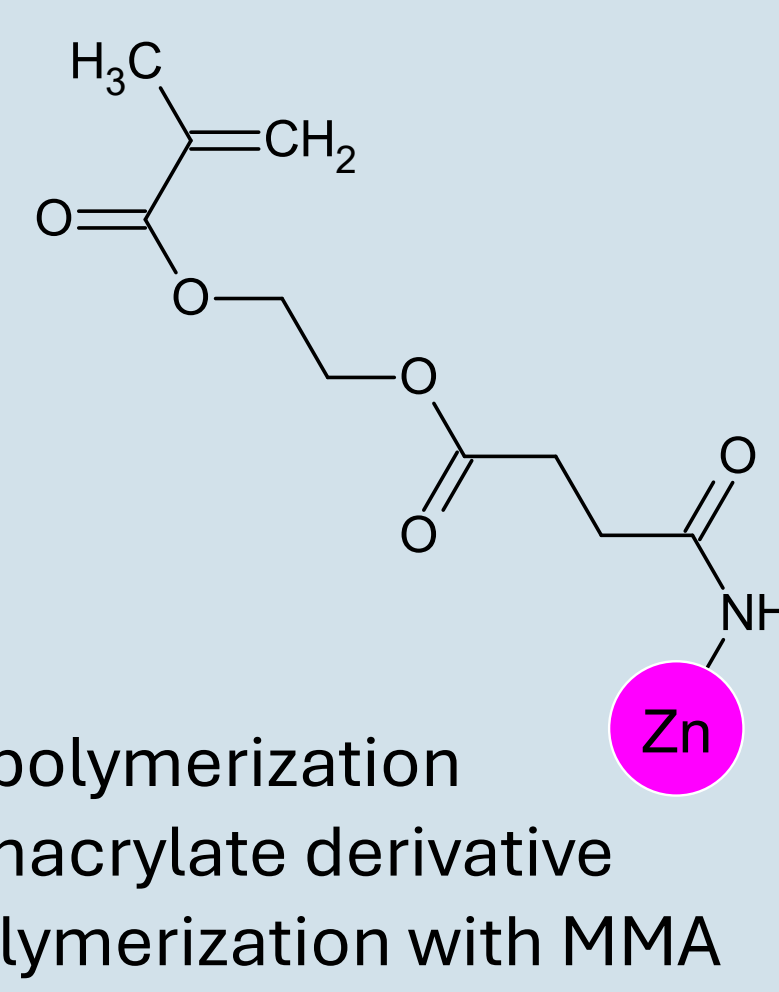
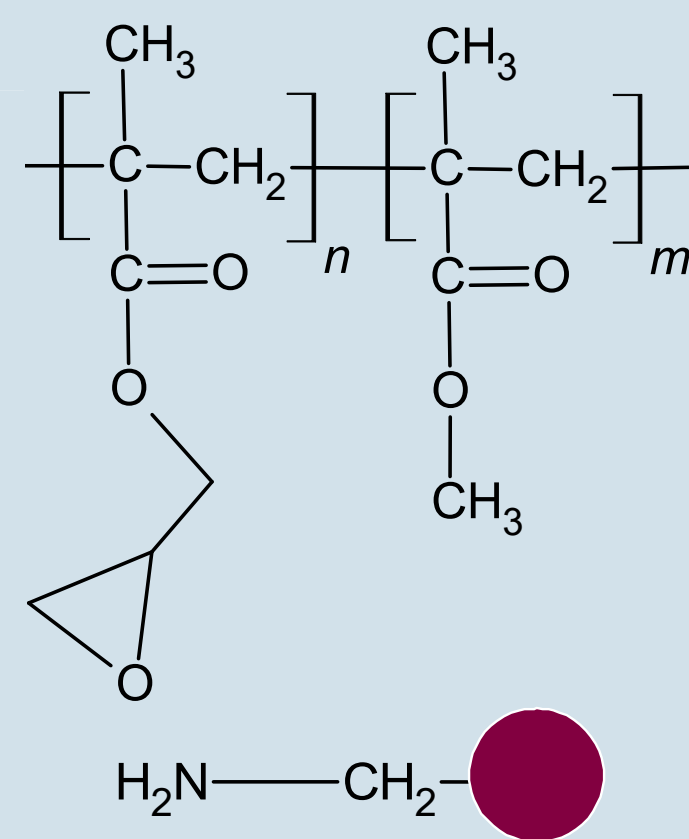
- To provide better connection with the matrix
- Under-researched approach

First attempts: reactions that did not occur in the intended way

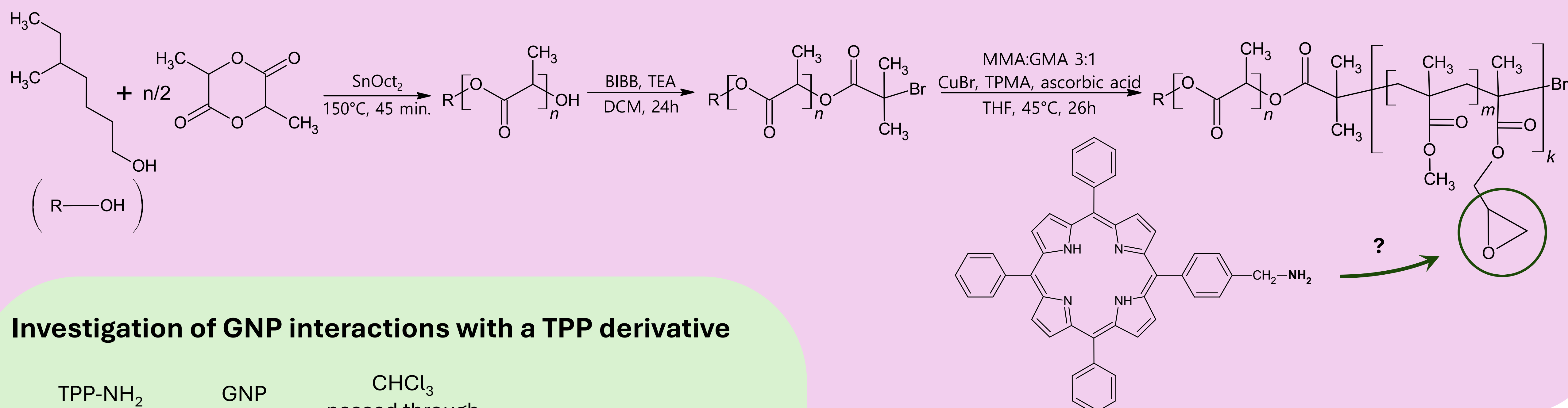
- × Opening epoxy rings in PGMA
- × Adding SnOct₂ as a catalyst



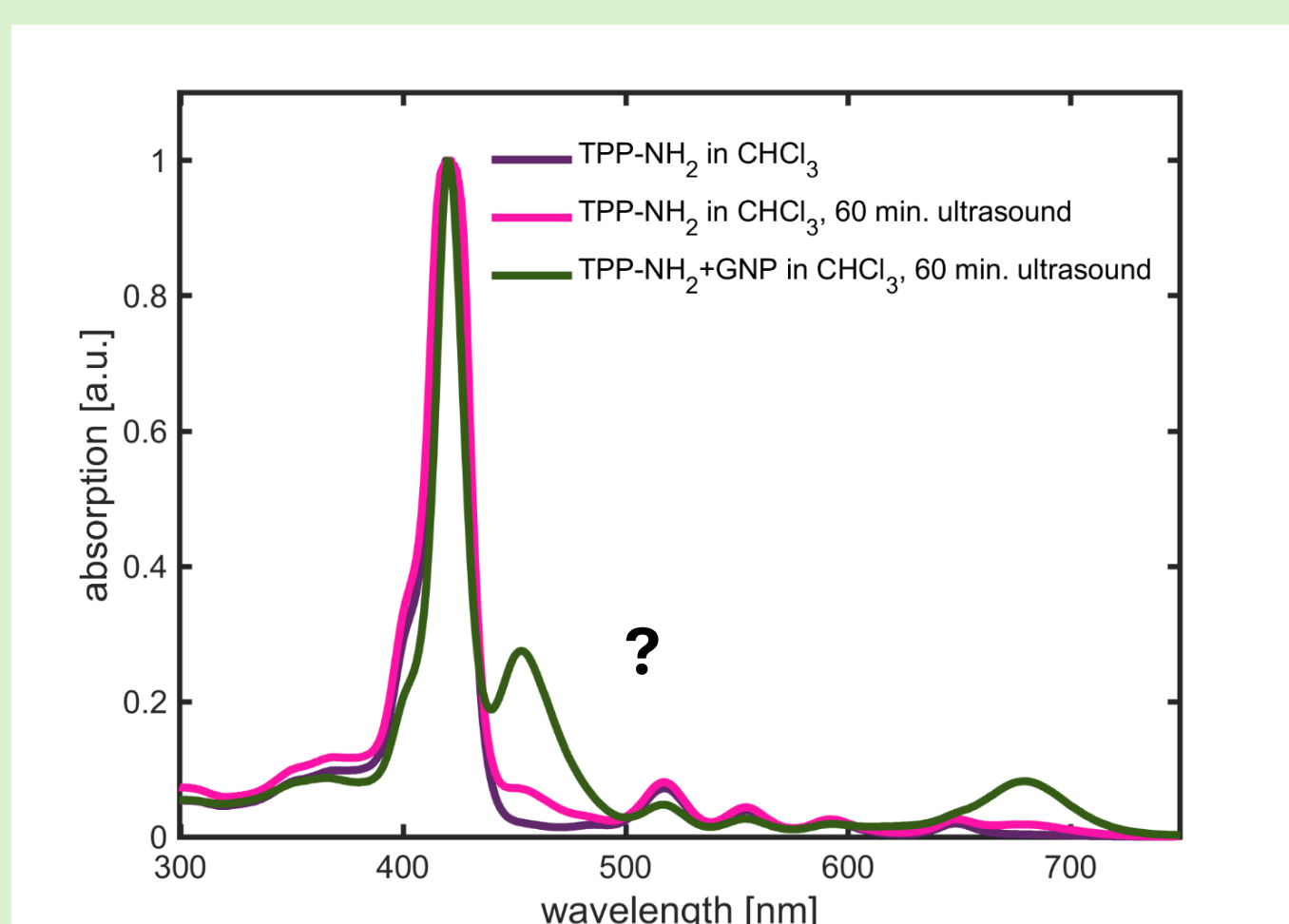
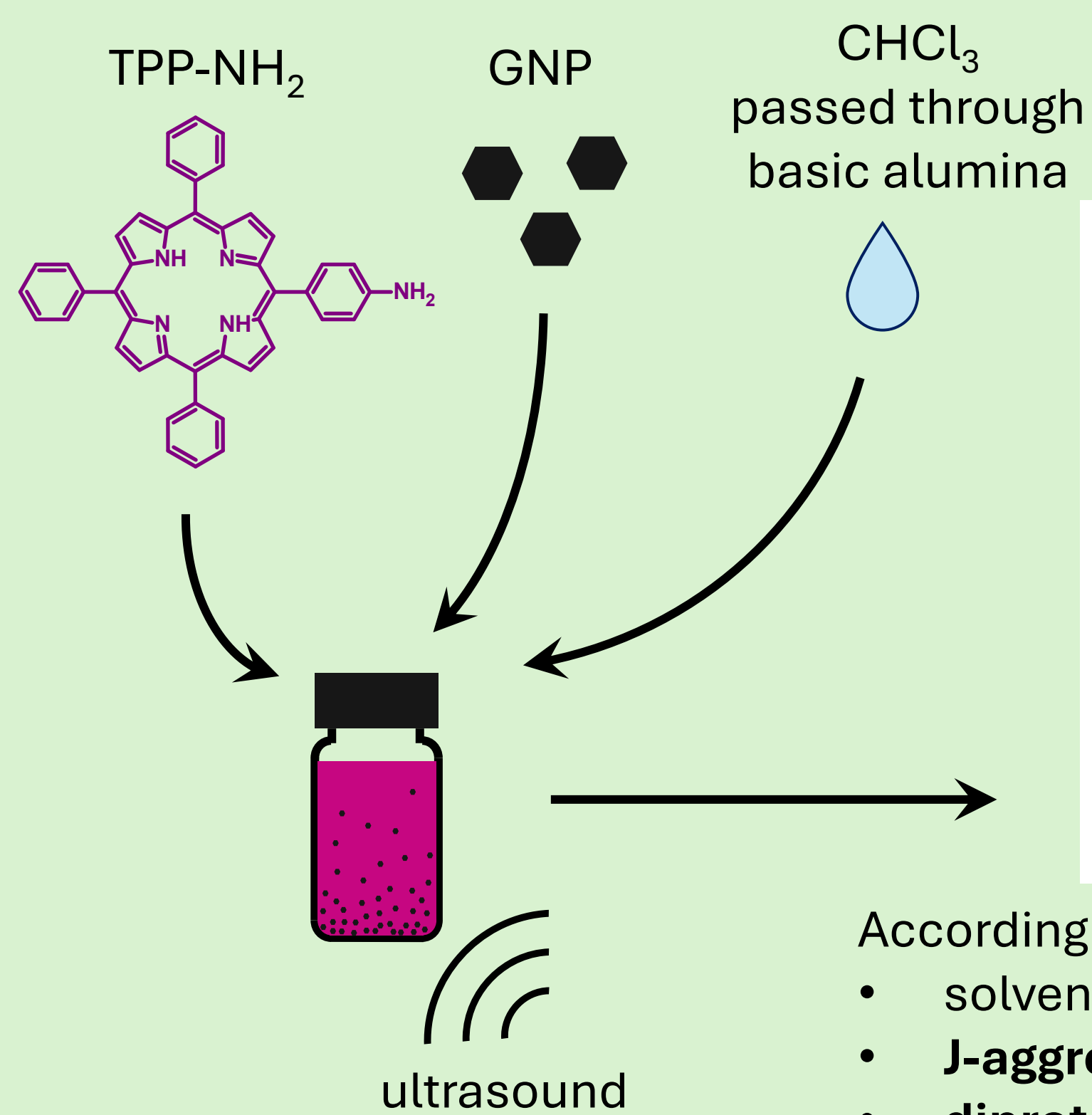
- × Opening epoxy rings in PGMA
- × Opening epoxy rings in P(GMA-co-MMA)



Current stage: copolymer synthesis and refunctionalization



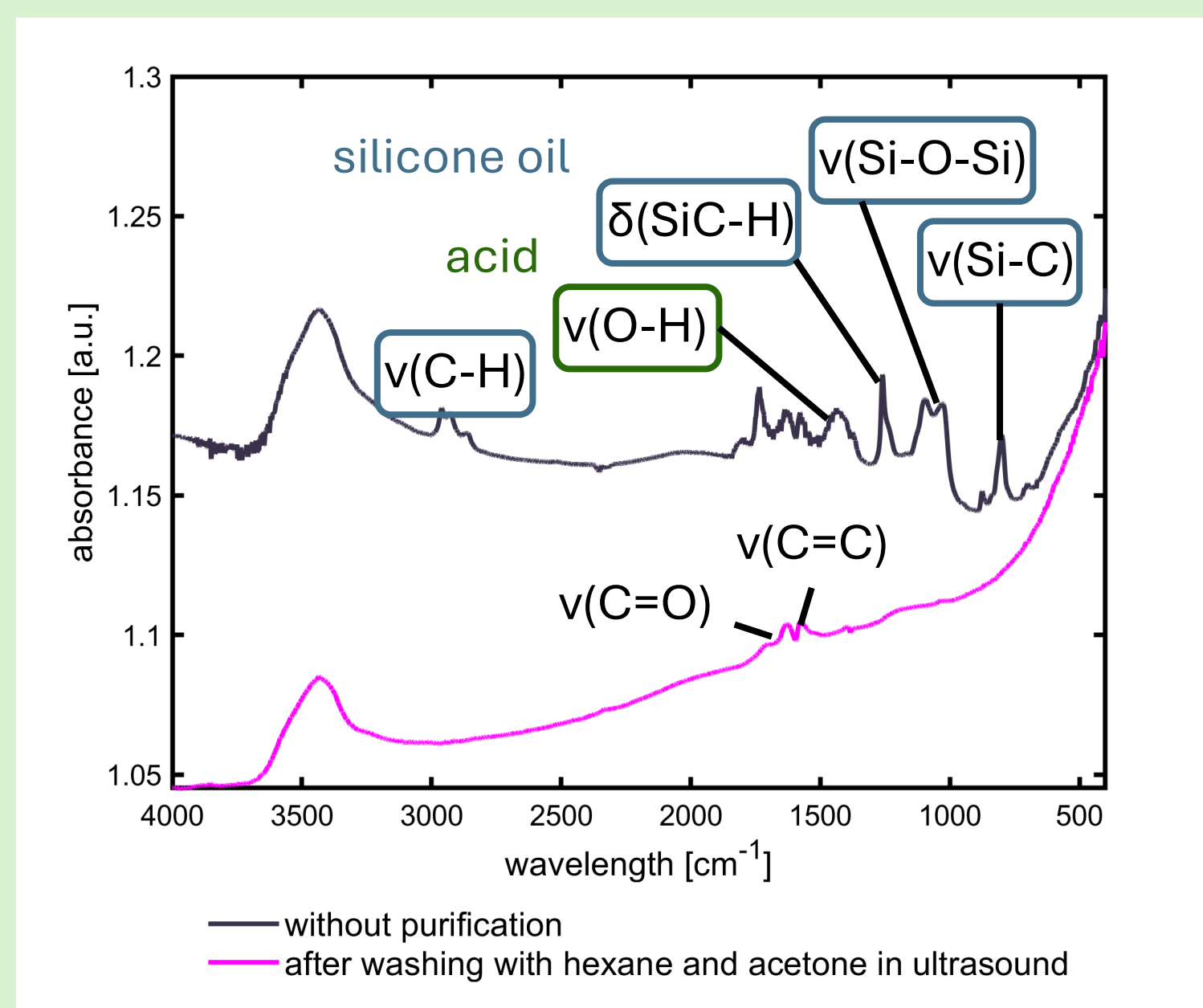
Investigation of GNP interactions with a TPP derivative



According to Xu et al. [3], the shift of Soret band can result from:

- solvent effect
- **J-aggregation** of porphyrin molecules
- **diprotonation** of the porphyrin ring nitrogens
- flattening of porphyrin molecules (related to **adsorption**)

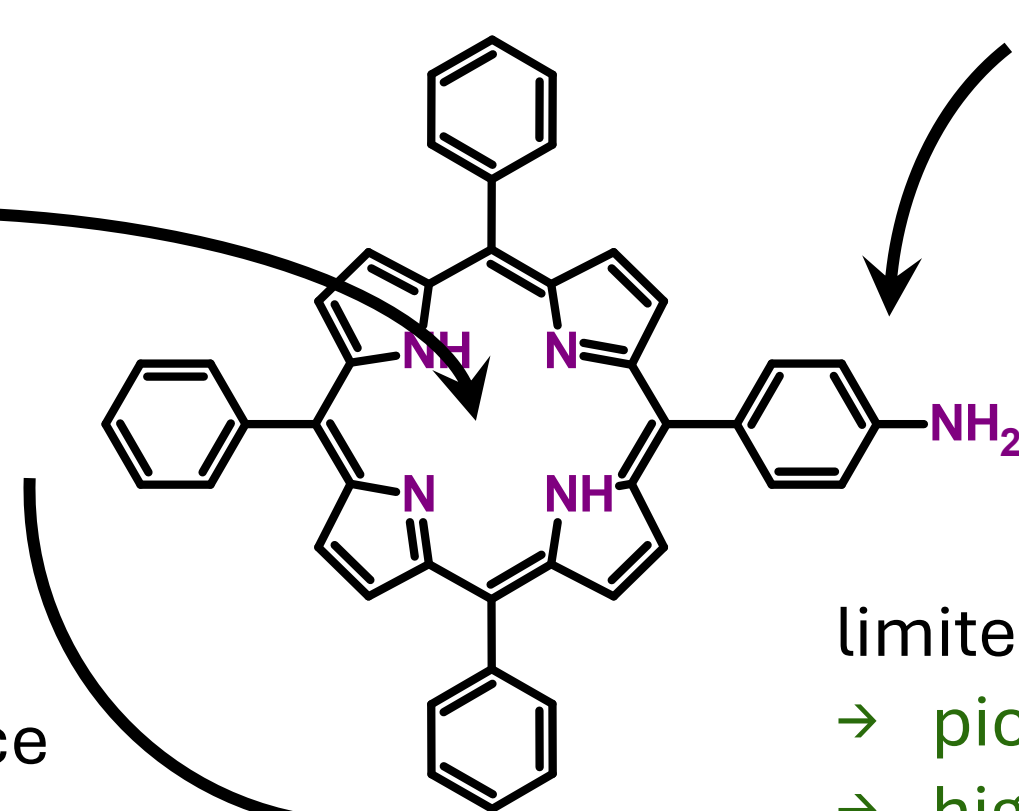
Acid-base titration:
677(82) μmol of acidic centers per 1 g GNP



Conclusions: challenges and possibilities

deactivation of the catalyst
by forming a complex with the metal ion
→ using a stable TPP complex
→ using a catalyst with a large metal ion

steric hindrance
→ copolymer with a small monomer as a spacer



electron withdrawing effect reducing amine group reactivity
→ using a derivative with an aliphatic „linker”

limited solubility in reaction and analysis media
→ picking other solvents
→ higher concentration of other substrates



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References

