Supporting Information for

Polymer Nanocomposite Microactuators for On-Demand Chemical Release via High-Frequency Magnetic Field Excitation

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Particle Size Distribution:

SEM image analysis shows an almost uniform distribution of the MNP aggregations in the PLGA microspheres (Figure S1A-C).

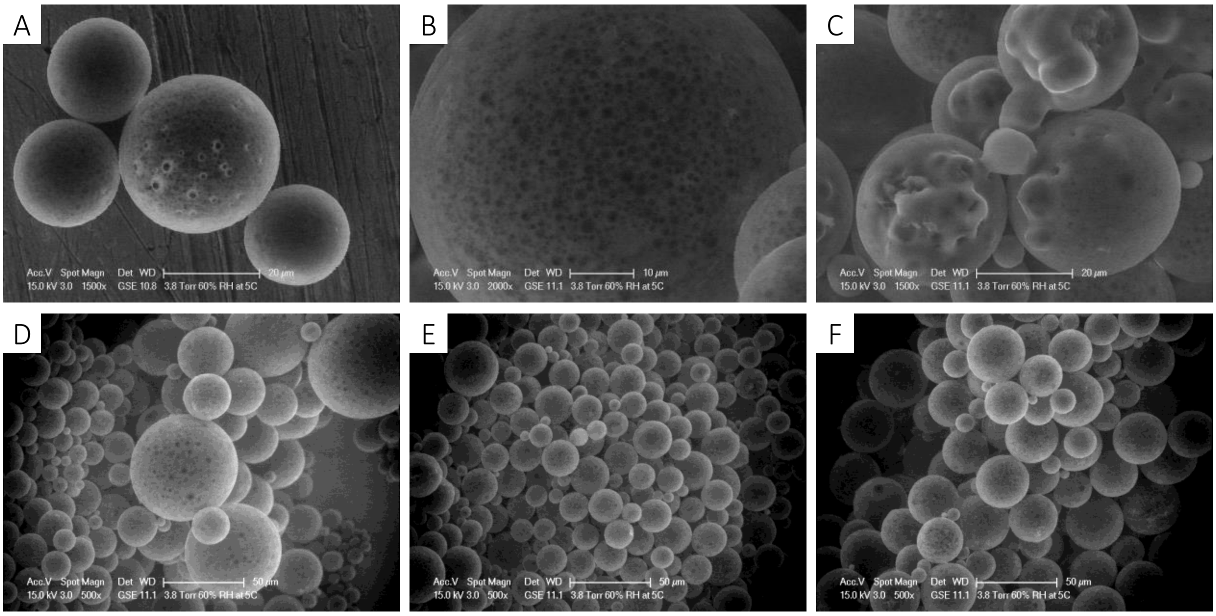

Figure S1. SEM images of the microspheres. MNP aggregations are visible in (A) and (B). (C) Shows the particles melting during the SEM/FIB operation. (D – F) Illustrate size distribution of the particles.

To find the size distribution of the particles, we used an image analysis technique to extract the size distribution from the SEM images (Figure S1D-F). The distribution plotted in Figure S2 suggests that the dominant size is between 15 µm – 20 µm.

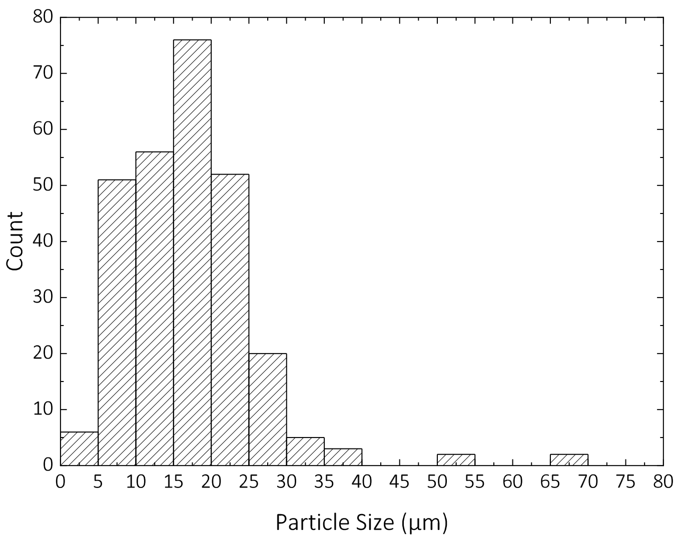

Figure S2. The size distribution of the core-shell particles.

Temperature Measurement:

Due to the significant magnetic noise generated by the induction coil, any wired sensor will have a poor signal-to-noise ratio. To avoid this issue, we used a fiber optic temperature sensor (Optocon FOTEMP1-OEM) in a setup illustrated in Figure S3.

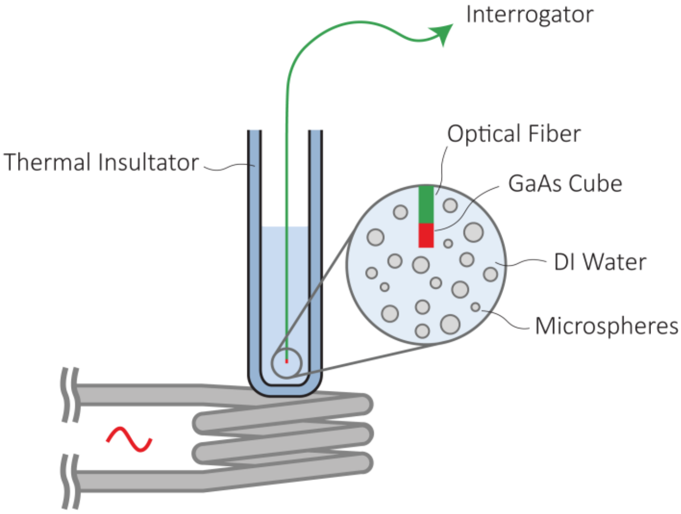

Figure S3. Illustration of the apparatus that was used to measure the temperature of the solution during excitation.

Calibration Procedure for Measuring the Fluorescent Model Compound:

A 2.5 mg/L solution of sodium fluorescein in deionized water was prepared. The solution was diluted by a factor of 2 with DI water 11 times. A Corning 96 Flat bottom black Polystyrol plate was used. For the concentration of each dilution, three wells were filled with 100 µL of the solution. Three extra wells were used for blank DI water for background measurement. The fluorescence intensity of the dye was read by the plate reader (Tecan, Infinite 200) and correlated with the concentration. The excitation and emission wavelengths were 460 nm and 515 nm, respectively. Two gain values were used to measure the calibration curve: 80 and 93, for experiments with a high and low released concentration, respectively. Figure S4 shows a linear fit with a slope of 21.442 and an intercept of 16.32 from the data collected by the plate reader measured with a gain of 80.

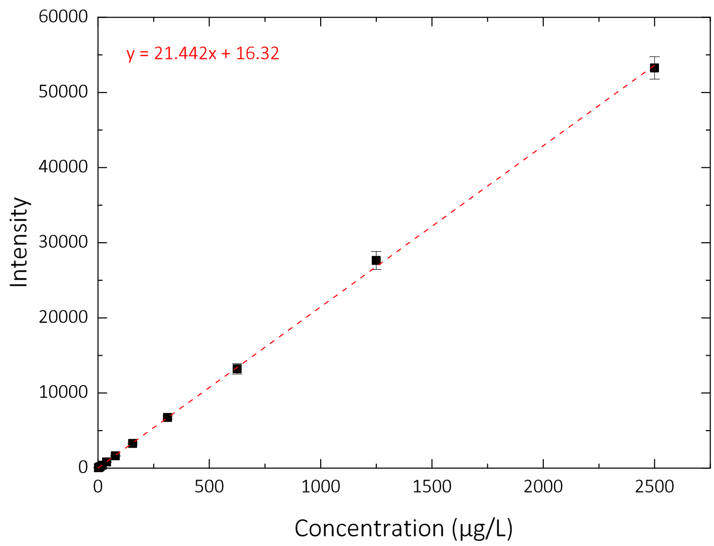

Figure S4. Calibration curve constructed from 2.5 mg/L sodium fluorescein in DI water measured with a gain of 80.

Induction Heating Coil:

The geometry of the induction heater's coil plays a critical role in setting the magnitude of the AC magnetic field. From the Biot-Savart law, we can find the magnetic field inside a coil to be (Figure S5A):

$$B_{z=0} = \mu_o n I \frac{h}{\sqrt{h^2 + 4R^2}} \tag{S1}$$

where μ_o is the magnetic constant, n is the number of loops, I is the current through the coil, h is the length of the coil, and R is the radius of the coil. By normalizing the magnetic field over $\mu_o nI$, we can find the dimensionless parameter ($\tilde{B}$) which is only a function of the coil diameter (d) and coil length (h), as described here:

$$\frac{B_{z=0}}{\mu_o n I} = \frac{1}{\sqrt{1 + \left(\frac{d}{h}\right)^2}} \tag{S2}$$

We can now take the limit of the $\tilde{B}$ with respect to d/h to find the behavior of the function for the extreme cases. As illustrated in Figure S5B, the $\tilde{B}$ is 1 when d/h approaches zero and 0 when d/h is extremely large.

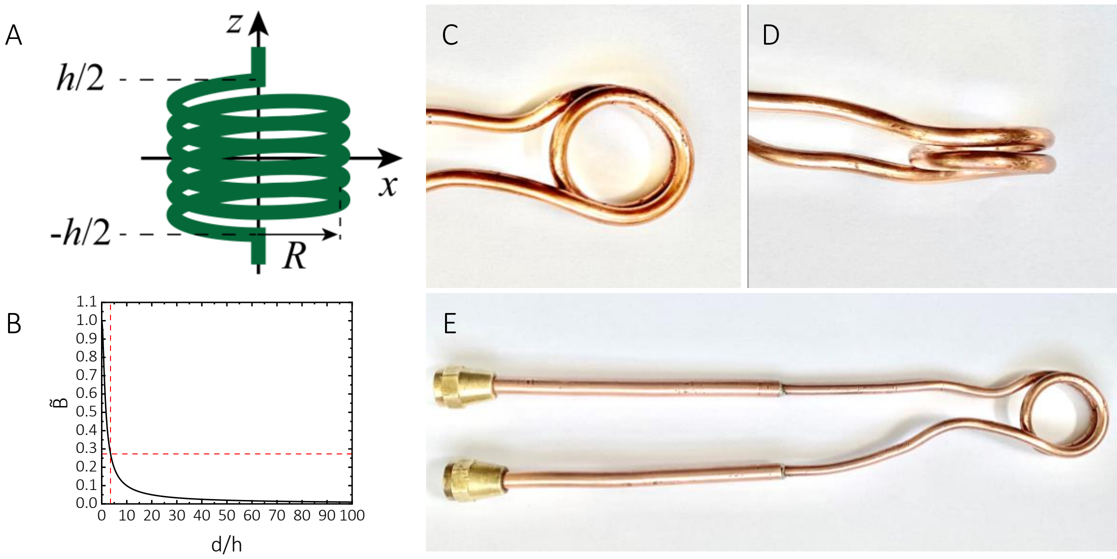

Figure S5. (A) Illustration and specifications of the coil that is used to derive equation S1. (B) The behavior of the normalized magnetic field as a function of the ratio of the coil diameter and coil length. (C) – (E) Images of the coil used in this project.

We made a coil with an inner diameter of 17.5 mm with *d*/*h* of 4.3 (Figure S5C-E). As suggested by Figure S5B, the magnetic field at the edge of the coil can be estimated to be $\approx 0.3\mu_o nI$.

We used copper pipe with OD of 1/8" and ID of 0.065" to make the coil and copper pipe with OD of 3/16" and ID of 0.128" to connect it to the device. Two 5/8" long, 45° flared fittings for copper tubing nut (3/16" Tube OD) were used to connect and seal the copper pipes to the device (Figure S5E). Both ends of the copper pipe were flared with a copper tube flaring tool to match the shape of the fitting on the induction heating device. A 12V water pump was then used to circulate cold water through the coil to maintain its temperature low during the experiments.