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Encapsulation of Anthocyanins in Surface Nanostructured Microparticles for Controlled Release and Colorimetric Sensing

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INTRODUCTION & AIM

Anthocyanins (AntCy) are natural pigments with pH-sensitive chromatic properties and antioxidant activity, making them attractive for stimuli-responsive materials. However, their application is limited by poor stability in neutral and alkaline environments.

This study aims to develop stable, environmentally responsive carriers for AntCy using Pickering emulsion-derived polymer microspheres (PE) [1].

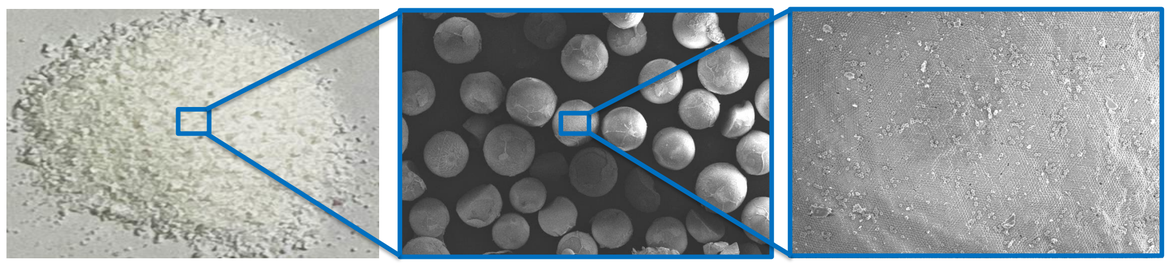
The main goals were to:

- ✓ Improve the stability of AntCy in neutral and alkaline conditions;
- ✓ Enable controlled release depending on the medium;
- ✓ Prototype colorimetric sensing platforms for gases and pH changes [2,3].

METHODS

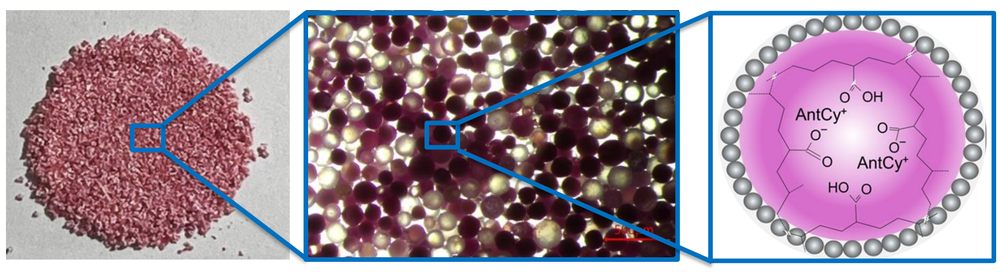
Microsphere Synthesis

- Pickering emulsion polymerization using methacrylic acid (MAA) and divinylbenzene (DVB);
- Stabilized with GLYMO-functionalized silica nanoparticles;
- Resulting microspheres: 245 ± 27 µm diameter, with nanostructured surface.



Anthocyanin Loading

- AntCy extract (from red cabbage) in acidic aqueous medium;
- Encapsulation capacity: 0.24 mg · g^{-1};
- Stabilization of flavylium cation inside acidic polymeric environment.



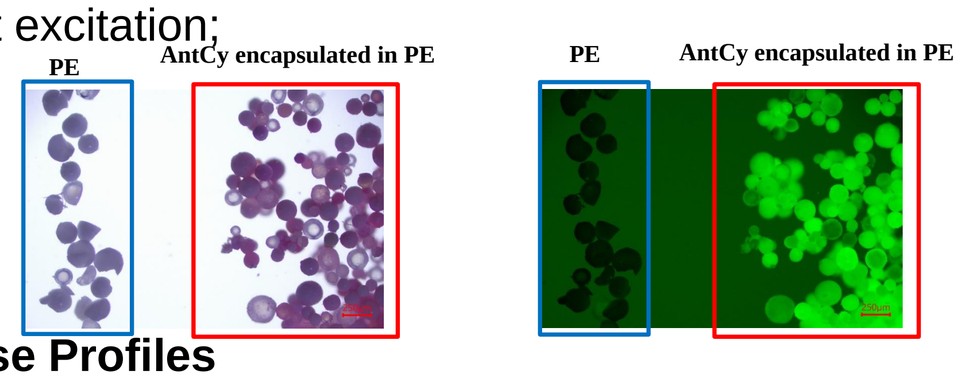
Characterization Techniques

- UV–Vis spectrophotometry (pH-differential and DPPH assays);
- SEM and fluorescence microscopy;
- Kinetic modeling: pseudo-first-order & Korsmeyer–Peppas.

RESULTS & DISCUSSION

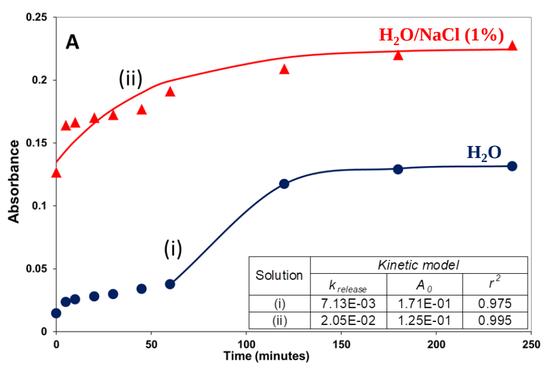
➢ Stability & Antioxidant Activity

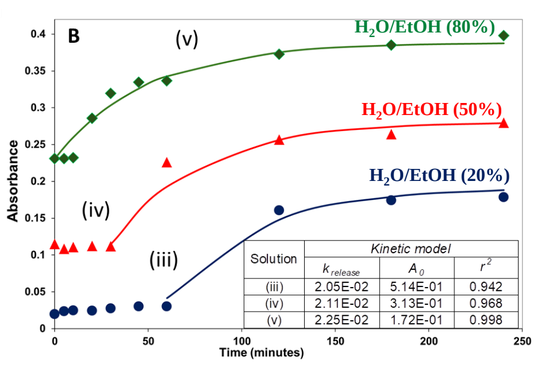
- Encapsulation preserves >90% antioxidant activity;
- Flavylium cation fluorescence confirmed via visible light excitation;



➢ Release Profiles

- Responsive to medium composition:
  - ✓ NaCl accelerates release via ionic screening
  - ✓ Ethanol enhances release via matrix swelling and solubilization

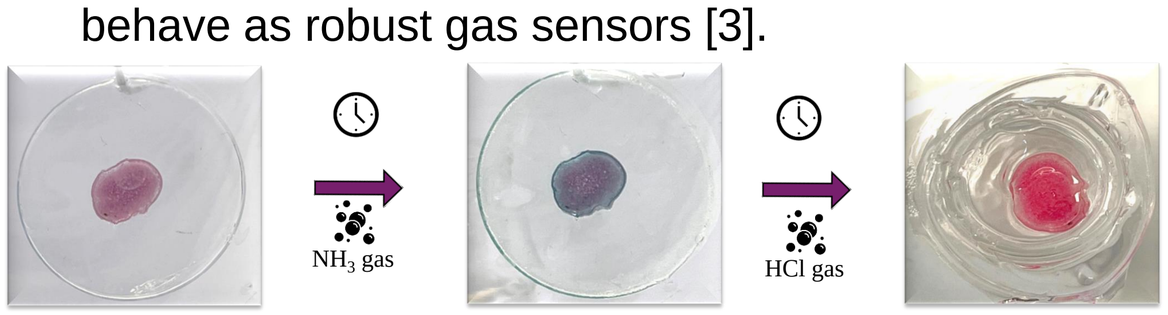




- Release is diffusion-controlled [3]:
  - ✓ Korsmeyer–Peppas exponent n = 0.1–0.3
  - ✓ Lag time decreases with increasing ethanol or salt

➢ Colorimetric Sensing

- Visual response to acidic and basic gases (HCl/NH_3)
- Color changes reversible over 10+ cycles
- Composite PVA films with embedded microspheres behave as robust gas sensors [3].



CONCLUSIONS

Pickering emulsion-derived polymeric microspheres enable stable encapsulation and tunable release of anthocyanins. Their dual function as antioxidant carriers and pH/gas sensors makes them ideal for applications in:

- •Smart packaging
- •Biosensing
- •Environmental monitoring

REFERENCES

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3. Honciuc, M.; Honciuc, A.; Solonaru, A.-M. Colloids and Surfaces B: Biointerfaces 2025, 114905.