

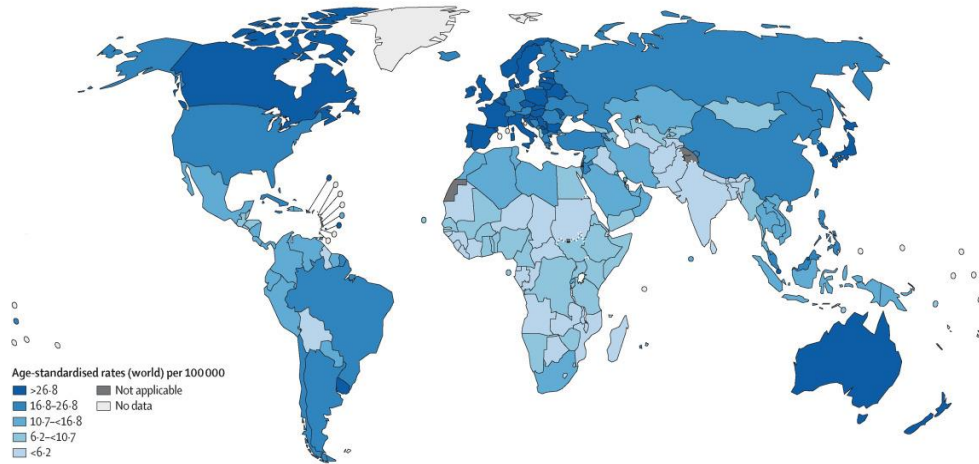
Magneto-responsive drug delivery systems for local treatment of colorectal cancer

Alexandra Teleki

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Tech Session V: Nanomedicine and Nanoscale Delivery (Focus: Oral)

Colorectal cancer (CRC)



Dekker et al., *Lancet* **394**, P1467 (2019).

- 7-8% of new cancer diagnoses
- Leading cause of cancer related death



Surgery

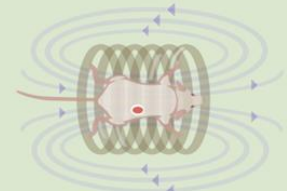


Radiotherapy



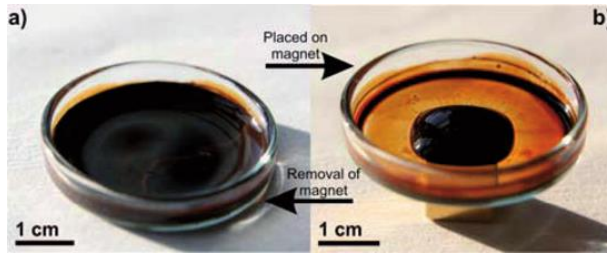
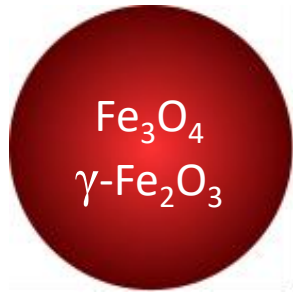
Chemotherapy

- Inaccessible tumors to surgery
- Resistance to chemoradiation
- Long treatment times, side effects



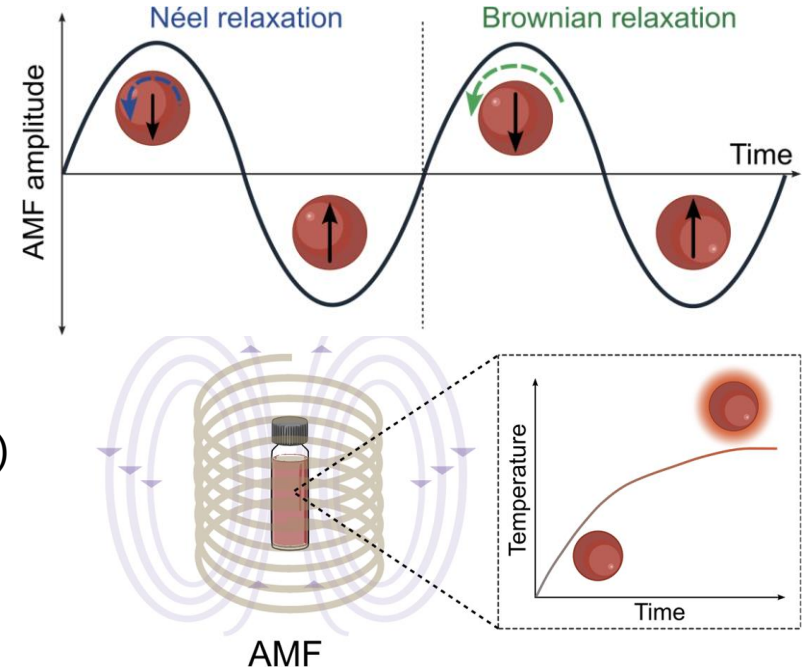
Magnetic hyperthermia

Magnetic hyperthermia



Teleki et al., *Chem. Mater.* **21**, 2094 (2009).

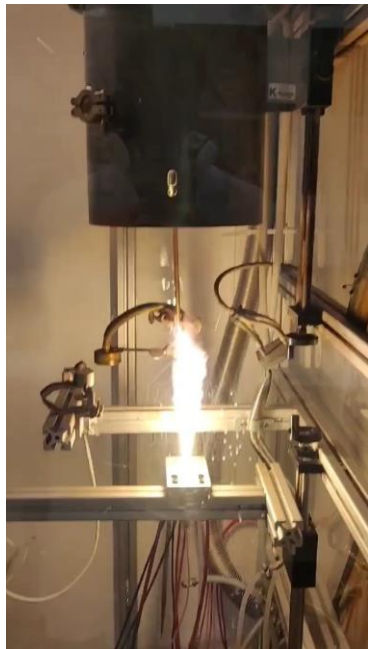
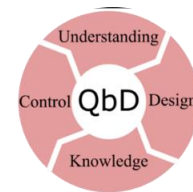
- Superparamagnetic iron oxide nanoparticles (SPION)
- Magnetic diameter < 30 nm
- Magnetic only in a magnetic field
- Release heat in an alternating magnetic field (AMF)



Ansari...Teleki, *WIREs Nanomed. Nanobiotechnol.* **16**, e1963 (2024).

Flame synthesis of SPIONs

QbD: quality by design



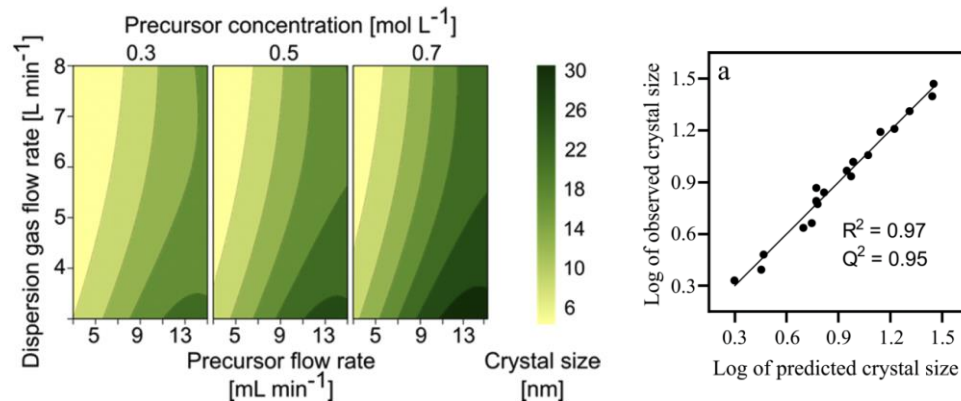
pilot-scale reactor



5 g in 30 minutes

Teleki et al., *Chem. Mater.* **21**, 2094 (2009). Asad...Teleki, *Small* 2407883 (2025).

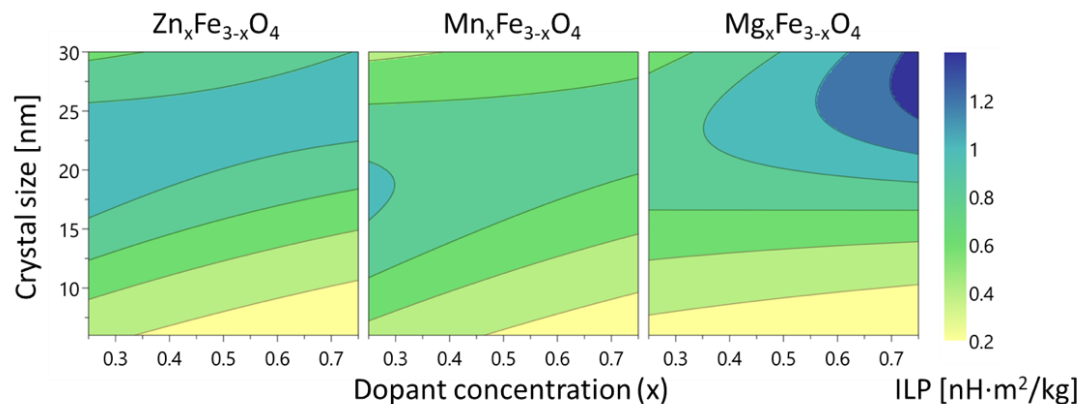
- Scalable
- Fine control of particle properties (composition, size, crystallinity)
- Predictive model for SPION synthesis following pharmaceutical QbD principles



Ansari...Teleki, *ACS Nano* **18**, 15284 (2024).

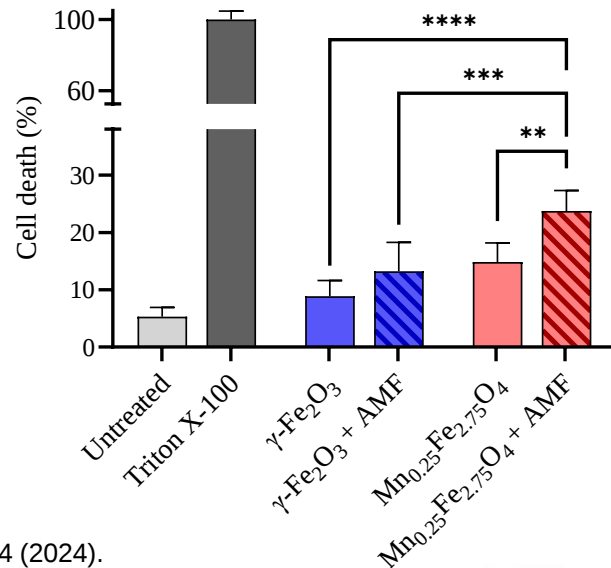
QbD approach to optimize magnetic hyperthermia

Flame-made doped ferrites



Alternating magnetic field (AMF): 14 mT, 592 Hz
ILP: intrinsic loss power

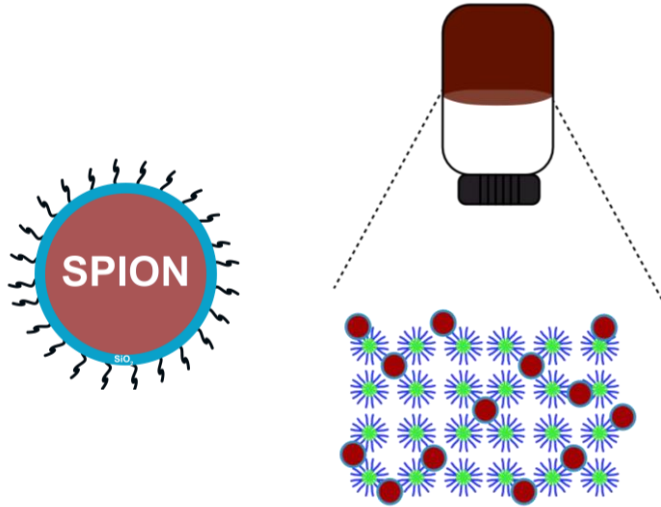
In vitro hyperthermia on Caco-2 cells



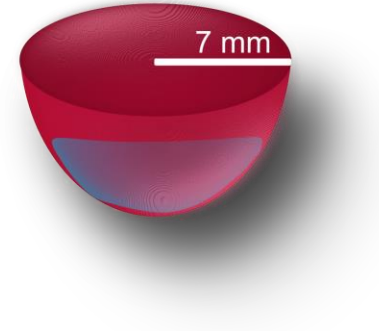
Ansari...Teleki, ACS Nano 18, 15284 (2024).

SPION-based formulations for CRC therapy

Magnetic hyperthermia & theranostics

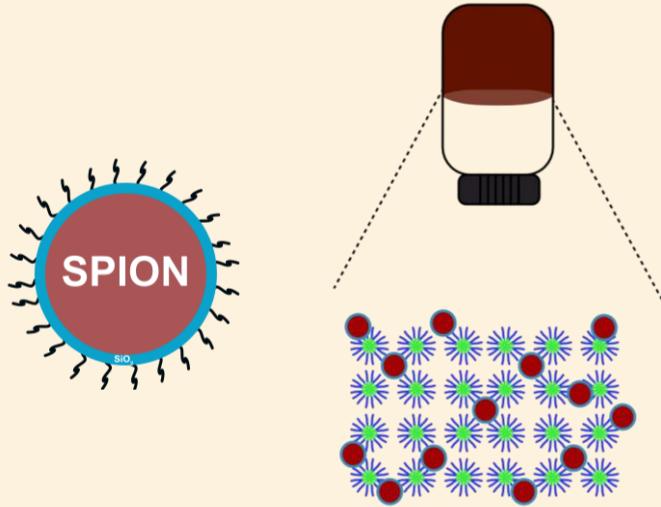


Magnetically-triggered drug release

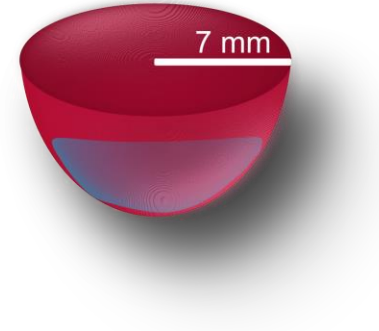


SPION-based formulations for CRC therapy

Magnetic hyperthermia & theranostics

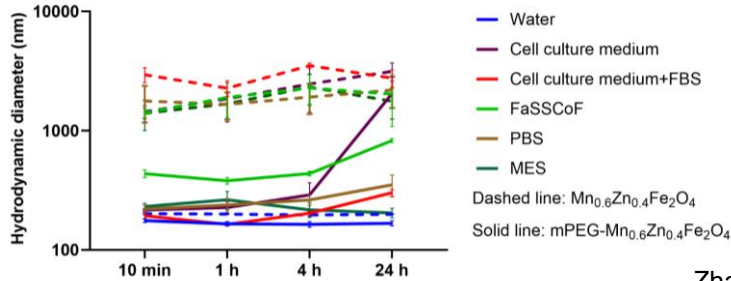
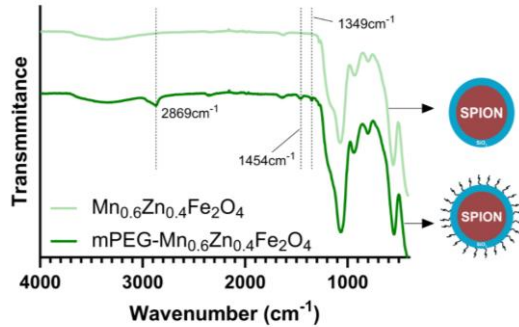


Magnetically-triggered drug release

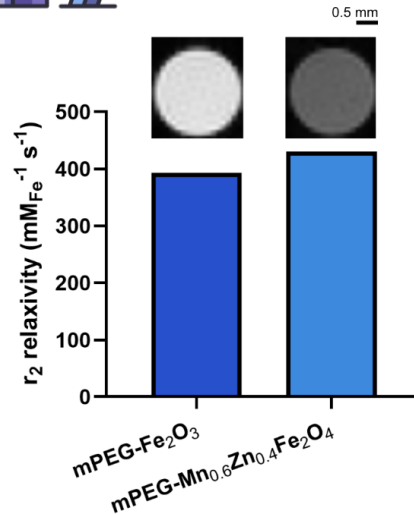


Theranostic SPIONs for local therapy in colon

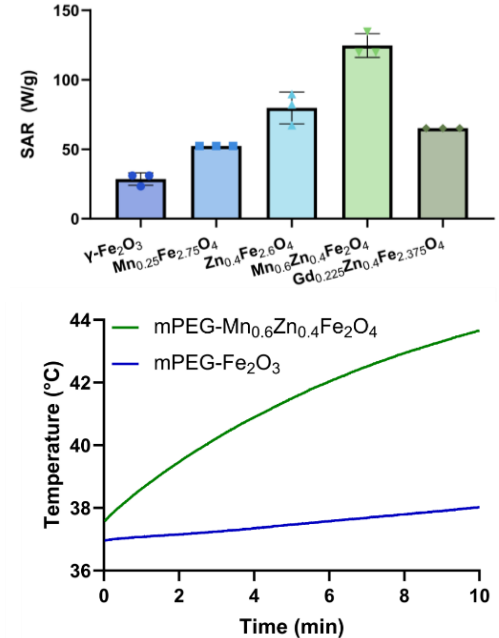
PEGylation for stability in colonic environment



T2 contrast enhancement

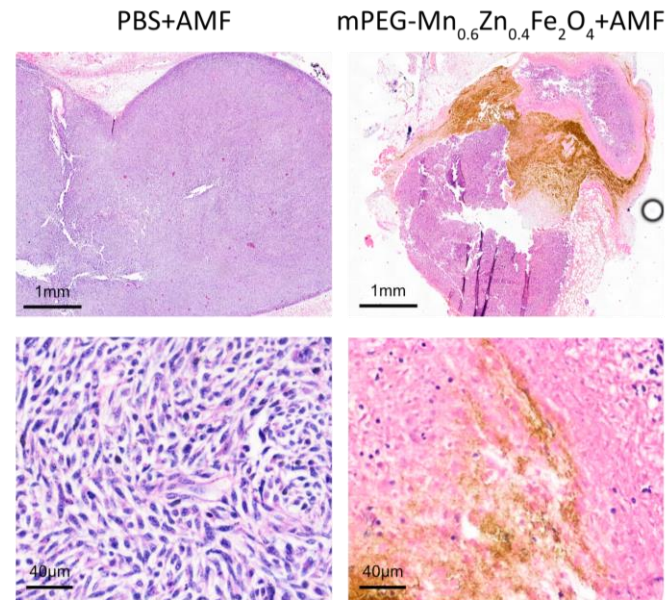
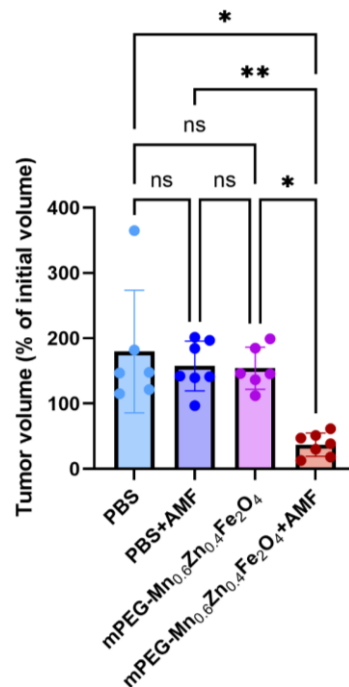
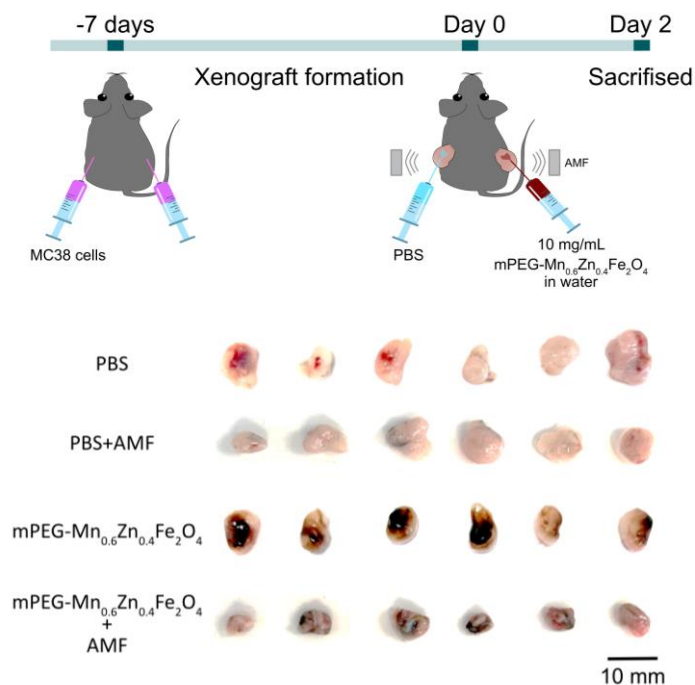


High magnetic heating efficiency



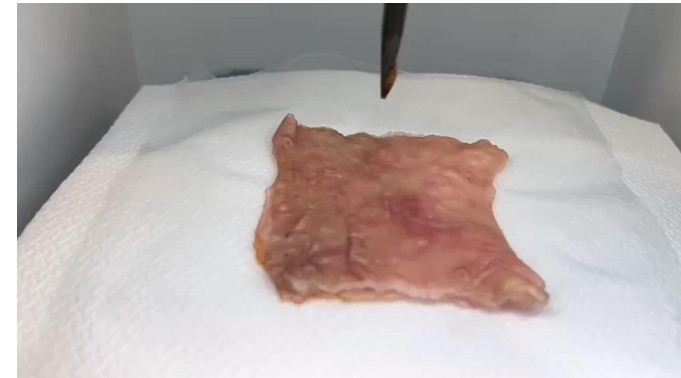
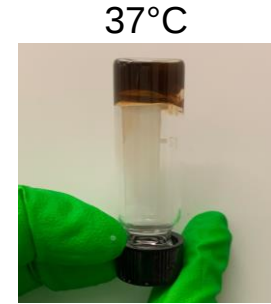
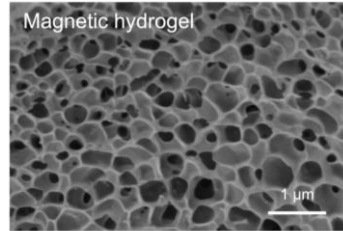
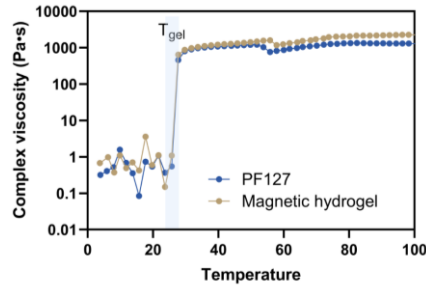
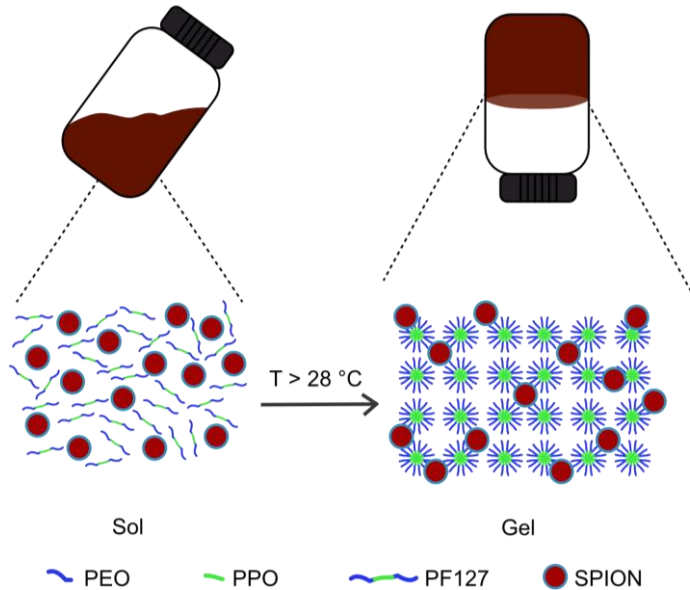
Zhang...Teleki, *Nanoscale Adv. in press* (2025).

Tumor size reduction *in vivo* by magnetic hyperthermia



Zhang...Teleki, *Nanoscale Adv.* in press (2025).

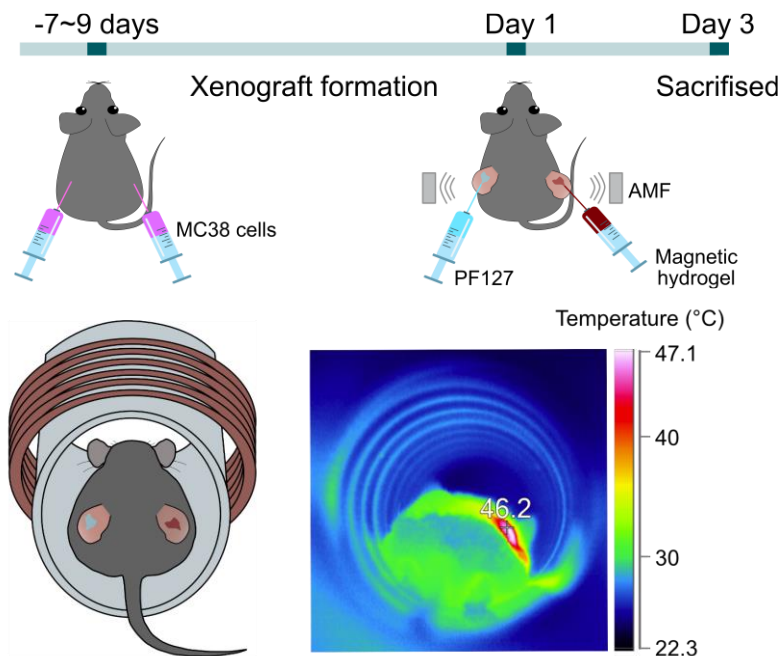
Thermoresponsive magnetic hydrogel



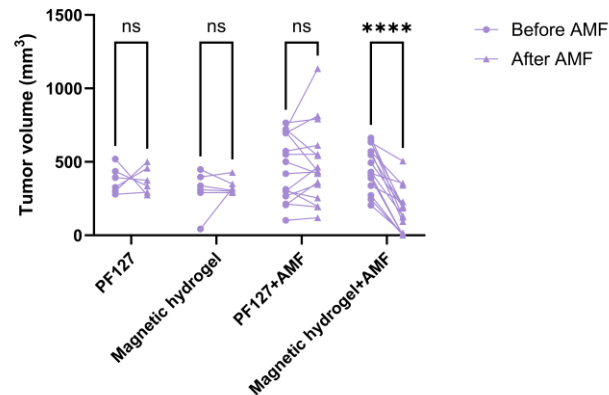
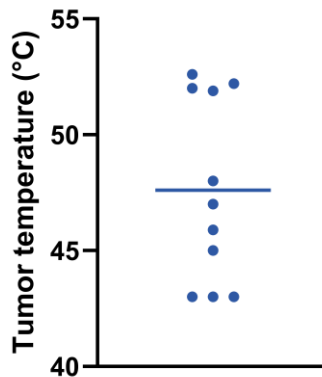
Zhang...Teleki, *in manuscript* (2025).

Porcine rectal tissue kept at 37°C

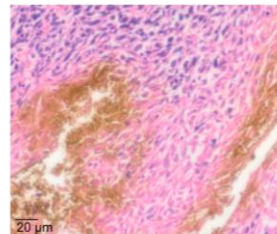
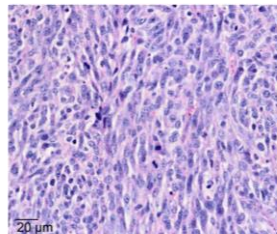
Localized heating *in vivo* by magnetic hyperthermia



Zhang...Teleki, *in manuscript* (2025).



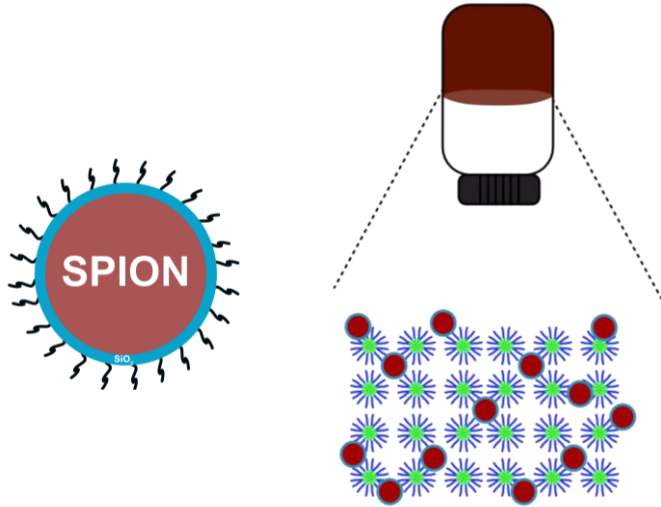
PF127+
AMF



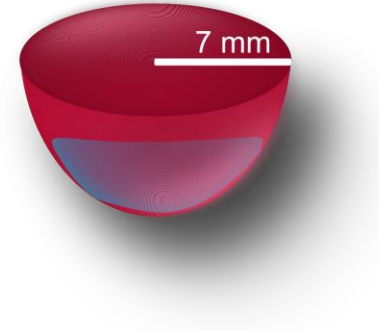
Magnetic
hydrogel +
AMF

SPION-based formulations for CRC therapy

Magnetic hyperthermia & theranostics

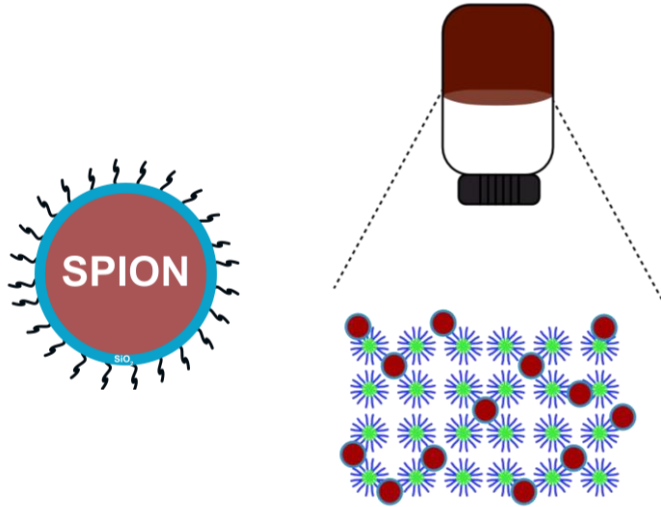


Magnetically-triggered drug release

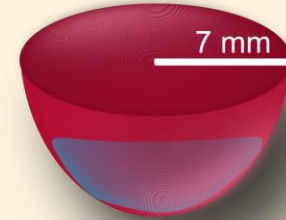


SPION-based formulations for CRC therapy

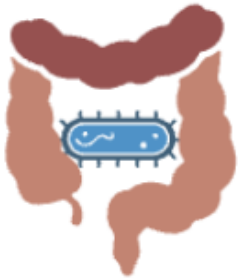
Magnetic hyperthermia & theranostics



Magnetically-triggered drug release



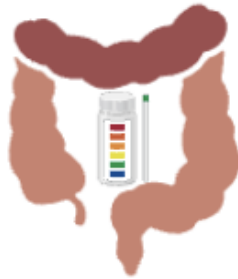
Controlled drug delivery in the gastrointestinal tract



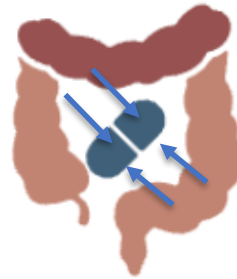
Bacteria stimulus



Time-dependent



pH-dependent

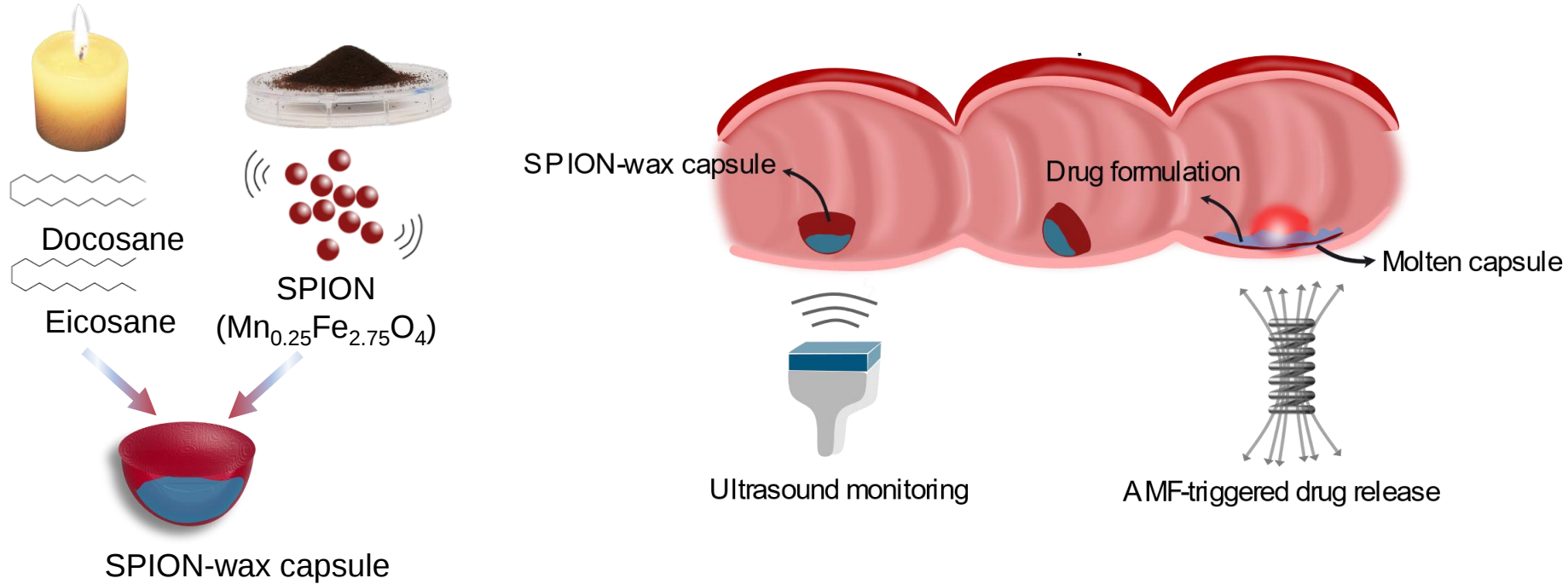


Pressure controlled

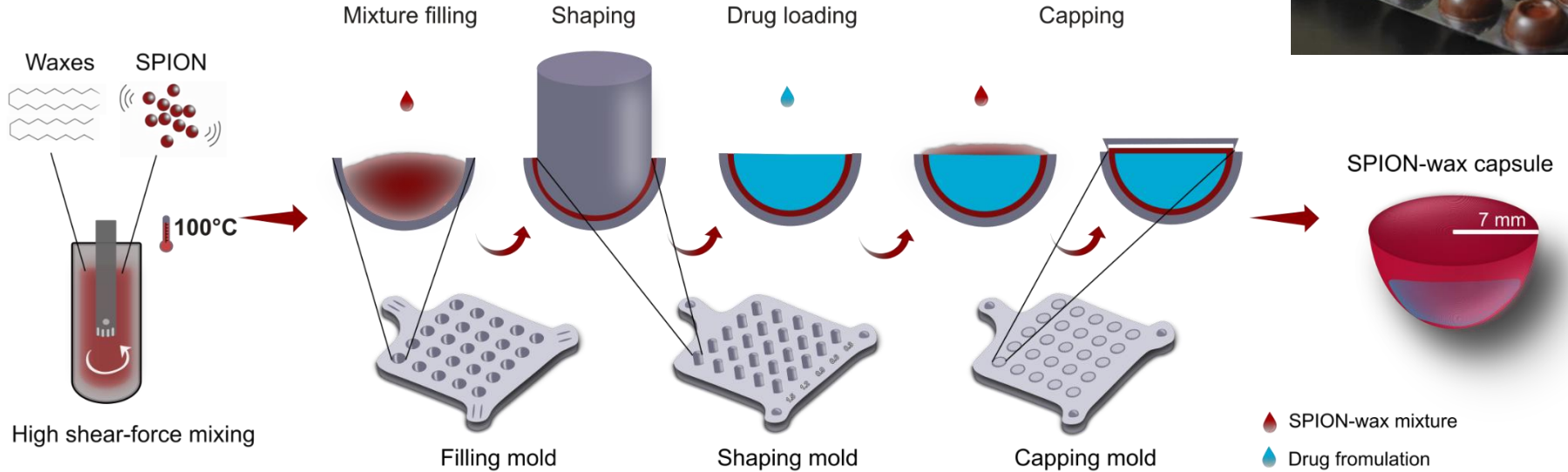


Magnetothermal stimulus

SPION-wax capsule for externally triggered drug release



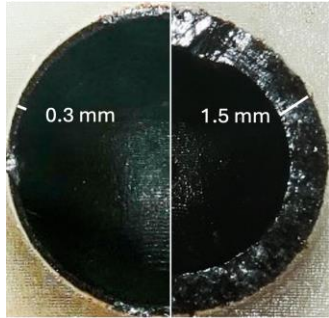
Capsule manufacturing



Magnetic wax capsules

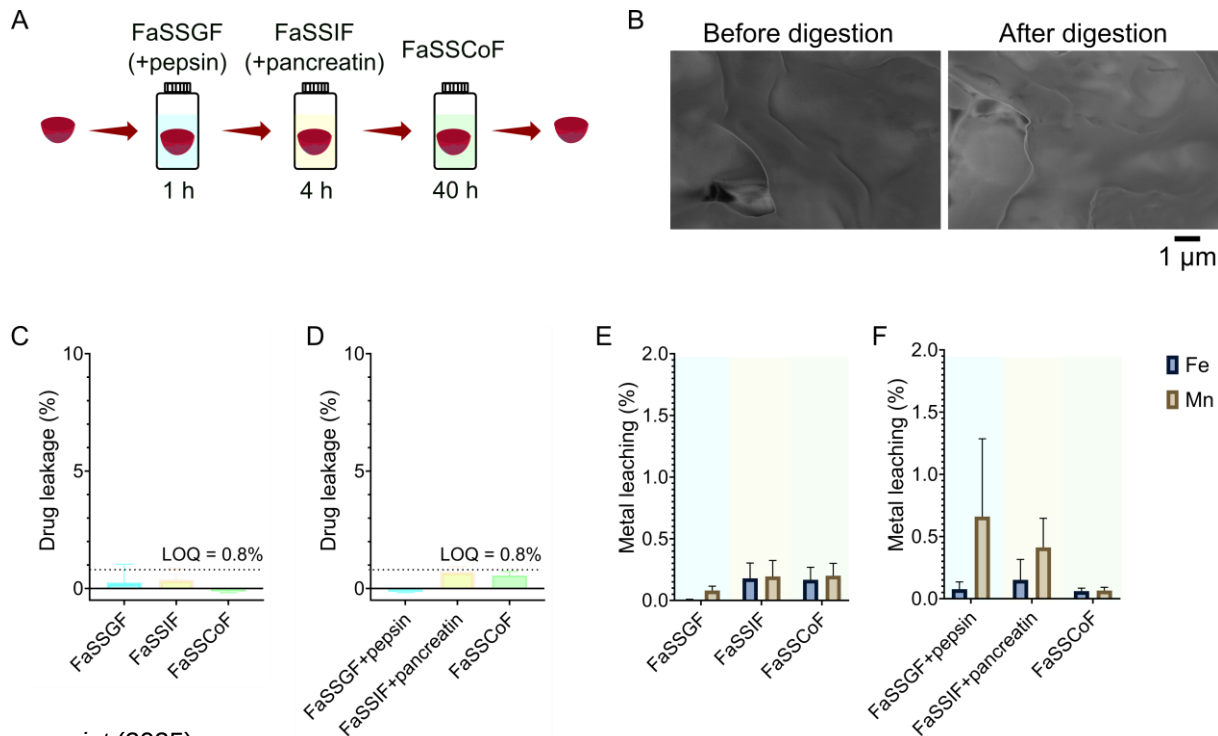


7 mm



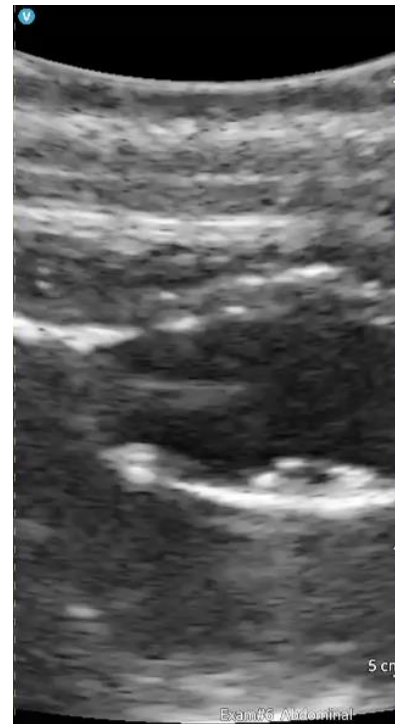
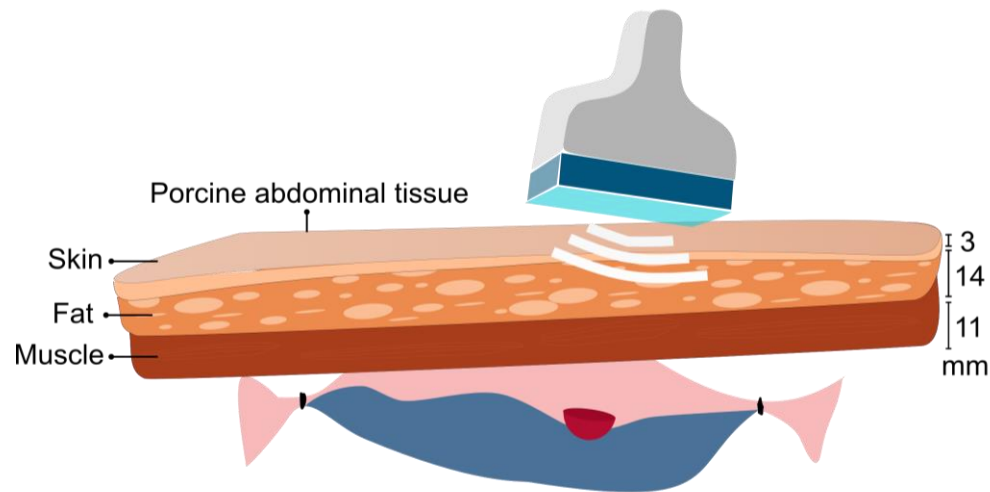
Zhang...Teleki, *in manuscript* (2025).

Capsule integrity in gastrointestinal fluids



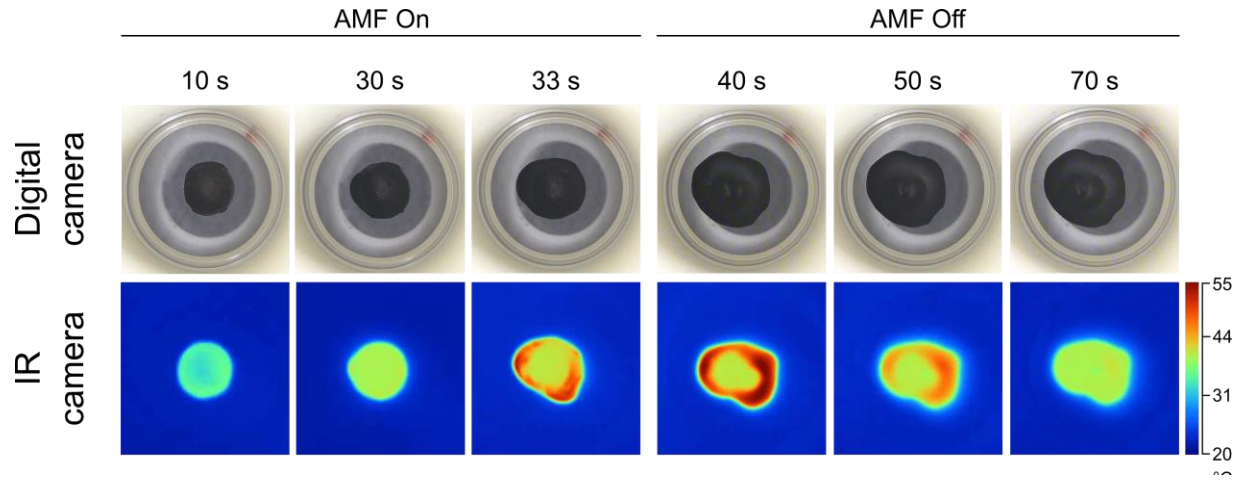
Zhang...Teleki, *in manuscript* (2025).

Capsule visualization in intestinal abdominal model



Zhang...Teleki, *in manuscript* (2025).

AMF-triggered capsule melting



Zhang...Teleki, *in manuscript* (2025).

Capsule melting *in vivo* in mouse colon

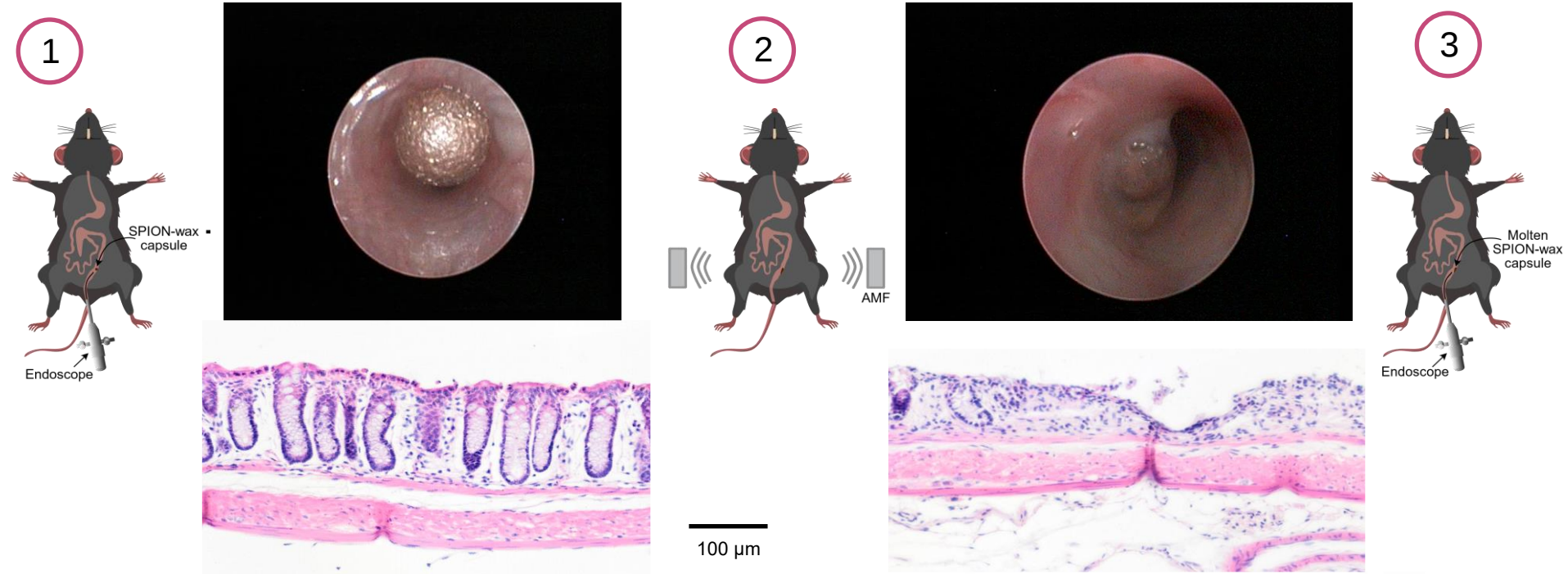
Before AMF

After AMF

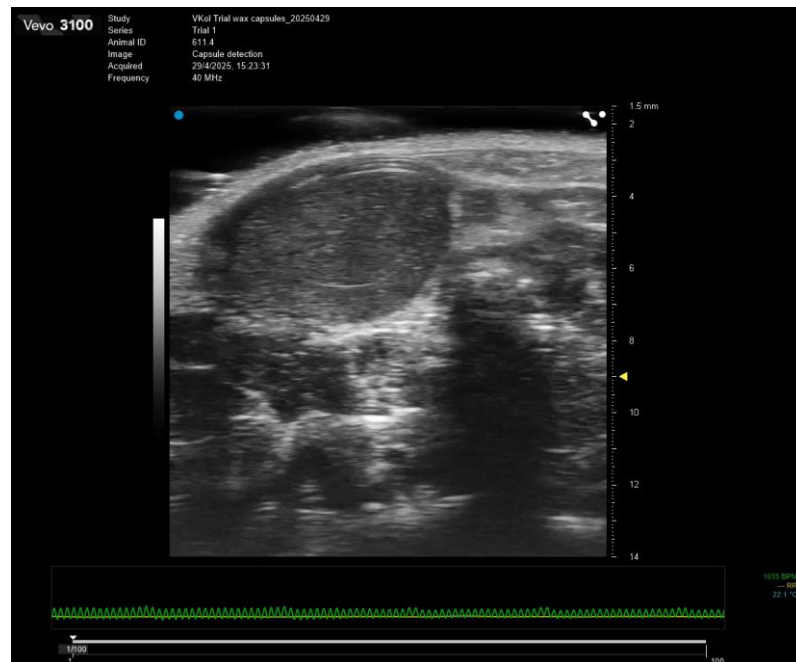
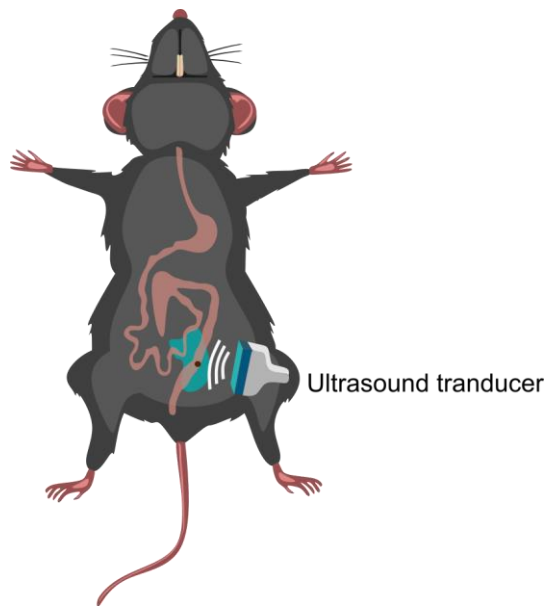
1

2

3



In vivo capsule visualization using ultrasound



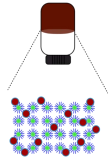
Zhang...Teleki, *in manuscript* (2025).

Conclusions

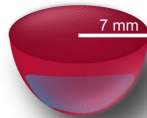
- Scalable synthesis of SPIONs with fine control over particle properties to optimize performance for magnetic hyperthermia
- PEGylated SPIONs are stable in colonic media



- Rapid gelation of thermo-responsive magnetic hydrogel at 37 °C
- 70% tumor size reduction *in vivo* after magnetic hyperthermia treatment



- Magnetic wax capsules are inert in gastrointestinal environment
- Rapid release of cargo upon AMF exposure
- Capsule imaging by ultrasound *in vivo*



Acknowledgements



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Uppsala University Hospital

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