

IRON OXIDE NANOFLOWERS AS EXCELLENT HEATING AGENTS FOR MAGNETIC HYPERHERMIA CANCER THERAPY

Professor Nguyễn T. K. Thành FRSC FInstP FIMMM FRSB
Chair in Nanomaterials, Vice Dean for Innovation and Enterprise,
Mathematical and Physical Sciences Faculty



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- Number 6 worldwide in mean ranking
- 30 Nobel laureates
- UCL's annual impact of £9.9bn across the UK economy



THE ROYAL INSTITUTION of GREAT BRITAIN
Founded in 1799
is the oldest independent research body in the world.
15 Nobel Prizes
discovery of **10 elements**



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THE ROYAL INSTITUTION

Some Past Directors of the Laboratory

- 1825 Michael Faraday
- 1867 John Tyndall
- 1887 James Dewar

Some Past Directors of the Davy-Faraday Research Laboratory

- 1923 William Henry Bragg: Nobel Laureate
- 1954 William Lawrence Bragg: Nobel Laureate



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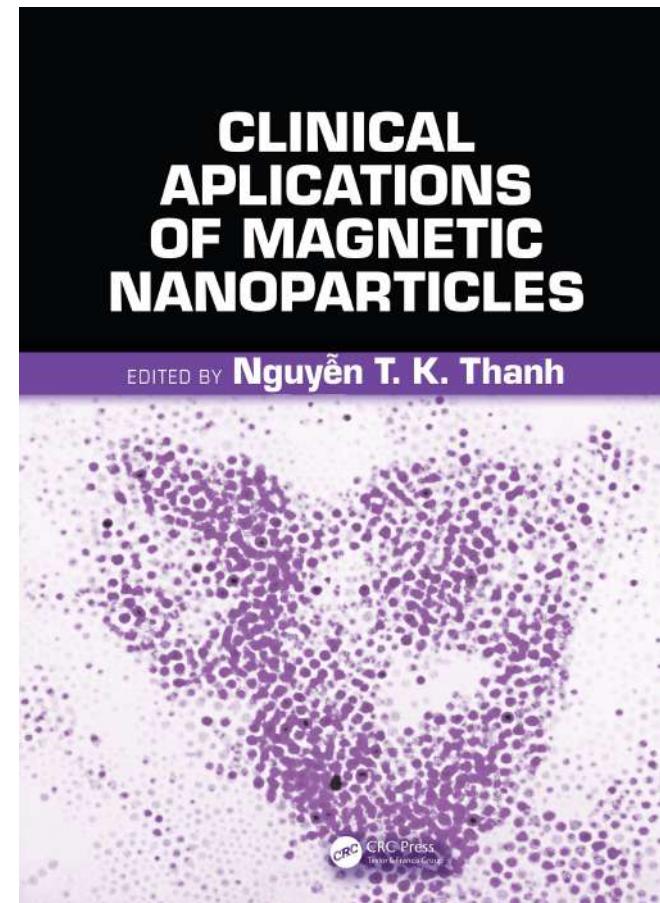
MICHAEL FARADAY's MAGNETO-OPTICAL APPARATUS



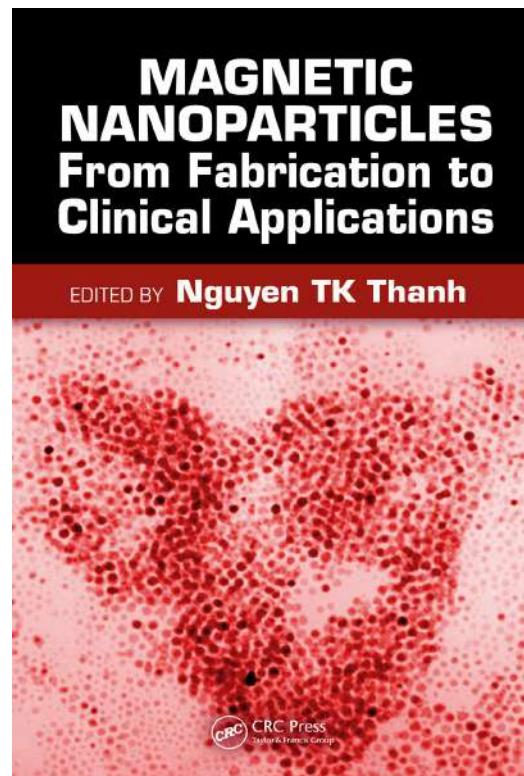
@2019 Nguyen T. K. Thanh

The Faraday museum, The Royal Institution

2018: 26 chapters



eBook ISBN 9781315168258



eBook ISBN 9780429062247



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Magnetisation of Magnetic Materials

| Materials | Ms at 300 K (emu/g) | Standard Red . Pot. E ⁰ /V |
|----------------------|---|--|
| <i>3d transition</i> | α-Fe Co | 217 161 |
| | | Fe ²⁺ /Fe: -0.44 Co ²⁺ /Co: -0.28 Au ⁺ /Au: +1.83 |
| <i>Alloys</i> | CoFe FePt | 235 216 |
| <i>Oxides</i> | Fe ₃ O ₄ -magnetite Co ₃ O ₄ | 90-92 6 |



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Fe⁰ Microparticles Firework!



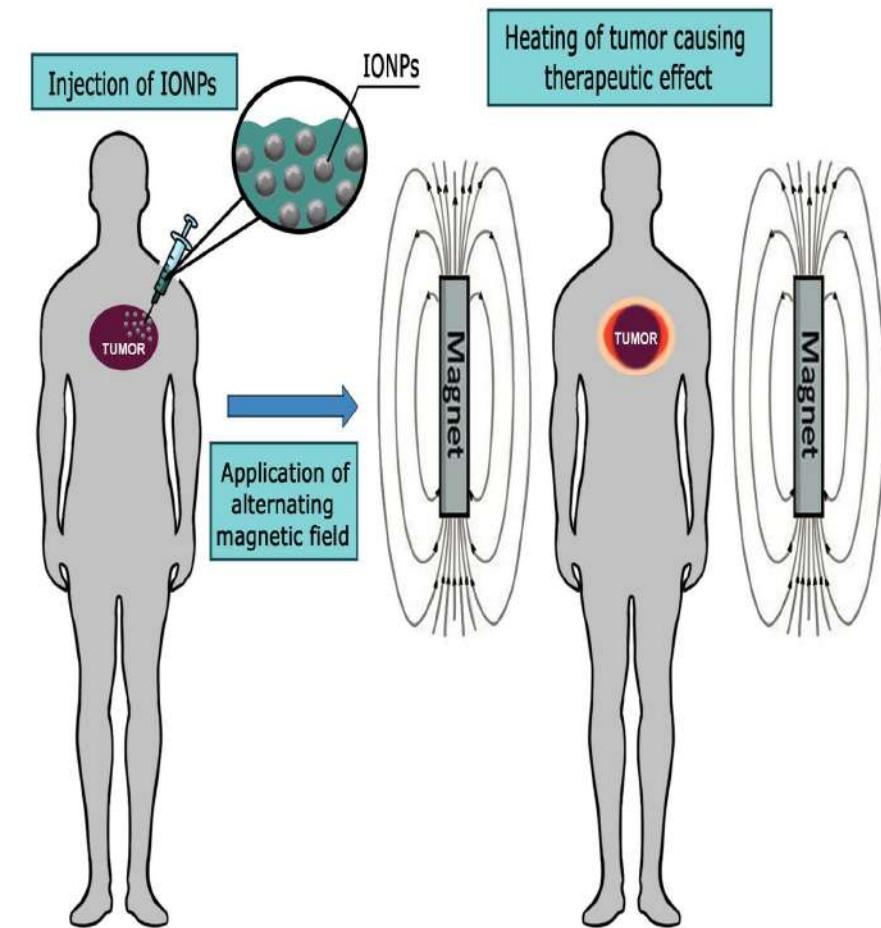
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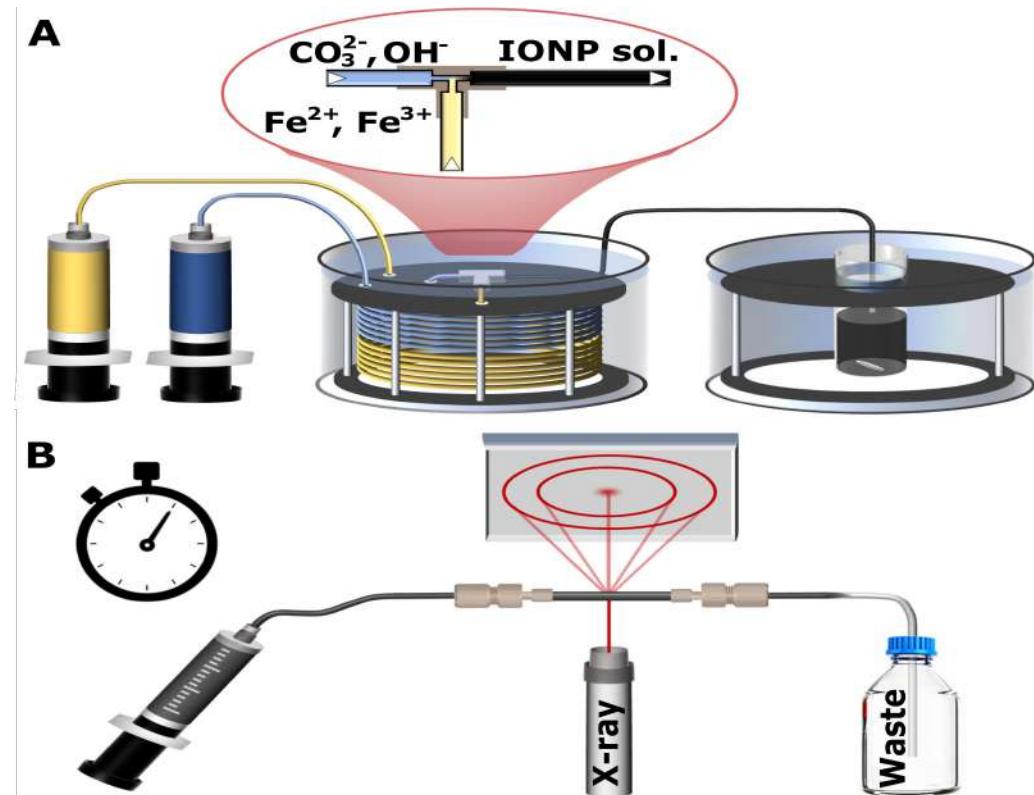
- Cancer problem: 2.7 million people in the 27 EU countries
- Current treatments:
Chemotherapy: serious side-effects
Radiotherapy: specialised x-ray facilities
invasive radioisotopes
Surgery: invasive
- **New Magnetic Hyperthermia Modality**
 - no side effect
 - minimally invasive

But,

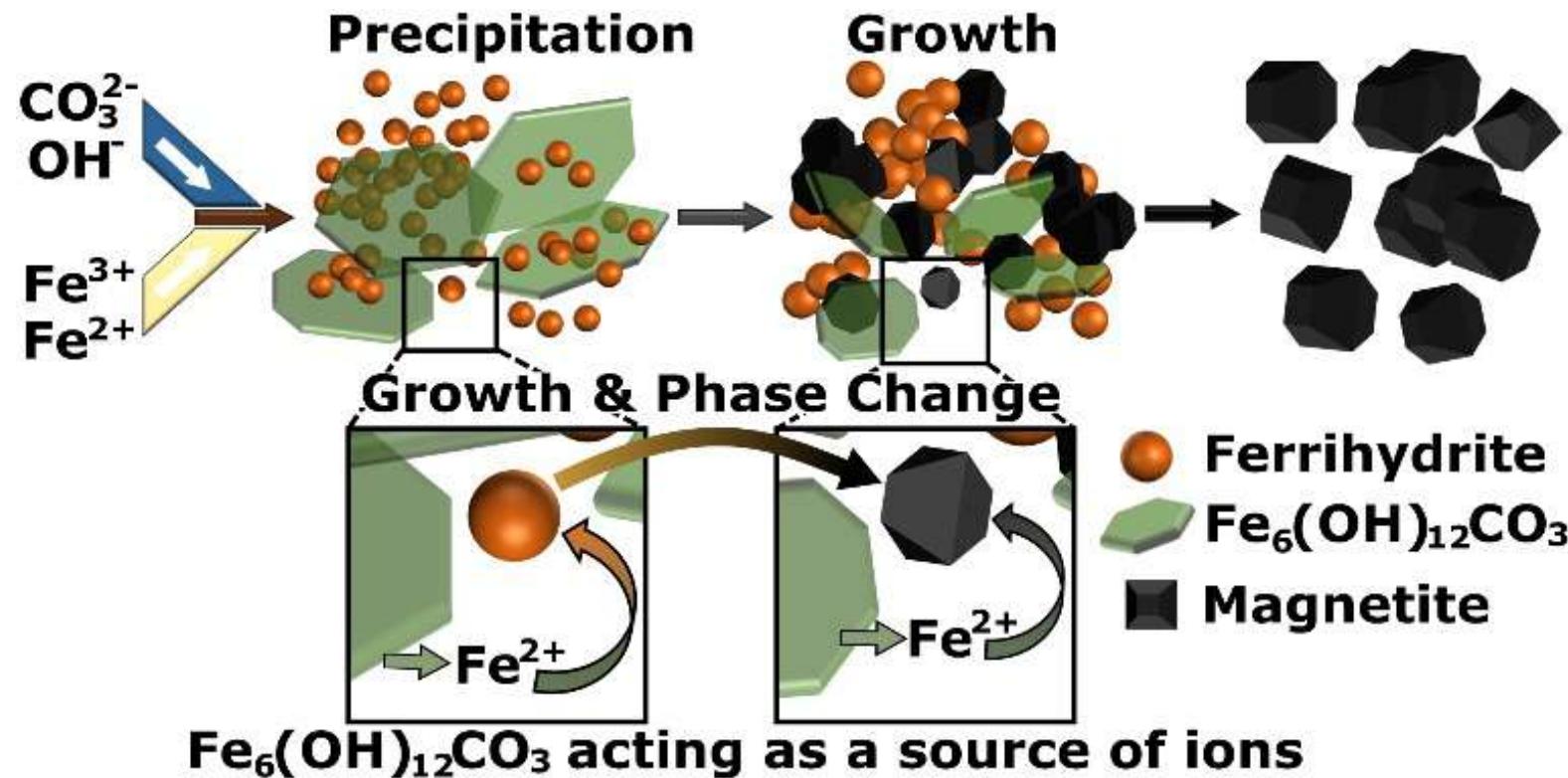
- requires high dose of IONPs
- production issues of current IONPs



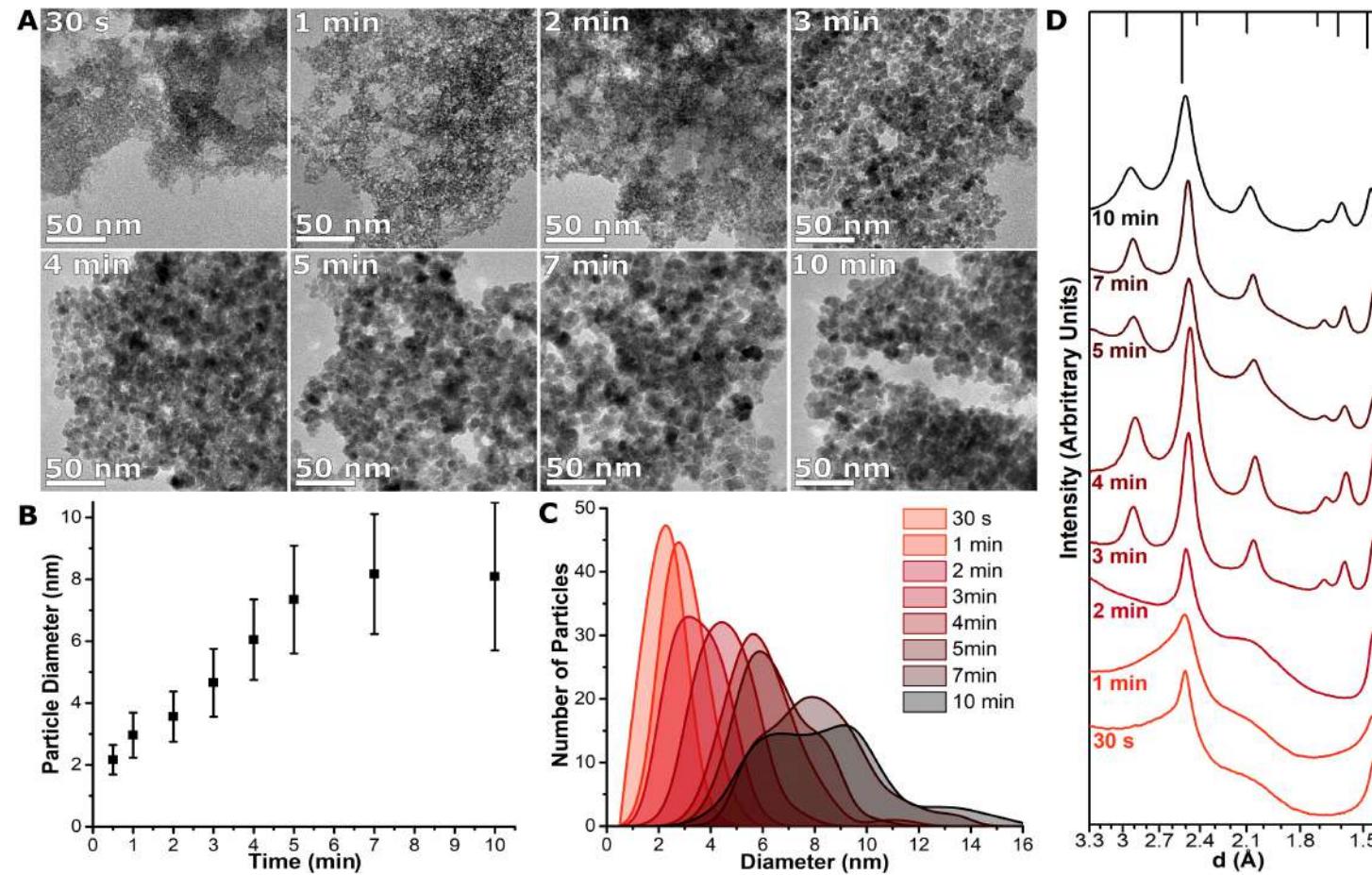
Iron oxide NPs in Milifluidic Reactors



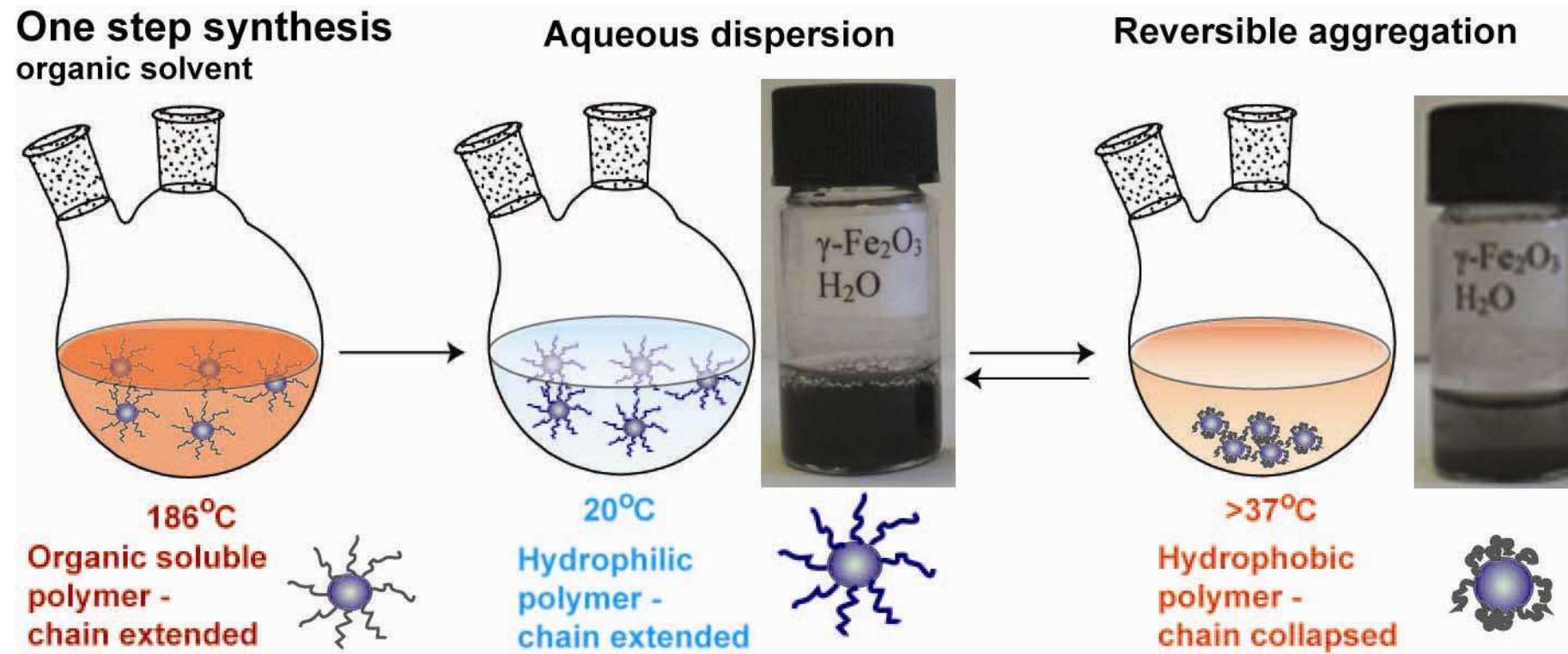
Growth Mechanism of the Co-Precipitation of Iron Oxide NPs with the Aid of Synchrotron X-Ray Diffraction in Solution



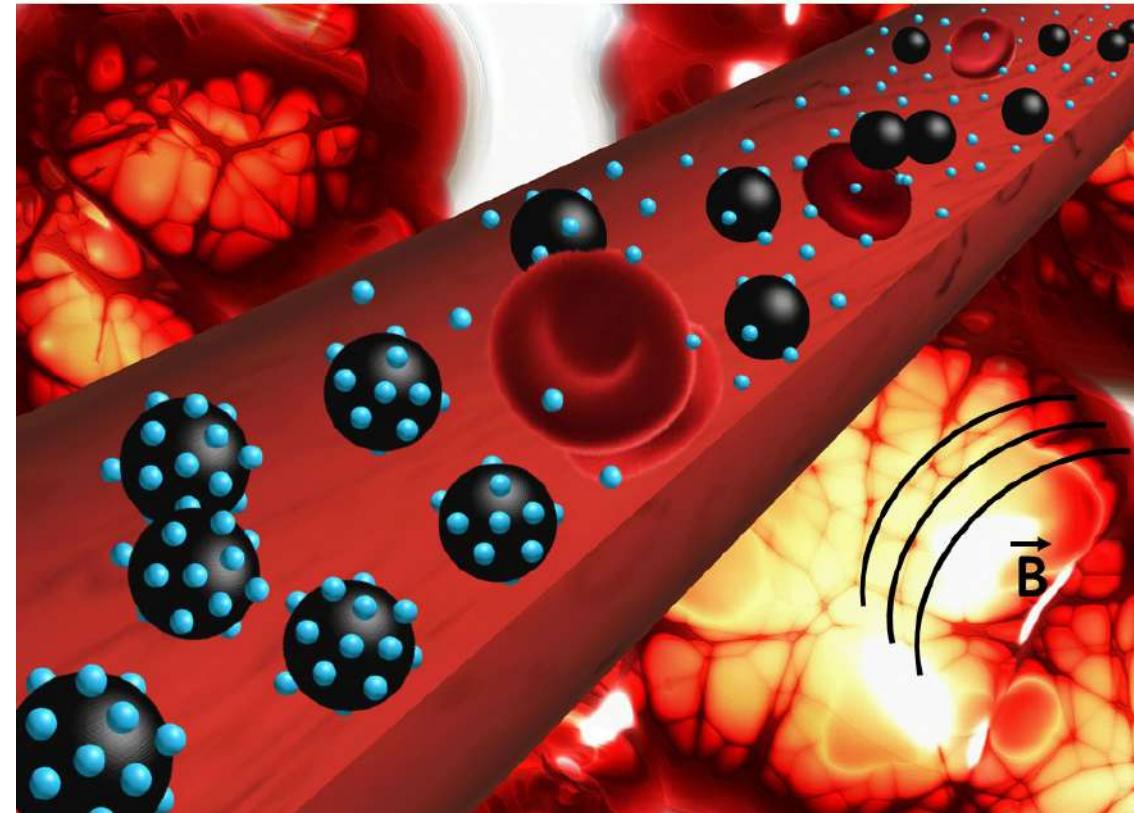
Growth Mechanism of the Co-Precipitation of Iron Oxide Nanoparticles with the Aid of Synchrotron X-Ray Diffraction in Solution



Thermoresponsive polymers



Doxorubicin loaded dual pH- and thermo-responsive magnetic nanocarrier for combined magnetic hyperthermia and targeted controlled drug delivery applications

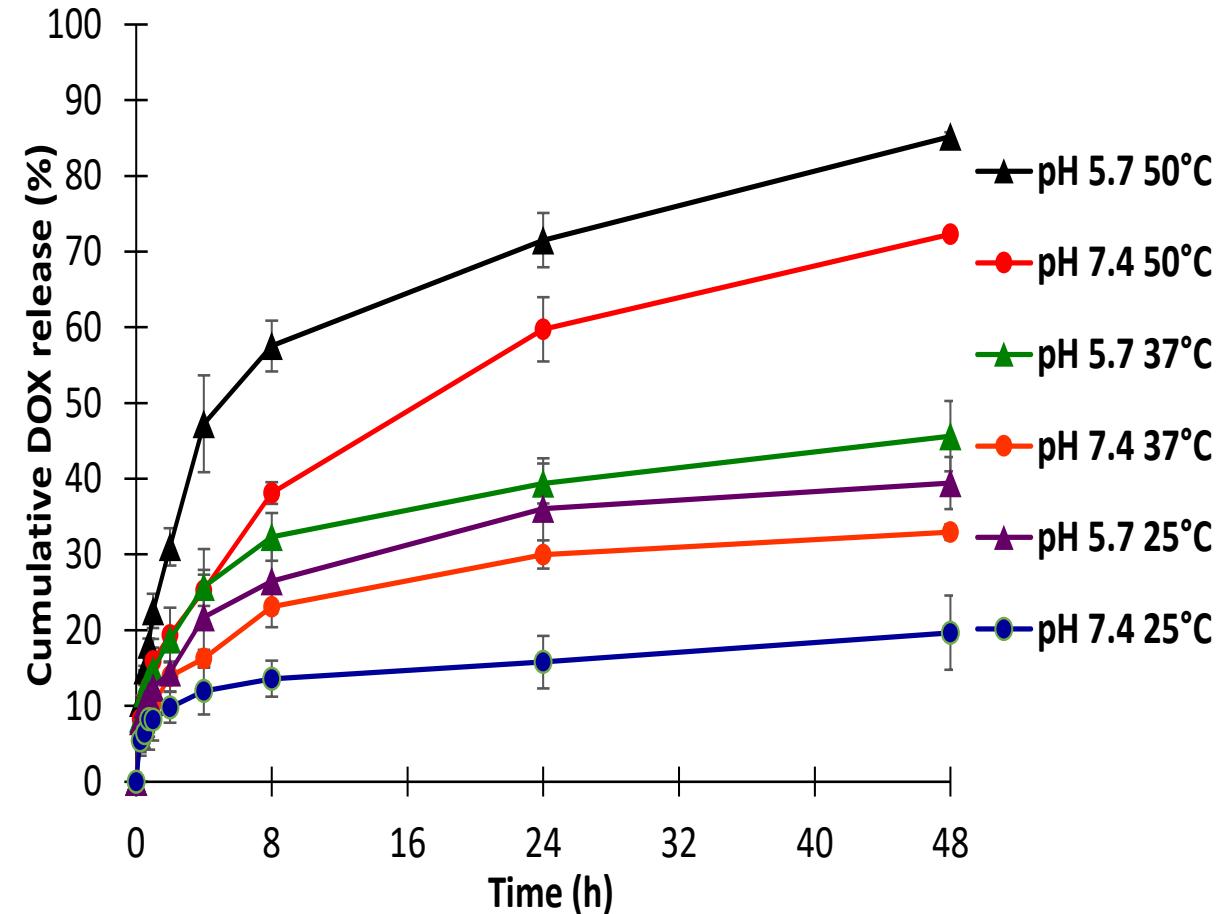
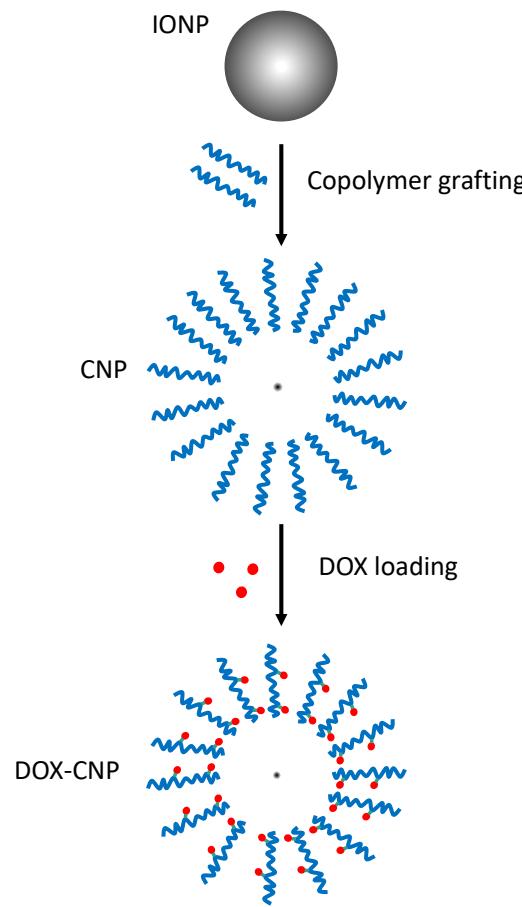


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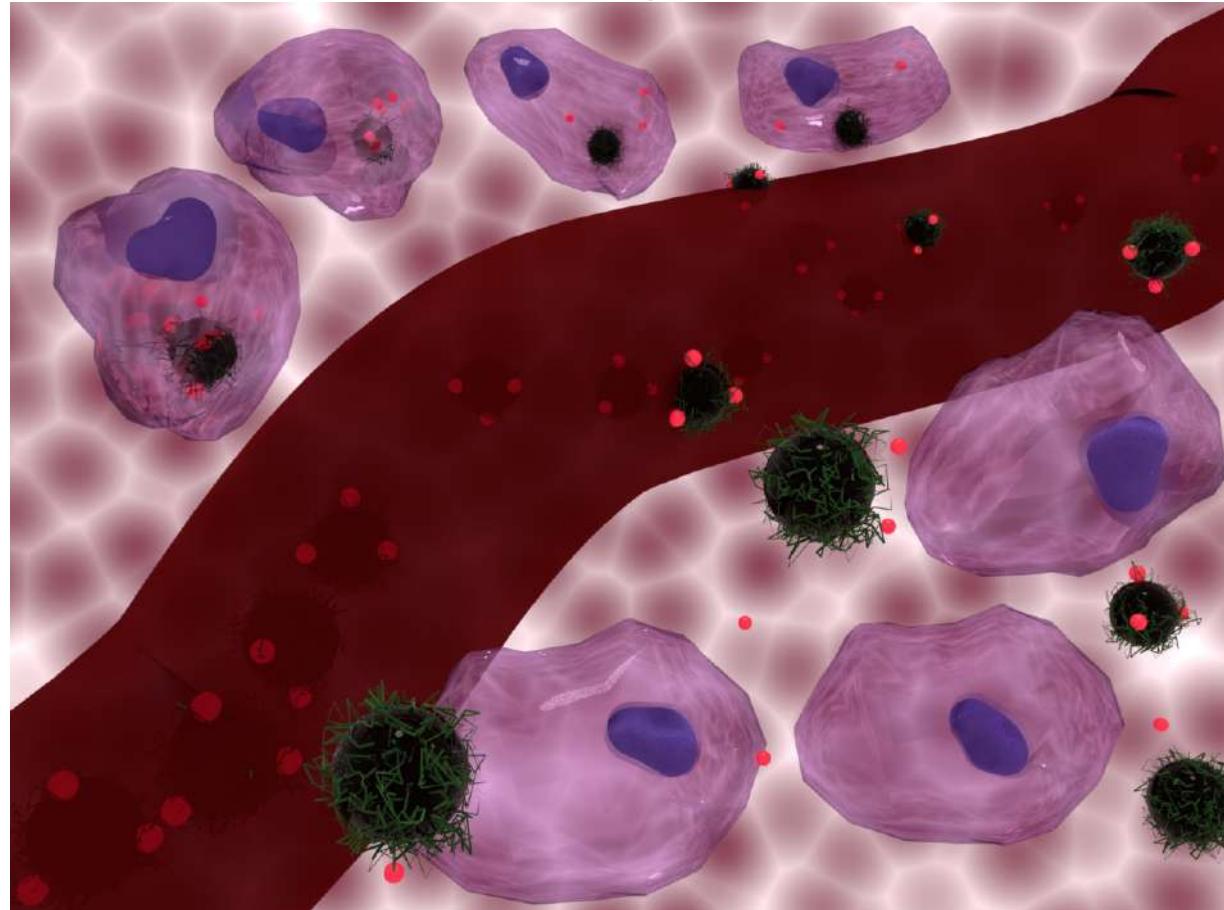


A. Hervault, M. Lim, C. Boyer, A. Dunn, D. Mott, S. Maenosono and N. T. K. Thanh, 2016, *Nanoscale*, **8**: 12152.

Targeted controlled drug release



Thermo-chemotherapy with doxorubicin loaded dual pH- and thermo-responsive magnetic nanocomposite carriers.

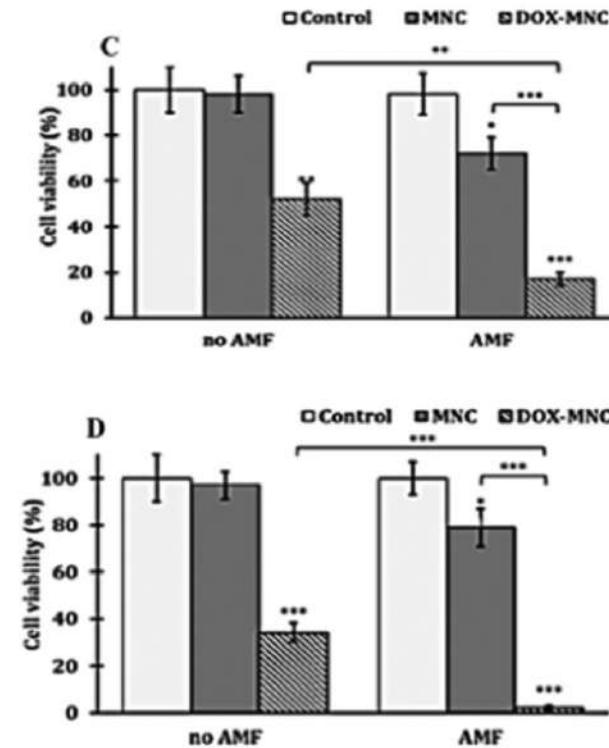
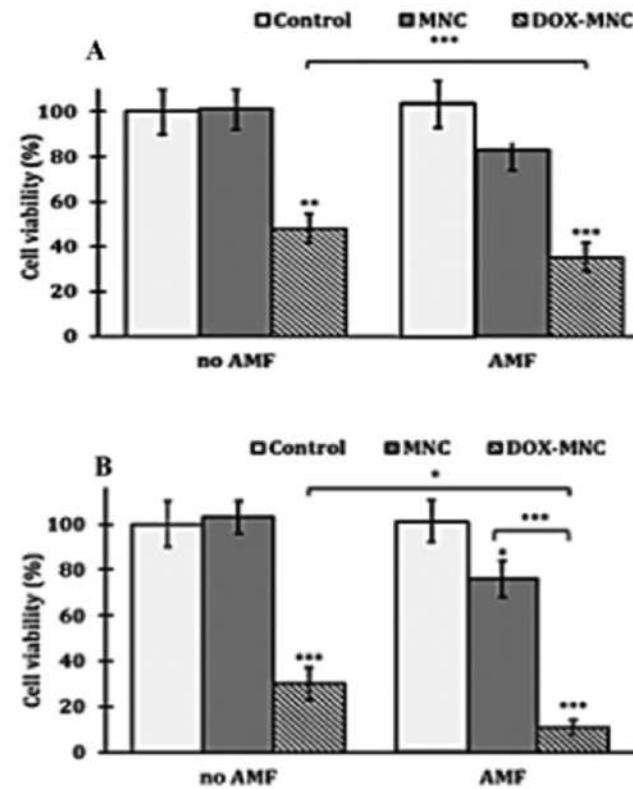


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Wang, L., Hevault, A., Southern, P., Sandre, O., Couillaud, F., **Thanh, N. T. K.*** (2020) *J Mat Chem B* **8**: 10527.

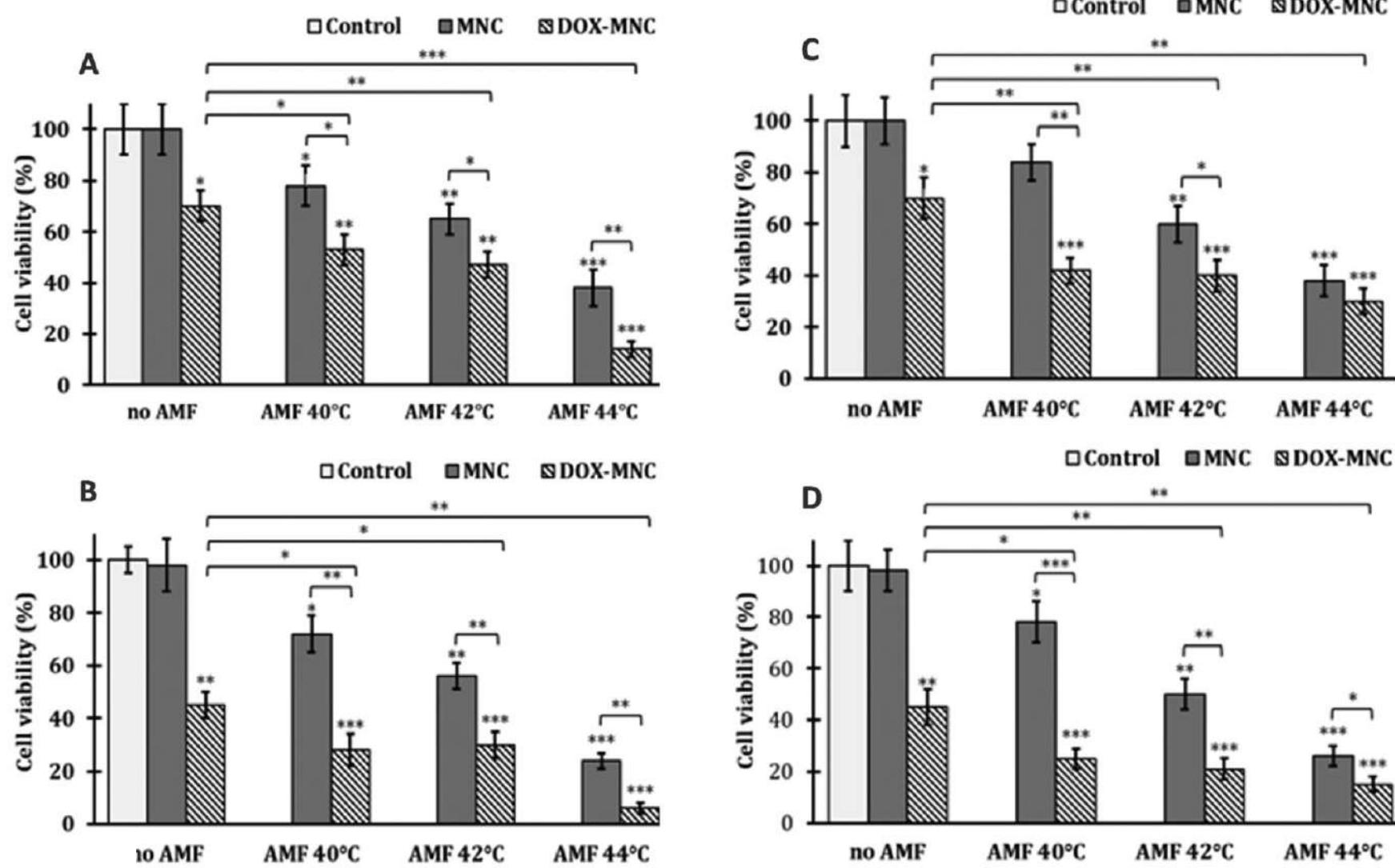
Cell viabilities of internalized nanoparticles



24 h: A and C, 48 h: B and D post , MCF-7 cells: A and B U-87: C and D, 1 h at $f = 950$ kHz and $H = 10.5$ kA/m

Chemotherapy could be up to 34% more effective

Cell viabilities



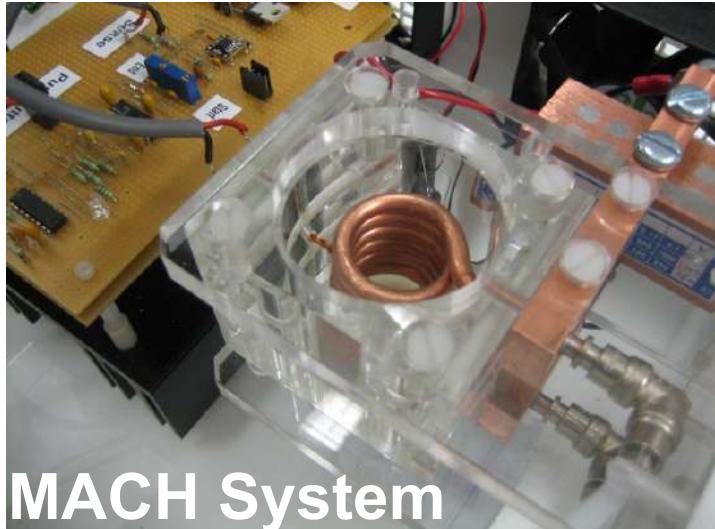
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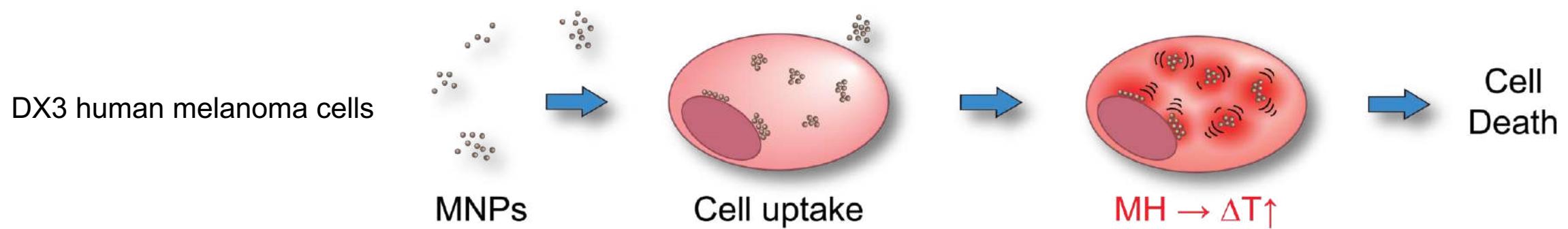
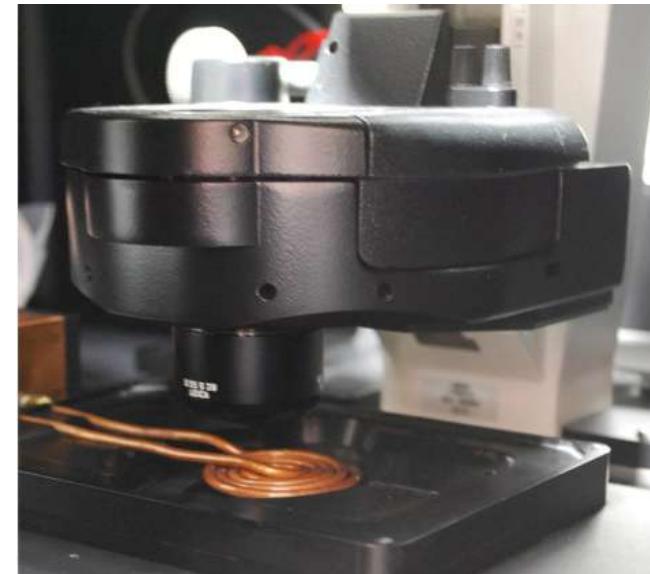
Direct treatment

Wang, L., Hevault, A., Southern, P., Sandre, O., Couillaud, F., Thanh, N. T. K.* (2020)
J. Mat. Chem. B: 8: 10527. Front Cover

Real-time tracking of delayed-onset cellular apoptosis induced by intracellular magnetic hyperthermia



Magnetic AC
field treatment
applied

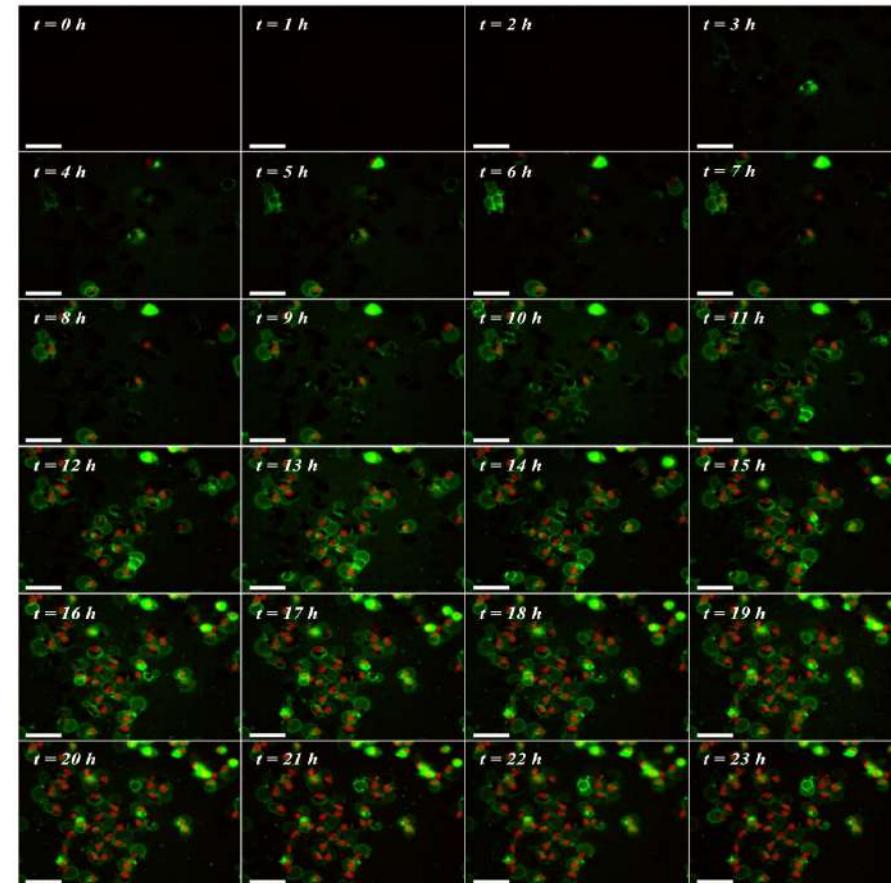


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C Blanco-Andujar, D Ortega, P Southern, SA. Nesbitt, QA. Pankhurst and NTK Thanh (2016)
Nanomedicine. *Nanomedicine*. 11: 121-136

Real-time tracking of delayed-onset cellular apoptosis induced by intracellular magnetic hyperthermia

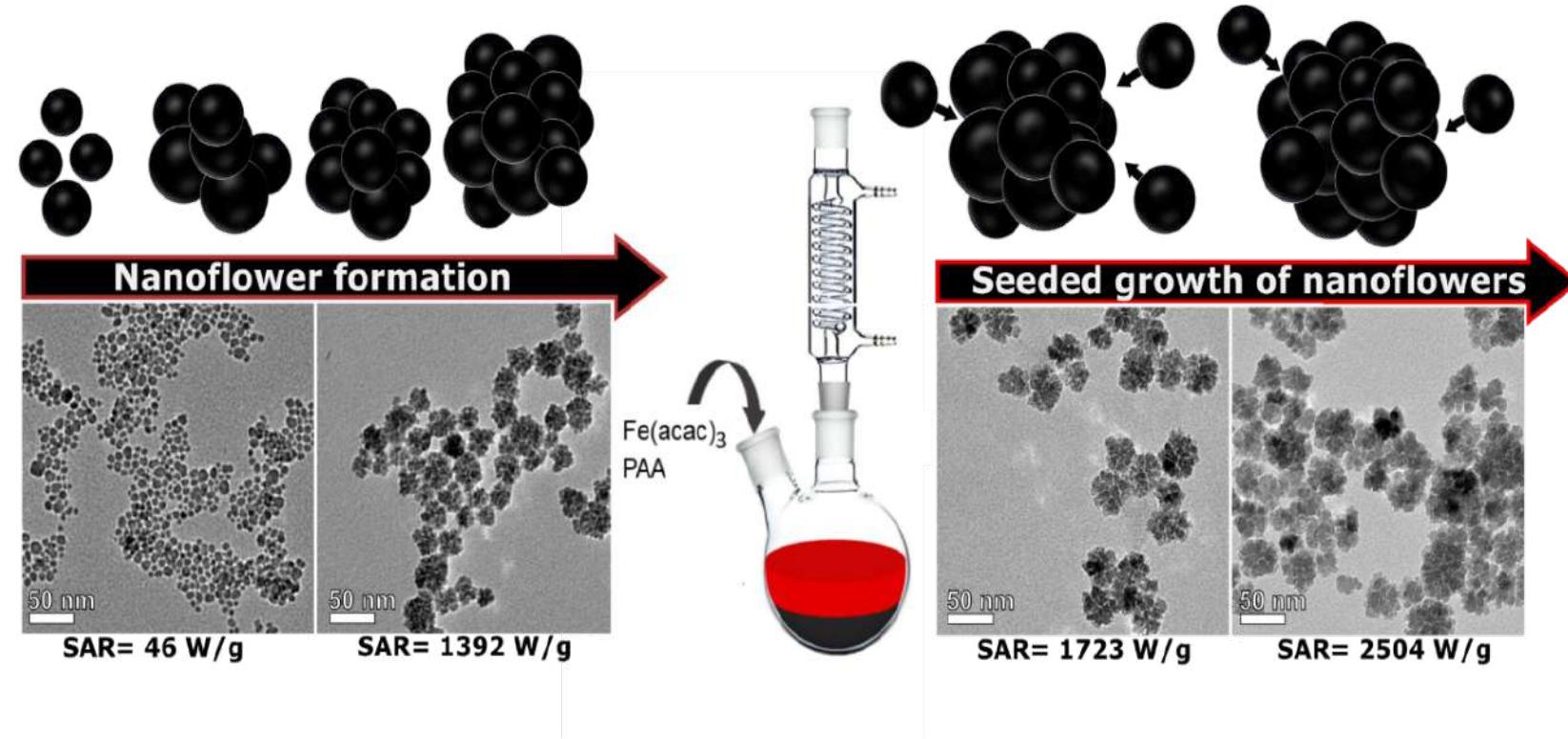


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C Blanco-Andujar, D Ortega, P Southern, SA. Nesbitt, QA. Pankhurst and NTK Thanh
(2016) Nanomedicine. *Nanomedicine*. **11**: 121-136

Simple and Fast Polyol Synthesis of Stable Iron Oxide Nanoflowers with Exceptional Heating Efficiency



SAR(W/g_{Fe}): 2426 ± 76

ILP(nHm²/ kg_{Fe}): 8.08 ± 0.41



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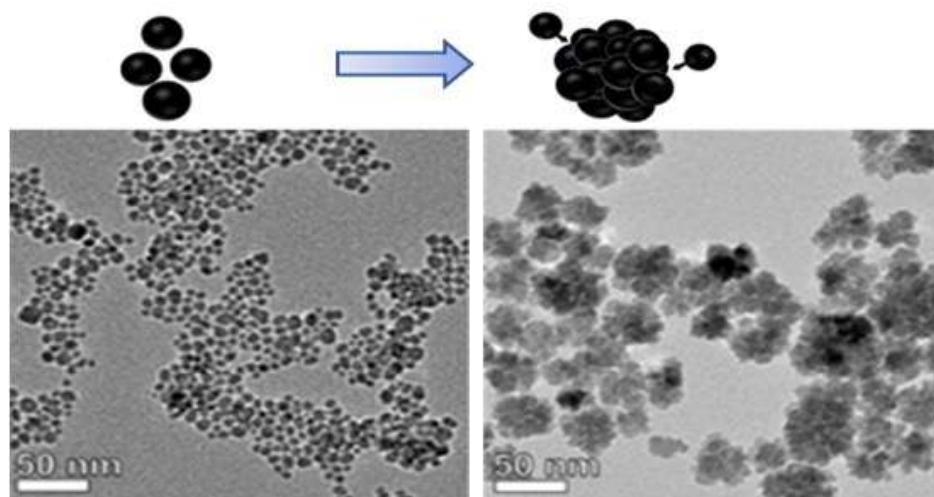
Storozhuk, , Besenhard M. O., Moudikoudis, S., LaGrow, A. P., Lees, M.R., Tung, L. D., Gavriilidis, A., Thanh, N. T. K* (2021). *Journal of Applied Materials and Interface*. **13**: 45870–45880.

RESOVIST
Commercially
available
Clinically approved
IONPs

Heating rate = 3.1

- requires high dose of IONPs
- production issues of current IONPs

Our Unique Selling Points



Heating rate = 8.5



**Stable
Biocompatible
Nanoflowers
Injectable**

SIMPLE, INEXPENSIVE, FAST, ROBUST, REPRODUCIBLE, SCALEABLE, GREEN, SUSTAINABLE PRODUCTION



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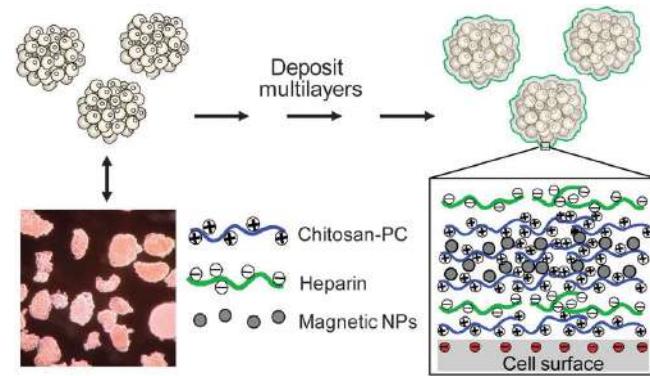
New modality needed for cancer treatment



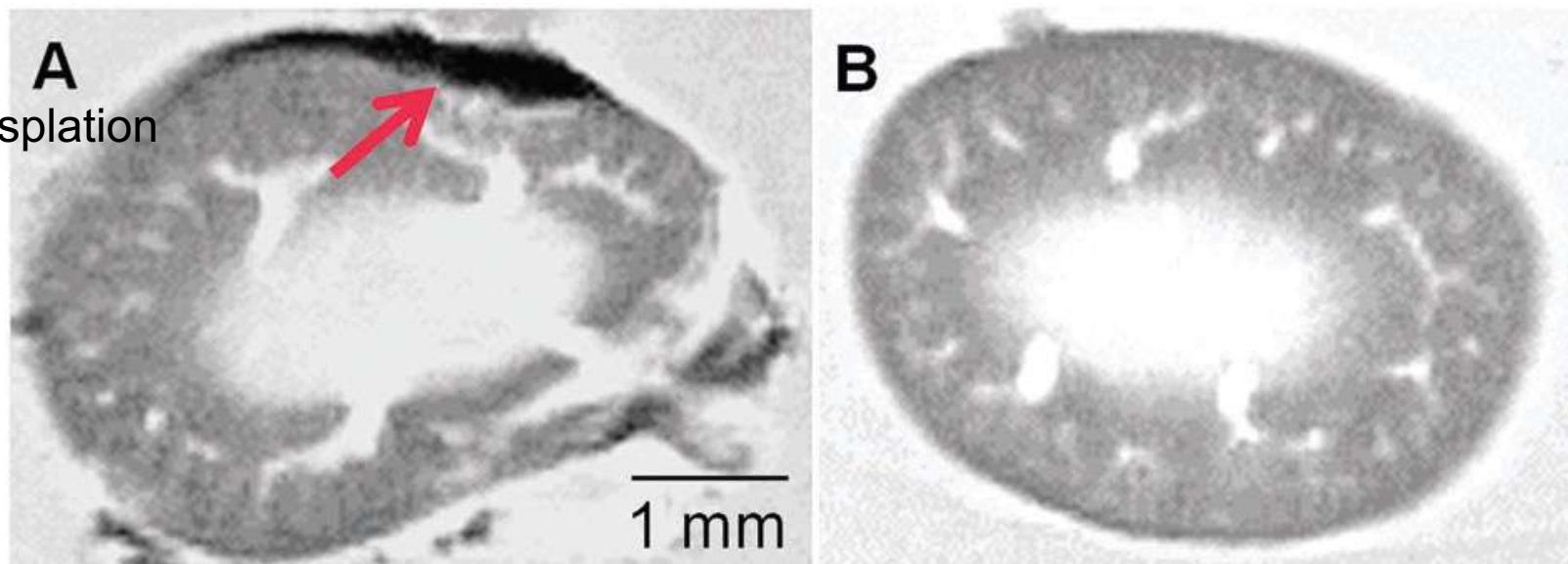
magforce®
THE NANOMEDICINE COMPANY

 RESONANT
CIRCUITS
LIMITED

 **micro mod**
MODULAR DESIGNED PARTICLES



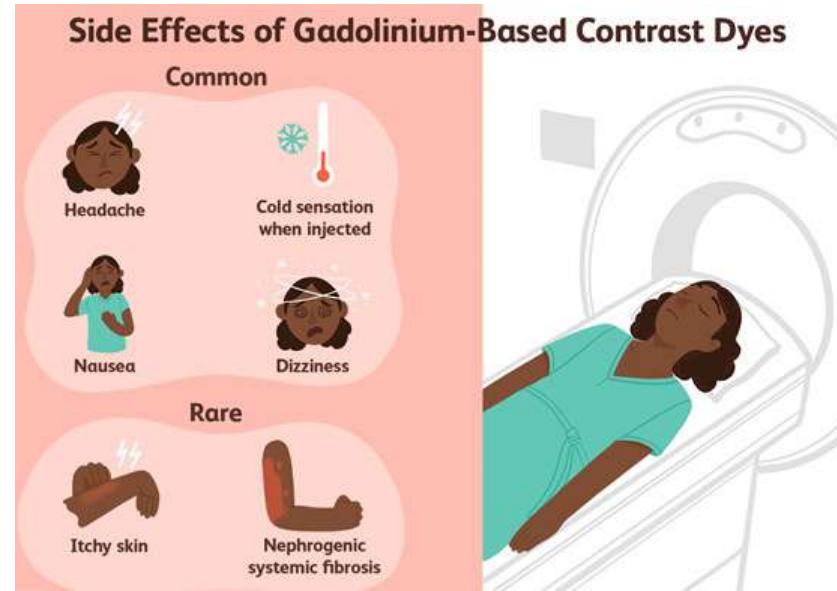
7 days after transplantation



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Y. Wang, C. Blanco-Andujar, Z. Zhi, P.W. So , **N. T. K. Thanh**, J. C. Pickup
(2013) *Chem Comm.* 49, 7255-7257



Possible Risks:

1. Brain Retention

neurologic disorders
(Parkinson's disease or multiple sclerosis)

2. Nephrogenic Systemic Fibrosis

thickening or hardening of the skin and fibrosis (scarring) in other parts of the body.

3. Gd relies on being excreted quickly from the body

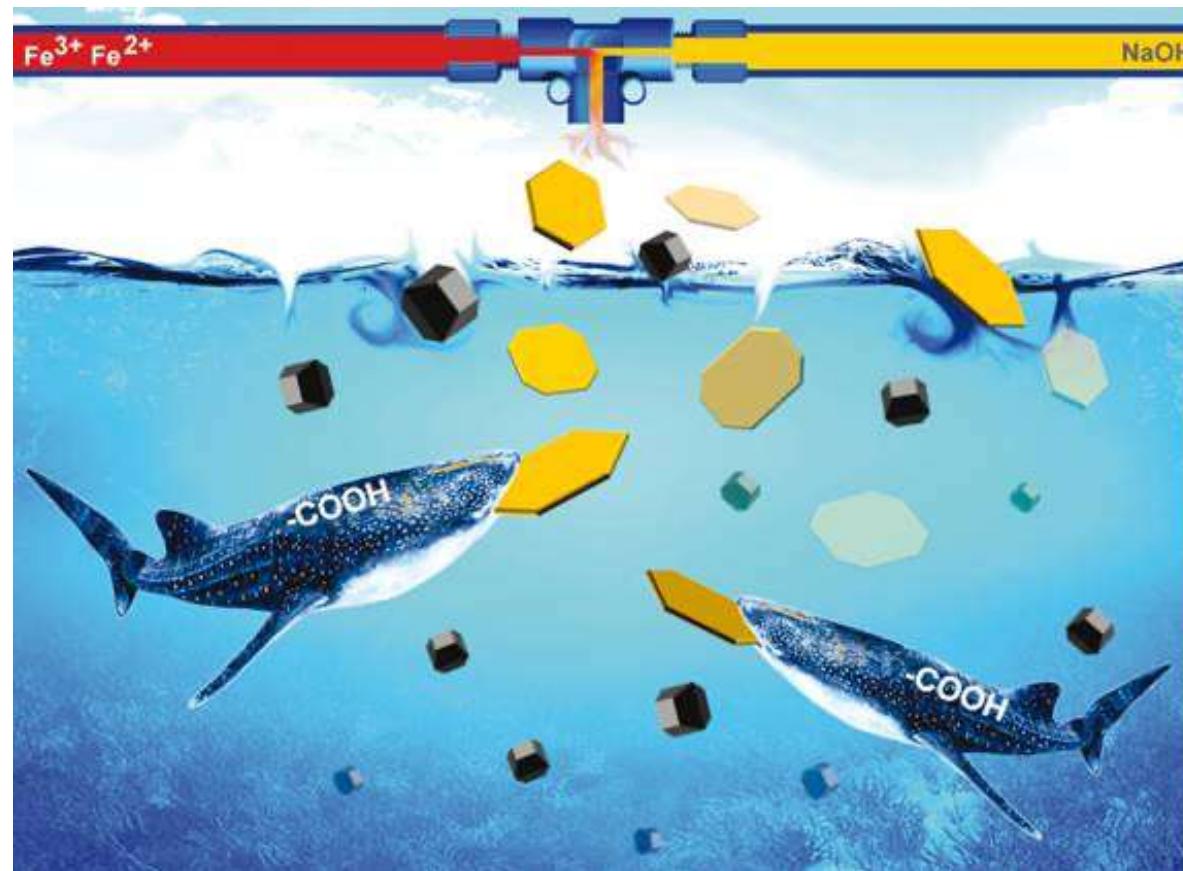
patients having kidney failure → could cause fatality

4. Gadolinium has been found in drinking water

No method for cleaning up Gadolinium in water

Use iron oxide-based agents instead of gadolinium

Small Iron Oxide Nanoparticles as MRI T₁ Contrast Agent: Scalable Inexpensive Water-Based Synthesis Using a Flow Reactor.

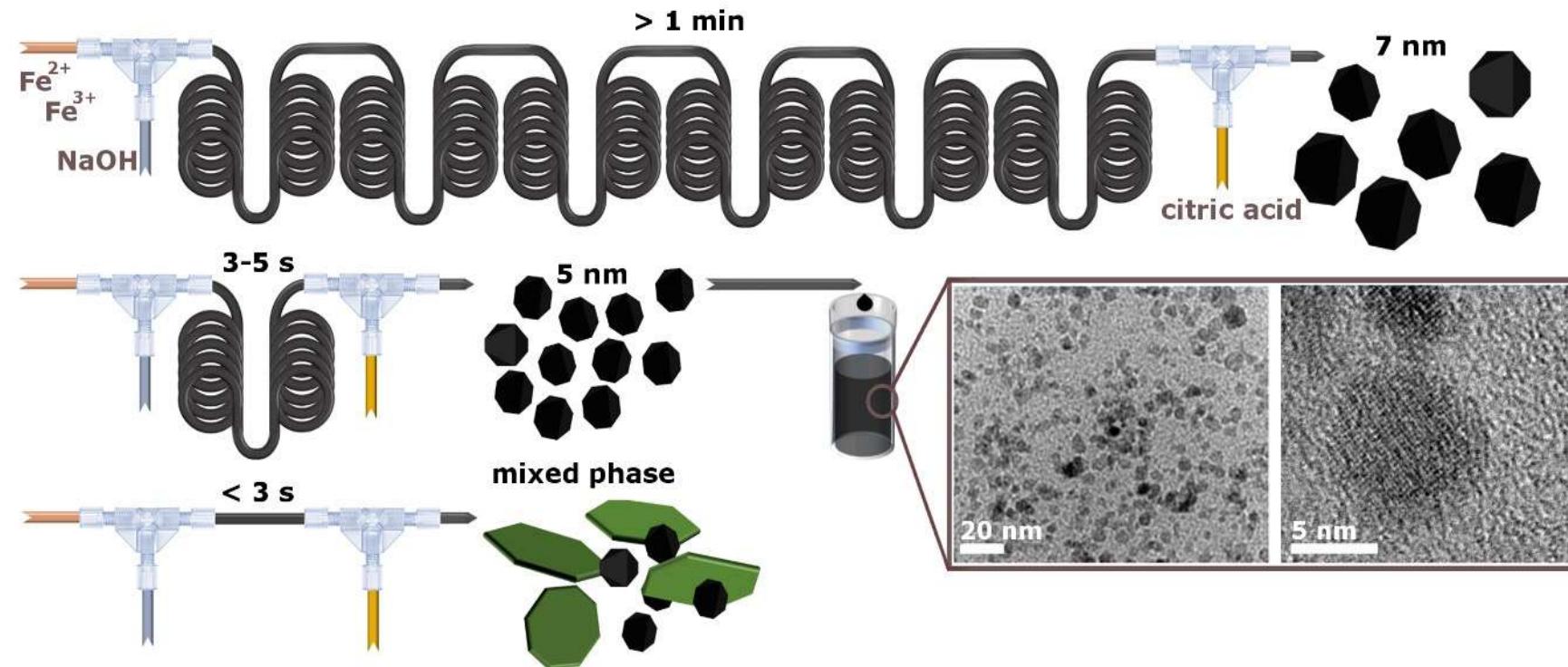


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Besenhard M. O., Panariello, L., Kiefer, C., LaGrow, A. P., Storozhuk, L., Perton F., Begin, S., Damien Mertz, D., **Thanh, N. T. K.*** and Gavrilidis, A. (2021) *Nanoscale*. **13**: 8795-8805. FRONT COVER PAGE

Small Iron Oxide Nanoparticles as MRI T₁ Contrast Agent: Scalable Inexpensive Water-Based Synthesis Using a Flow Reactor.



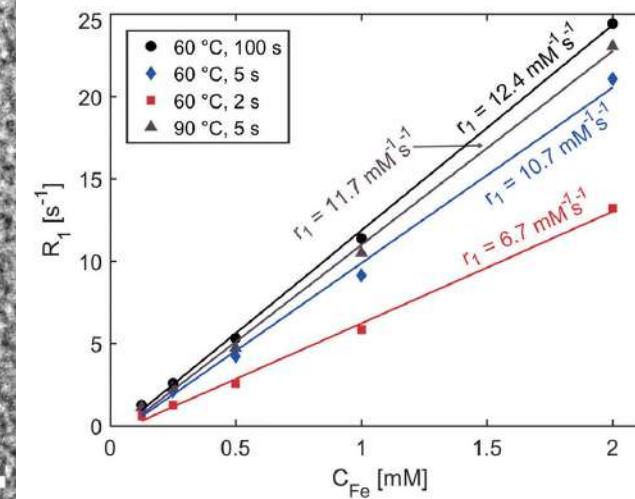
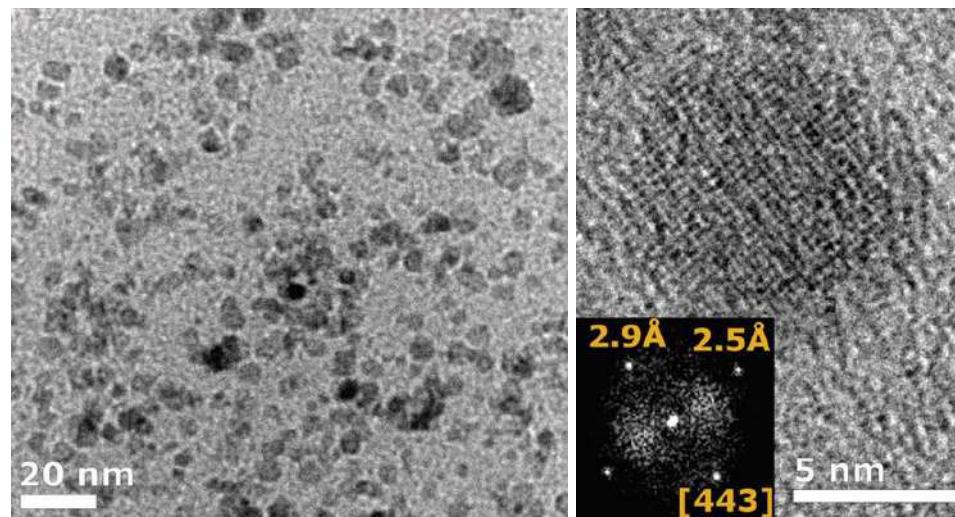
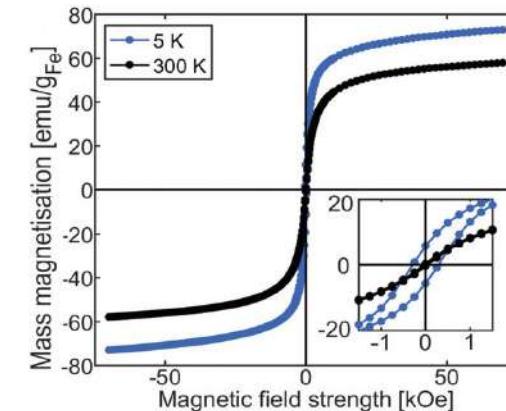
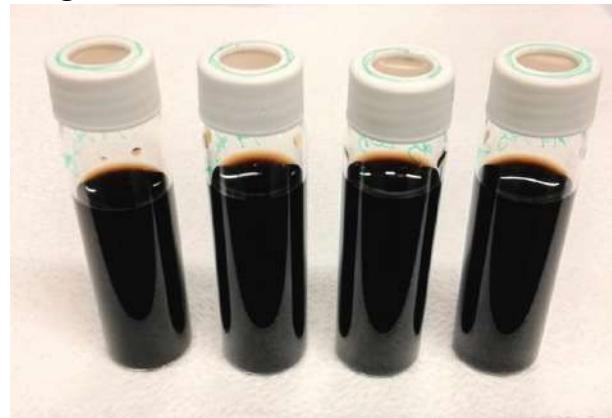
Besenhard M. O., Panariello, L., Kiefer, C., LaGrow, A. P., Storozhuk, L., Perton F., Begin, S., Damien Mertz, D., **Thanh, N. T. K.*** and Gavrilidis, A. (2021) *Nanoscale*. **13**: 8795-8805. [Gold Open Access](#). FRONT COVER PAGE



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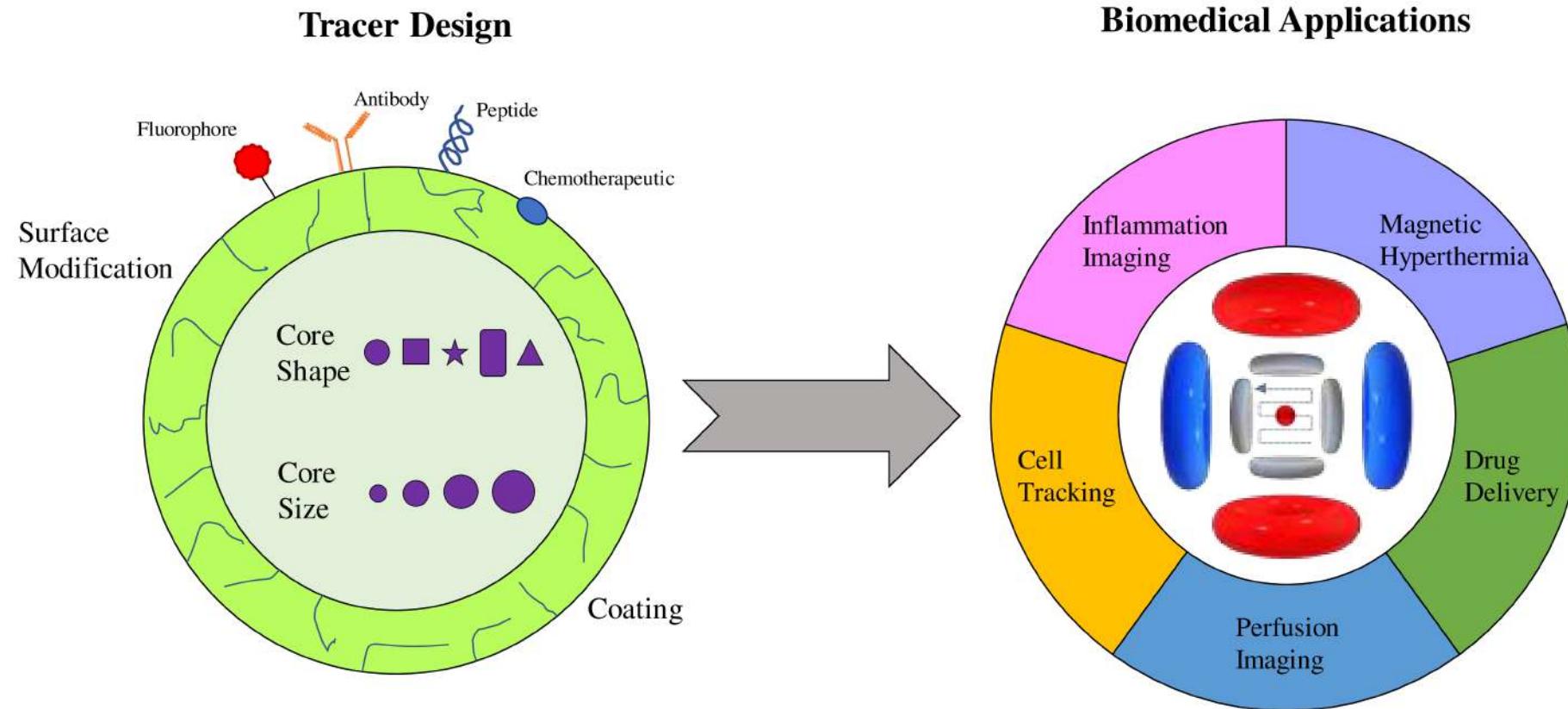
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Small Iron Oxide Nanoparticles as MRI T₁ Contrast Agent: Scalable Inexpensive Water-Based Synthesis Using a Flow Reactor



Magnetic Particle Imaging

Radiation-Free, Sensitive and Quantitative.



Over 166 years old Gold (Au) sols still exist at Ri

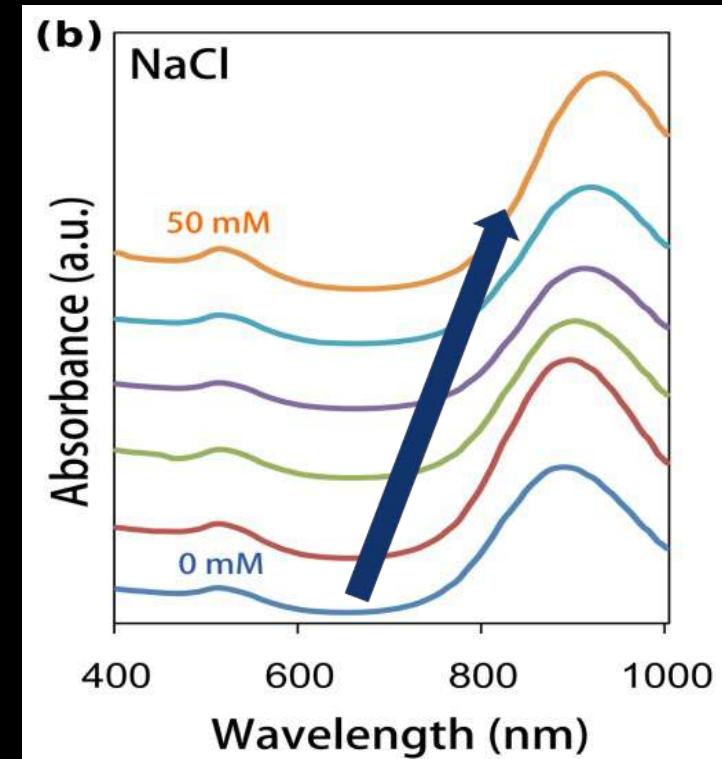
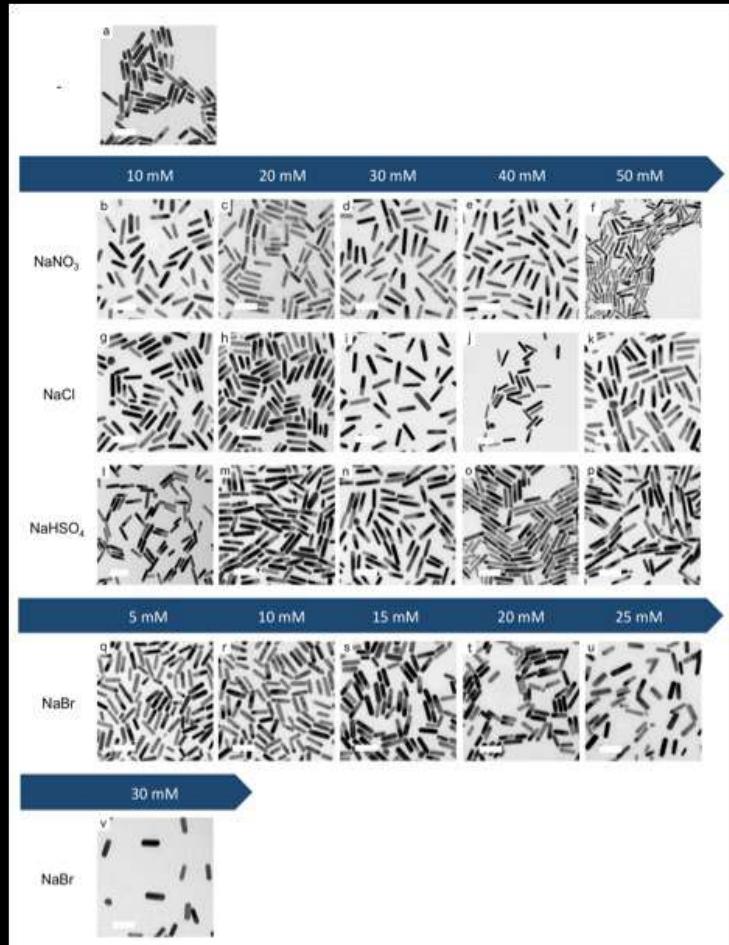


M. Faraday, *Diary*, 2 Feb 1856. 11,
14243 to 20 Dec. 1856

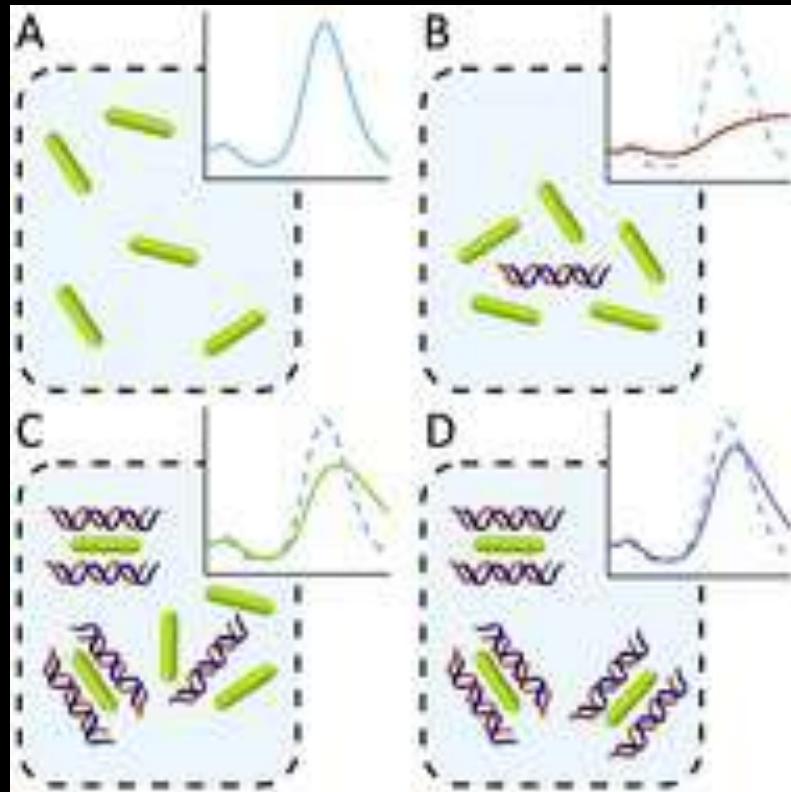
M. Faraday, *Phil. Trans. R. Soc.*
London, 1857, 147, 145-181

21-11-2011
in Faraday's
original lab

Fine-Tuning of Gold Nanorods



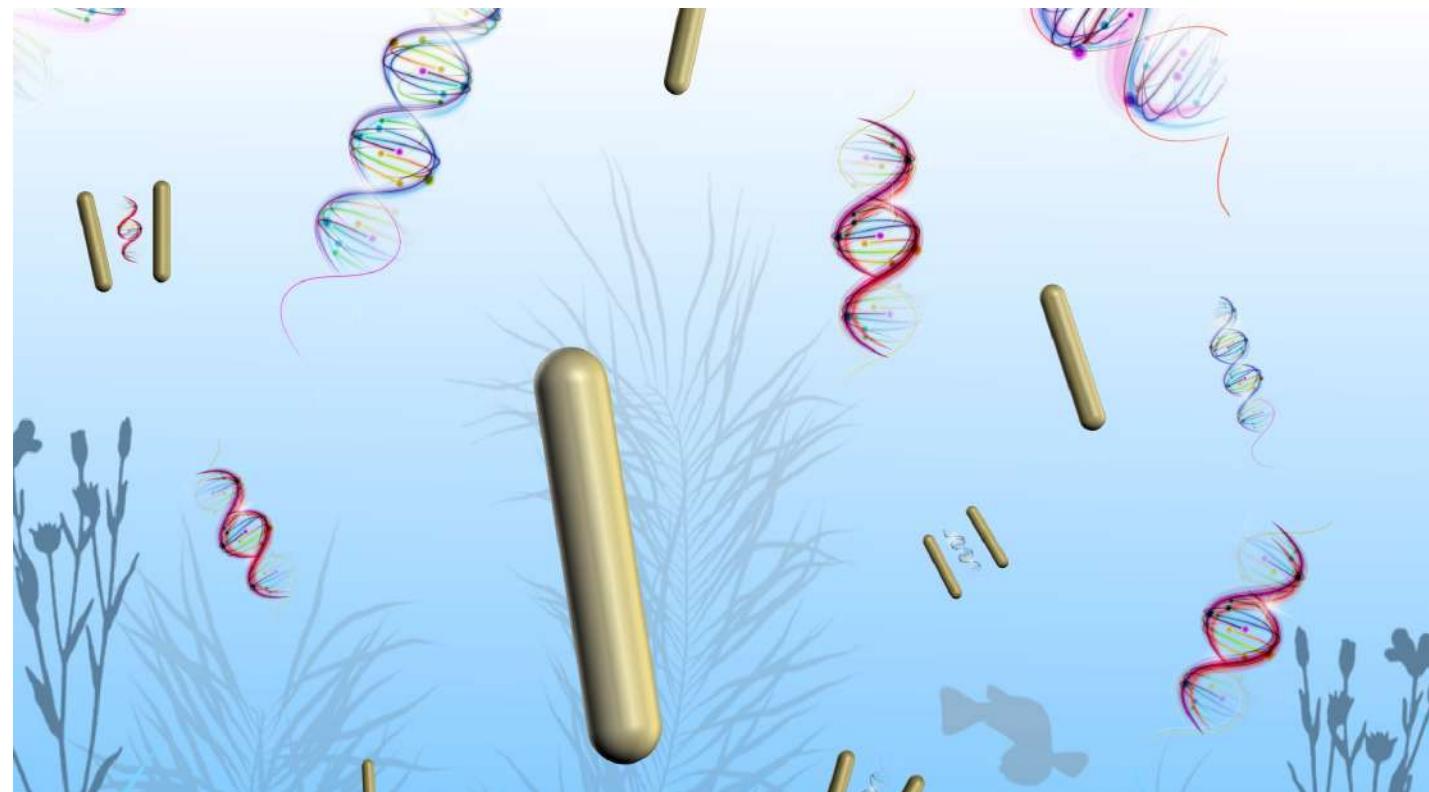
A plasmonic nanosensor with inverse sensitivity for circulating cell-free DNA quantification



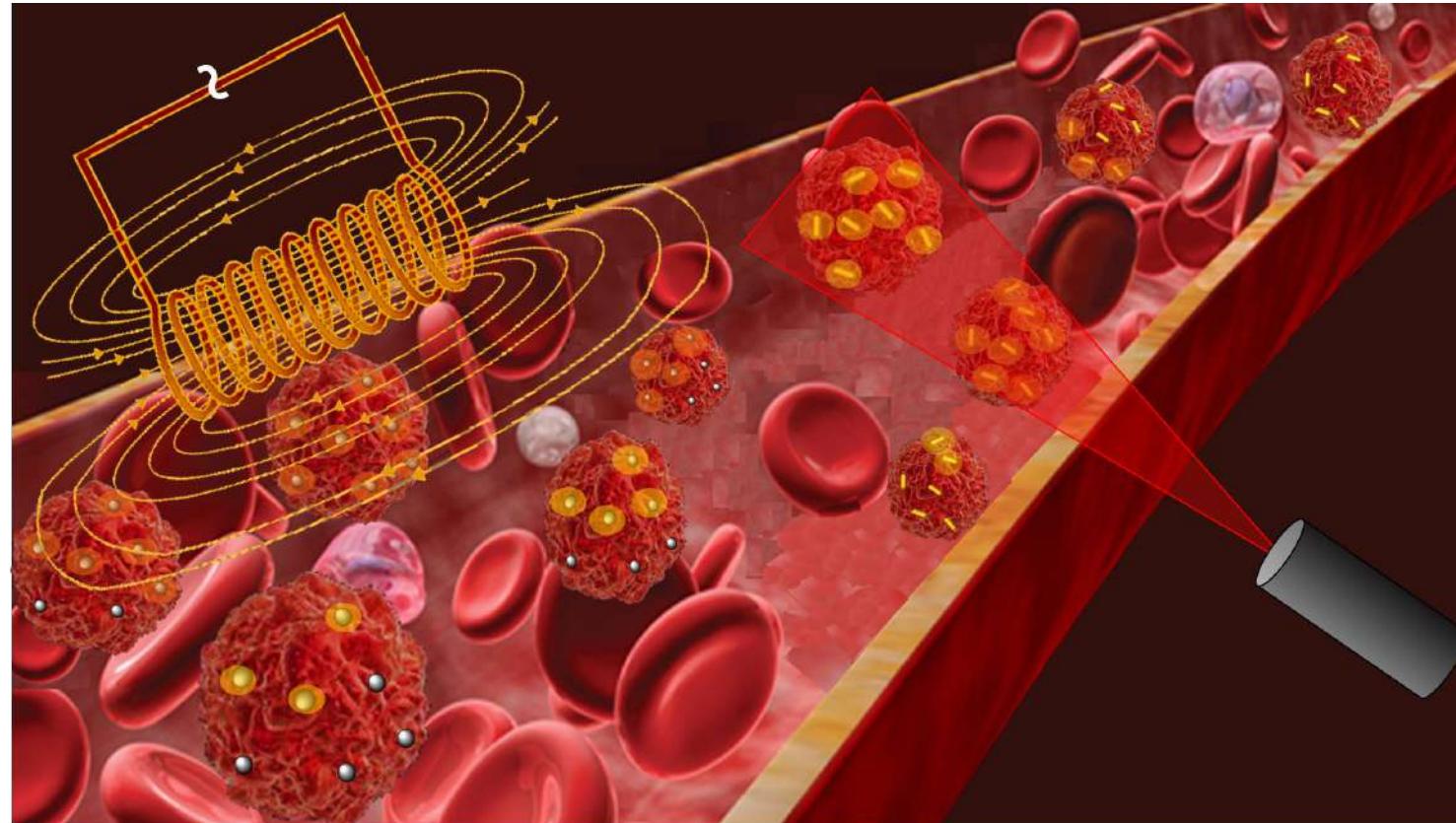
The inverse
sensitivity: the
lower the analyte
concentration,
the higher the
response
intensity

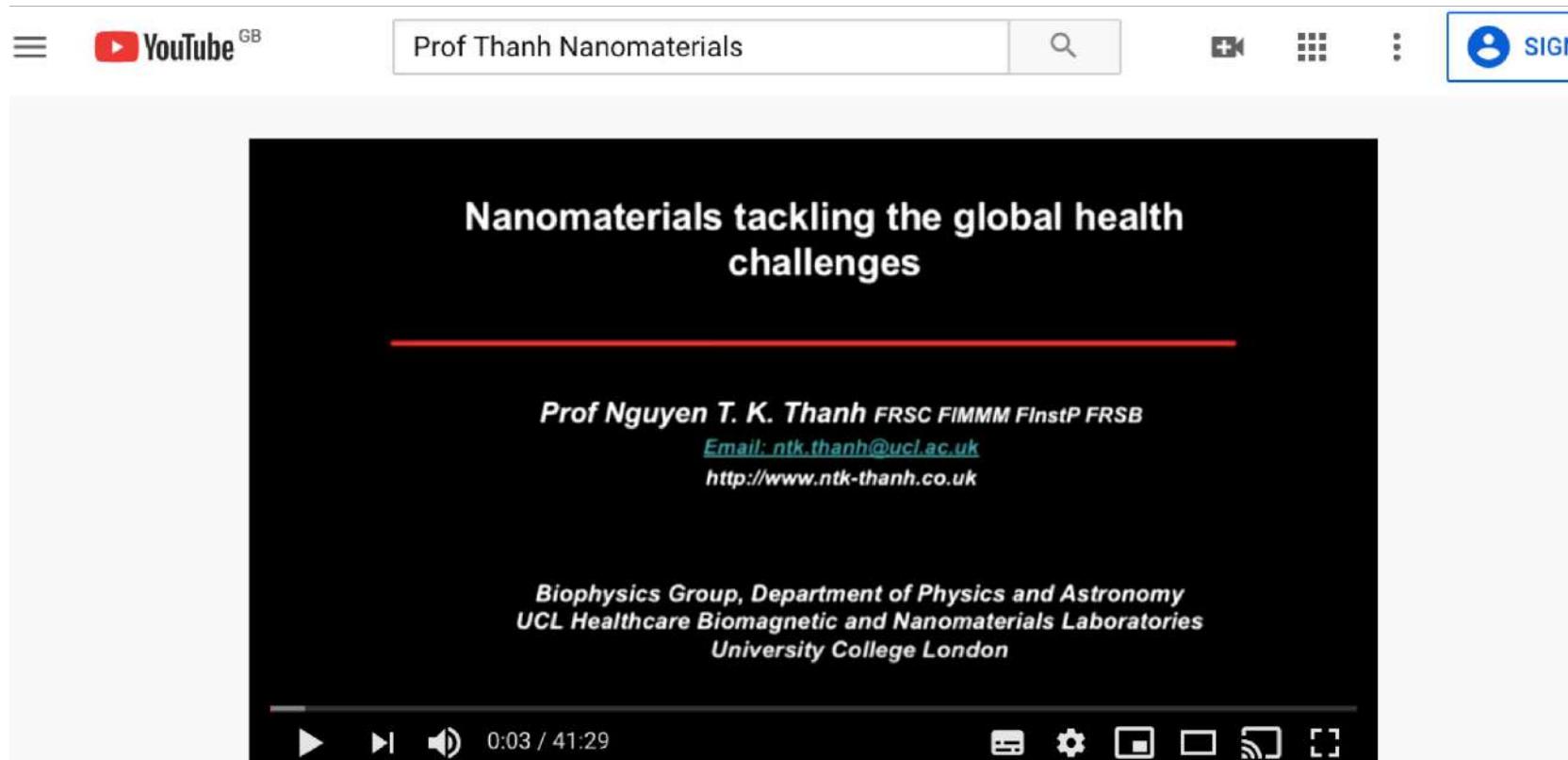
- 0.2 to 100 nM
DNA

Tunable plasmonic colorimetric assay with inverse sensitivity for extracellular DNA quantification



Nanoparticles based Magnetic and Photo induced hyperthermia treatment





The image shows a YouTube video player interface. At the top, there is a navigation bar with a menu icon, the YouTube logo, a search bar containing the text "Prof Thanh Nanomaterials", a magnifying glass icon, and other video controls. On the right side of the bar are icons for signing in and more options. Below the navigation bar is a large black rectangular video frame. Inside the frame, the title "Nanomaterials tackling the global health challenges" is displayed in white text. Below the title is a horizontal red line. Underneath the line, the speaker's information is shown: "Prof Nguyen T. K. Thanh FRSC FIMMM FInstP FRSB", "Email: ntk.thanh@ucl.ac.uk", and "http://www.ntk-thanh.co.uk". At the bottom of the video frame, there is a progress bar showing the video is at 0:03 / 41:29, and a row of video control icons (play, pause, volume, etc.).

#ucllh1

Lunch Hour Lecture - Nanomaterials tackling the global health challenges - Professor Thanh



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☰ YouTube GB Prof Thanh Nanomaterials



#ucllh1

Lunch Hour Lecture - Nanomaterials tackling the global health challenges - Professor Thanh

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Nanomaterials from bench to bedside

Prize lecture

Event video



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Magnetic Nanoparticles (2024) Ed López-Ortega, A., and Roca, A. G. Editor-in-chief **Thanh, N. T. K.**
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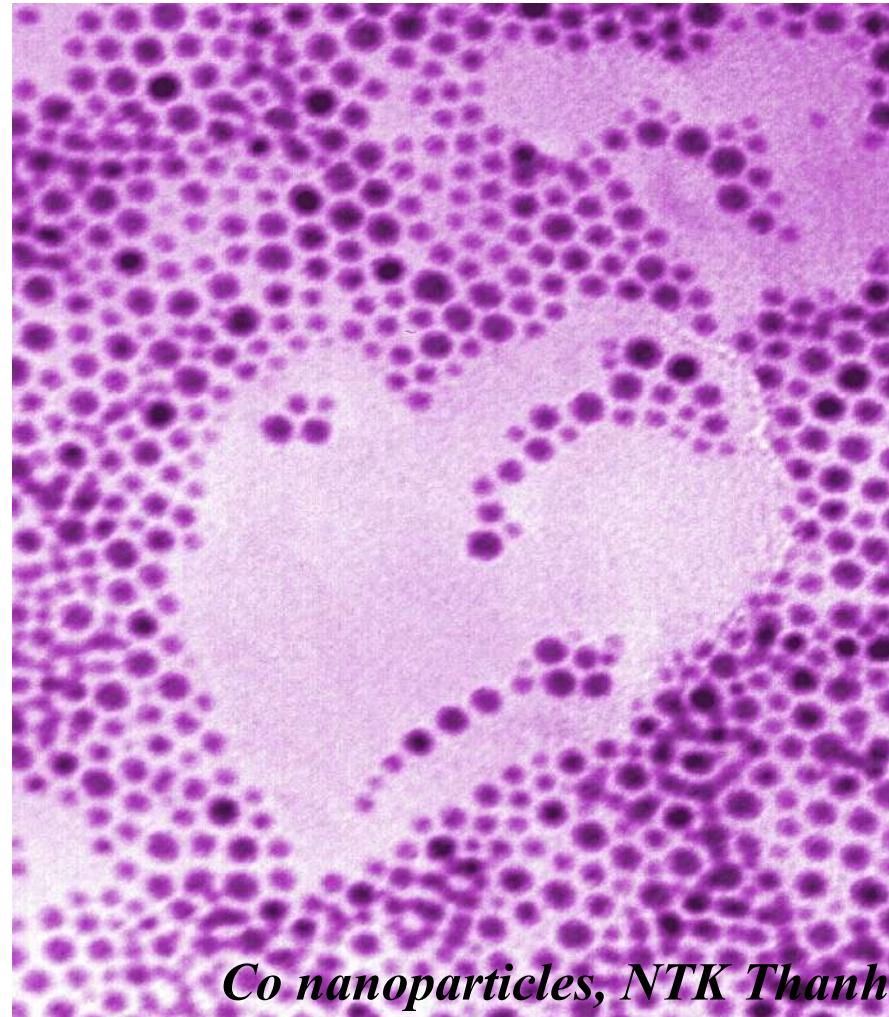
rsc.li/nanoscience

Thanks to



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Co nanoparticles, NTK Thanh

Thank you for your attention!



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