FEM Simulation of Magnetically Triggered Hydrogel Micro Particles as Advanced Drug Carriers

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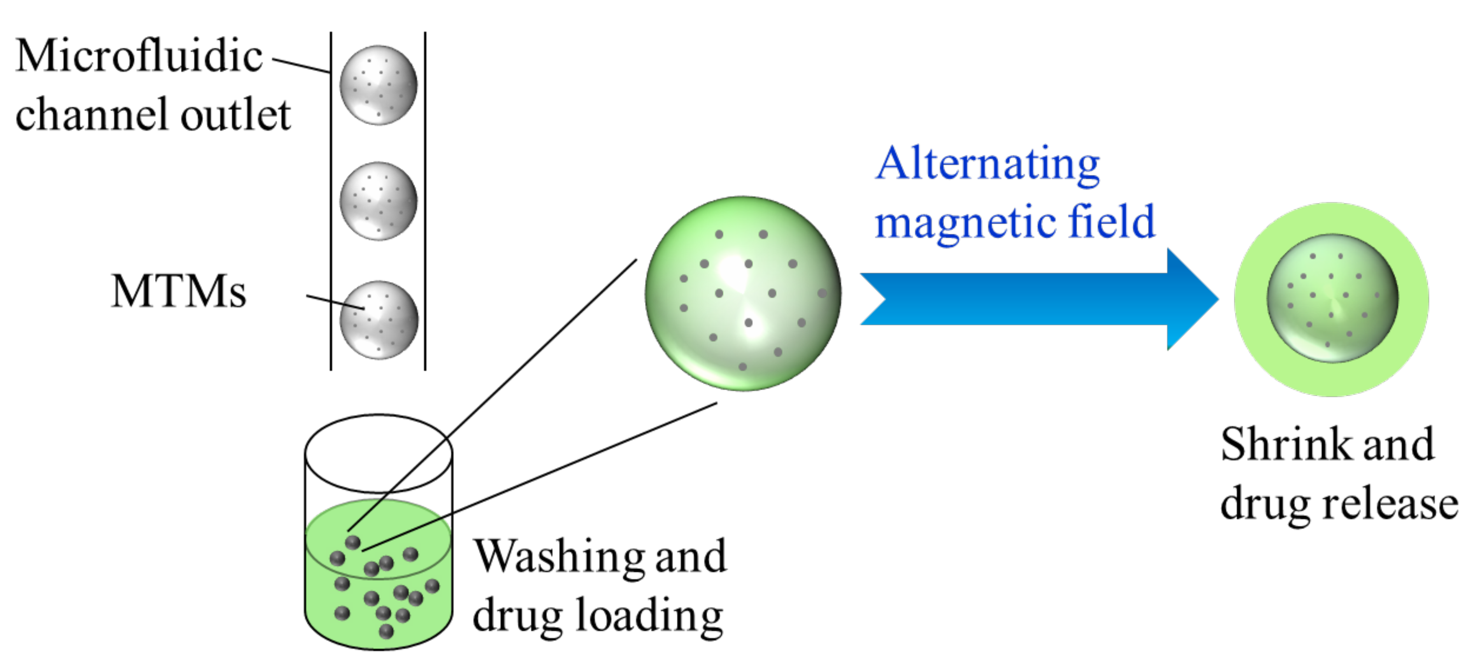
Introduction: Iron oxide nanobeads have been embedded into thermally responsive microgel Poly(N-isopropylacrylamide), or PNIPAM, creating magneto-thermally responsive microparticles (MTMs). The MTMs are activated by a magnetic field, rising the temperature to the lower critical solution temperature(LCST)[1-11].

◆ Fabrication of hydrogel drug carriers



Computational Methods: The average temperature over time is a transient problem described by Fourier's law of heat by adding time dependent power terms to both sides.

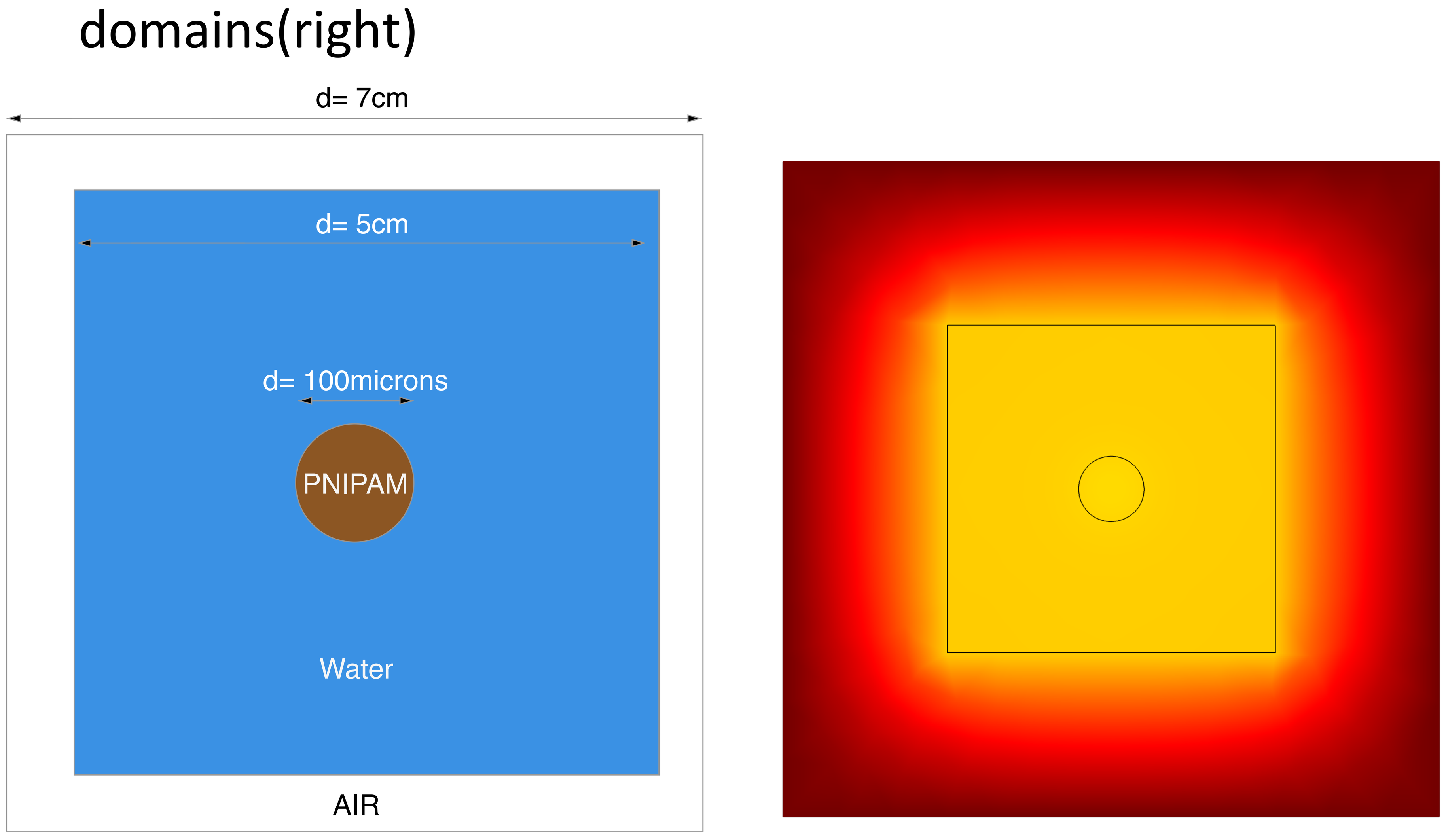
$$\rho C_p \frac{\delta T}{\delta t} + \rho C_p u \cdot \nabla T = \nabla \cdot (k \nabla T) + Q$$

A parametric sweep for the size of the heating domain is used in order to represent the shrinking for various time domains.

◆ Initial conditions for the simulation

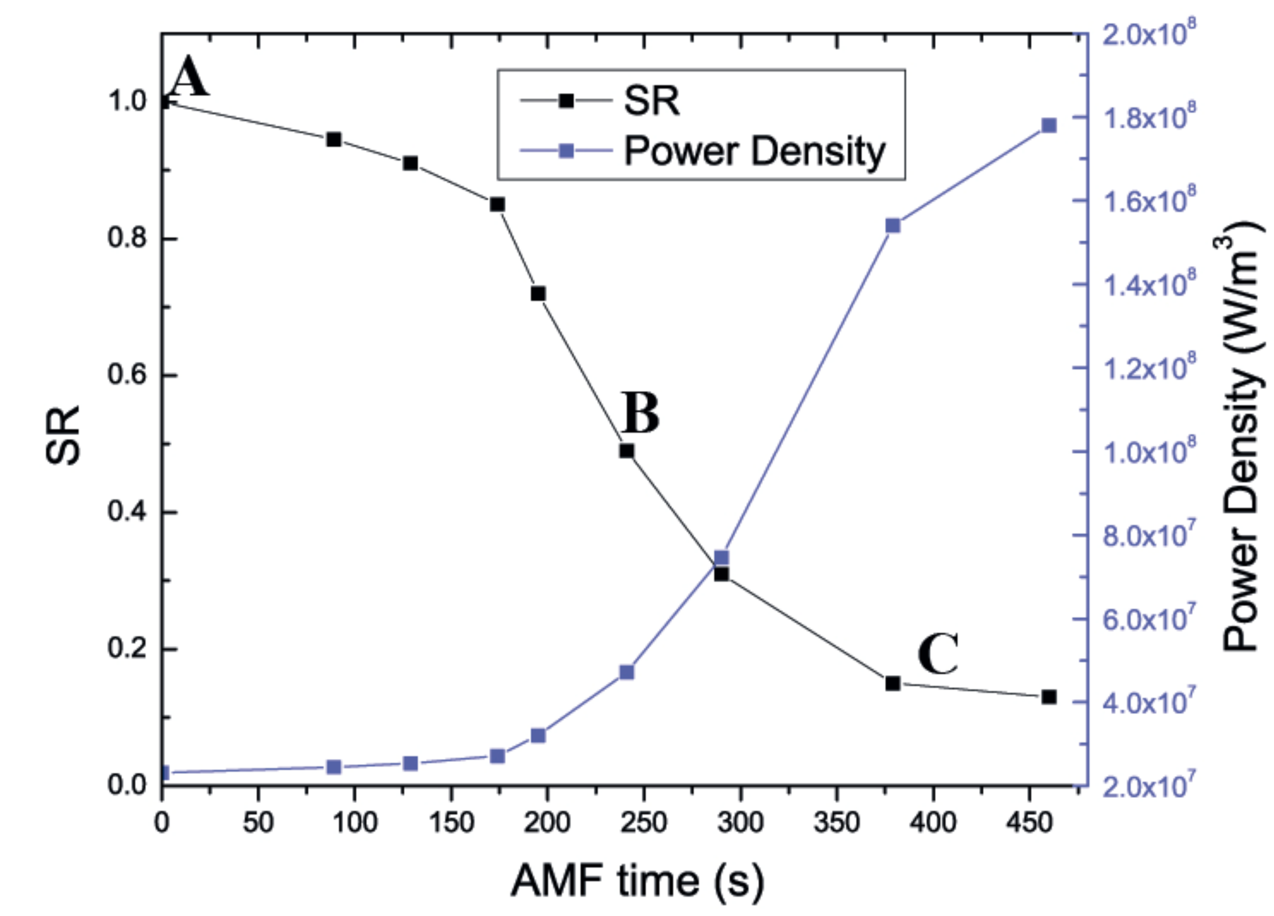
Temperature	294.15 [K]
Domain heat source	$2.3e^7 - 1.38e^8$ [W/m^3]

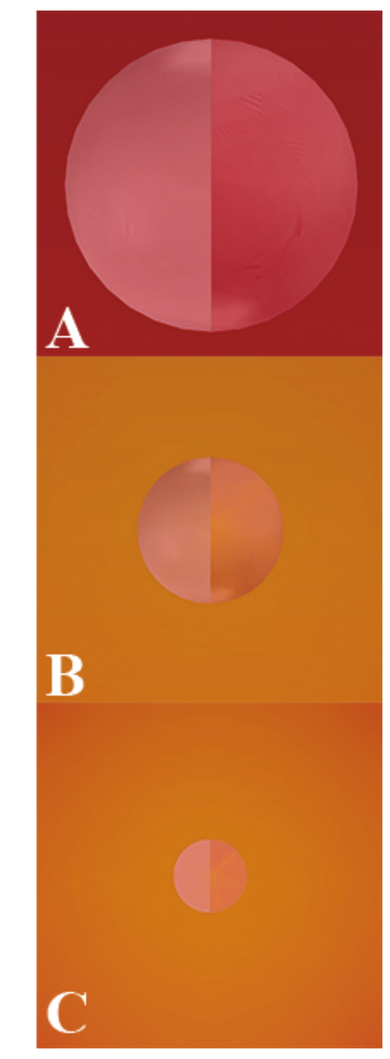
◆ MTM particle with it's dimensions surrounded by water and air domains (left). Thermal diffusion throughout different domains(right)



By appling Alternative Magnetive Field (AMF), the activation of the MTM reduces the size of the droplet leading to high concentration of magnetic material.

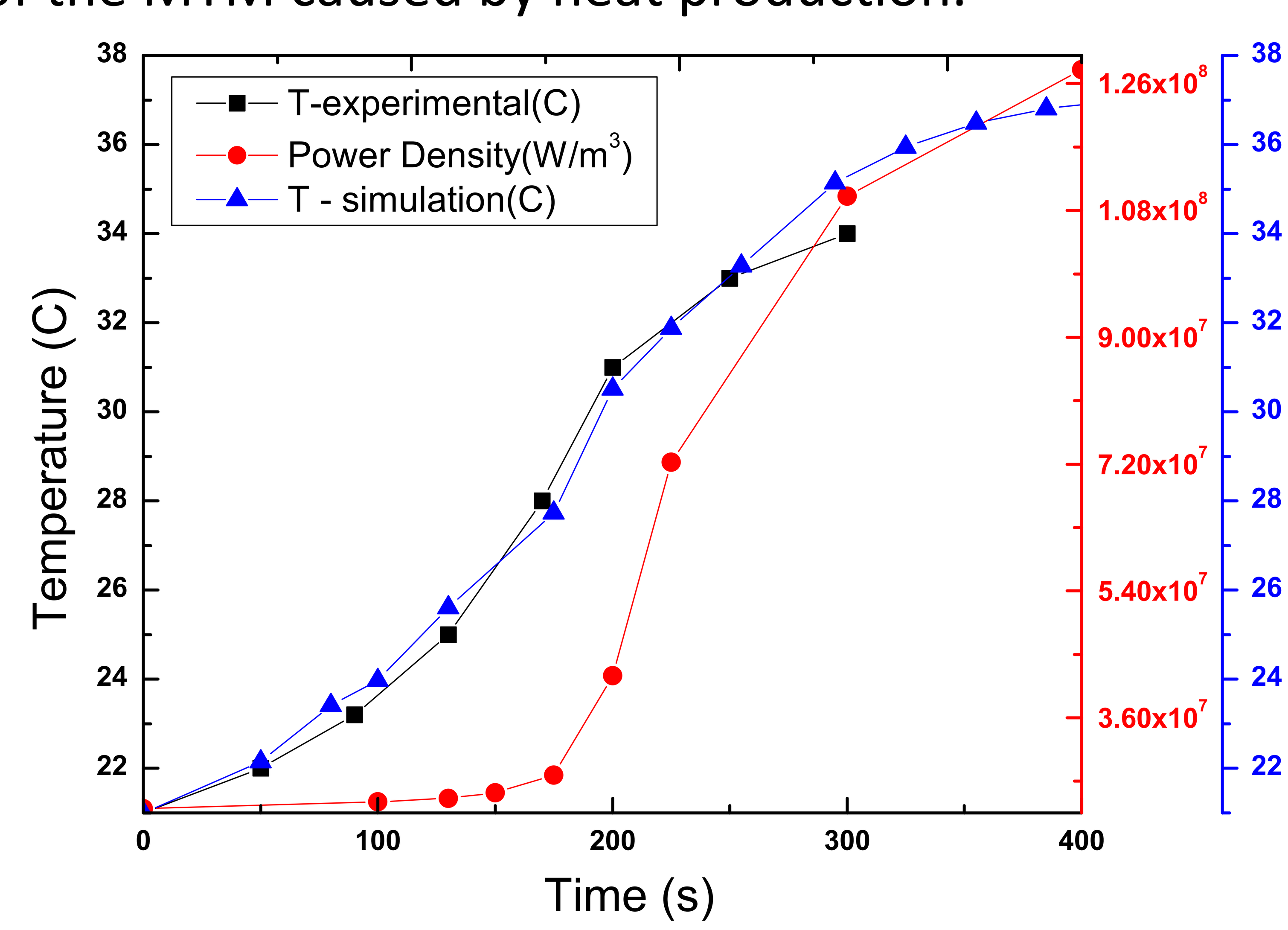
◆ Swelling Ratio (SR) changes over time governs the Power density inside the PNIPAM





Results: Experimental and simulation temperatures saturate after 400 sec, which means that the MTM has reached it's maximum deswelling ratio. A non linear release has been achieved for iron concentration of 8-10mg/ml.

◆ Temporal variation of the average temperature (experimental & simulation) and power density of the MTM caused by heat production.



Conclusions: Using COMSOL, the experimental results could be reproduced by a FEM simulation. A thorough understanding of the interrelation of magnetic losses, temperature and volume of the MTMs has been achieved, providing the means to tailor MTMs for specific drug delivery applications.

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