Synthesis and Characterization of Hybrid Nanoparticles for Biomedical and Environmental Remediation Applications

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6th International Conference and Exhibition on Materials Science and Engineering

9/13/2016



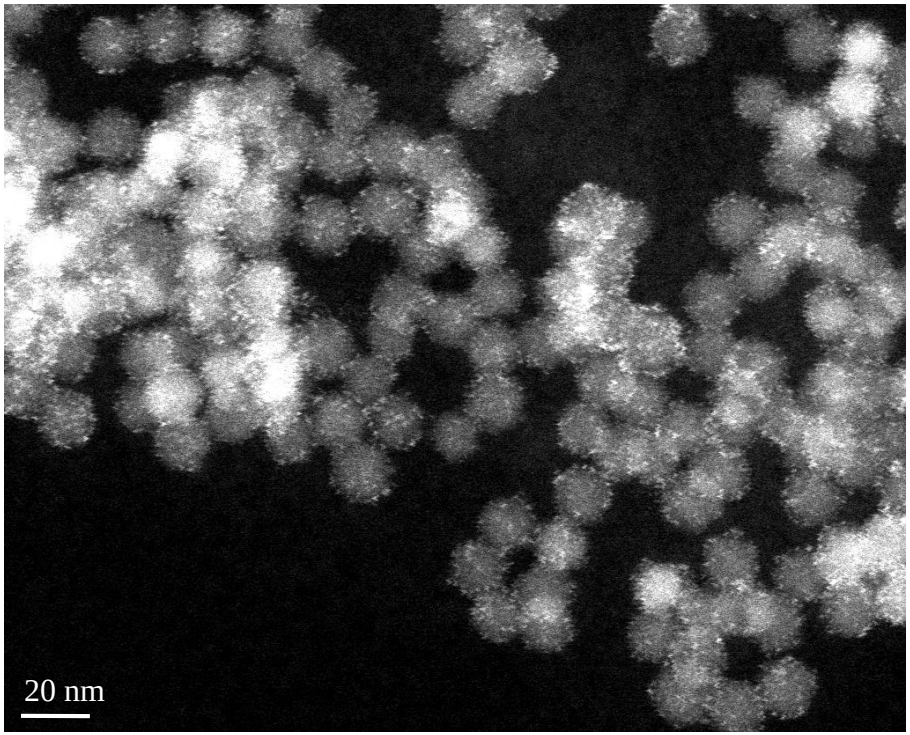
Outline

Platinum Decorated Iron Oxide Nanoparticles for Biomedical Applications

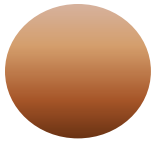
New Materials for Oil Spill Remediation

- Motivation
- Research
- Conclusion

Platinum Decorated Iron Oxide Nanoparticles for Biomedical Applications

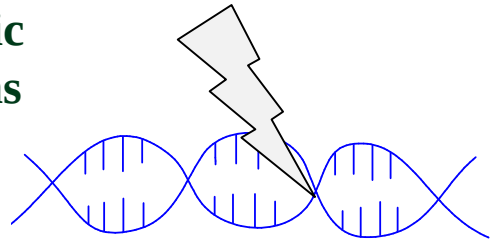


Motivation

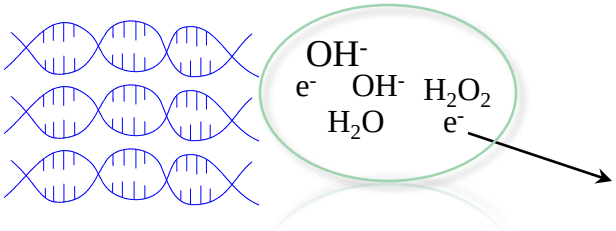


Pt nanoparticle

Therapeutic applications



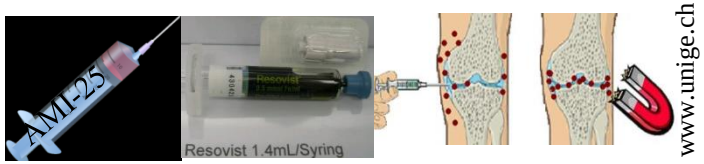
DNA damage, DNA dissociation, nanomedicine for antitumor treatment



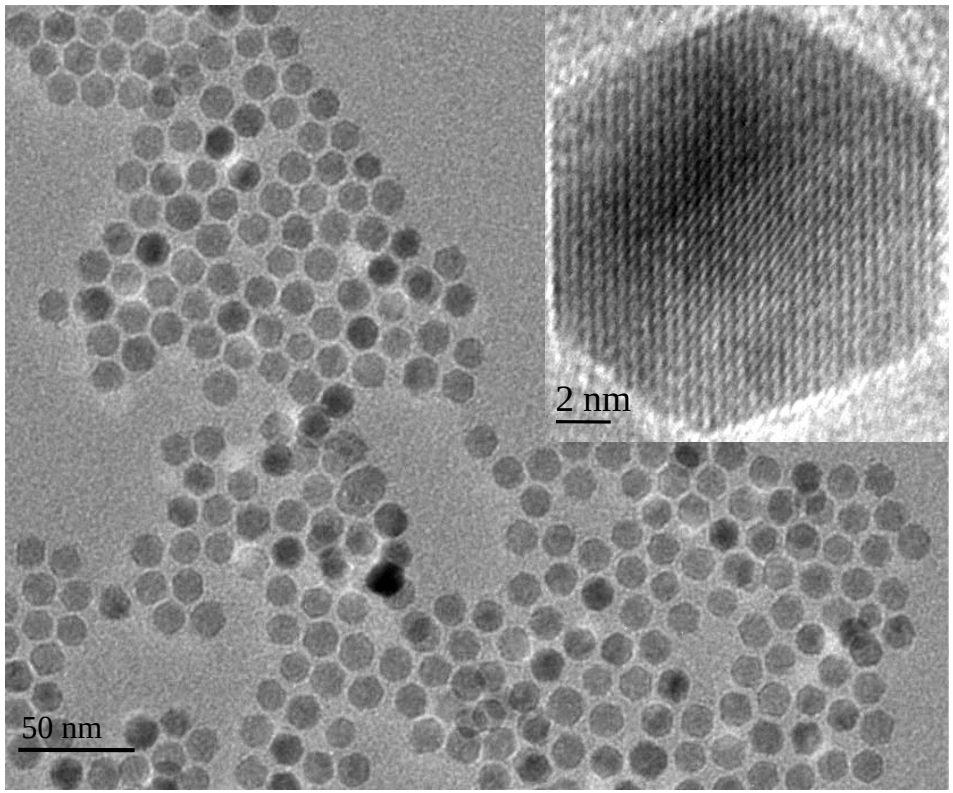
Free radical scavenging activity for oxidative stress disease

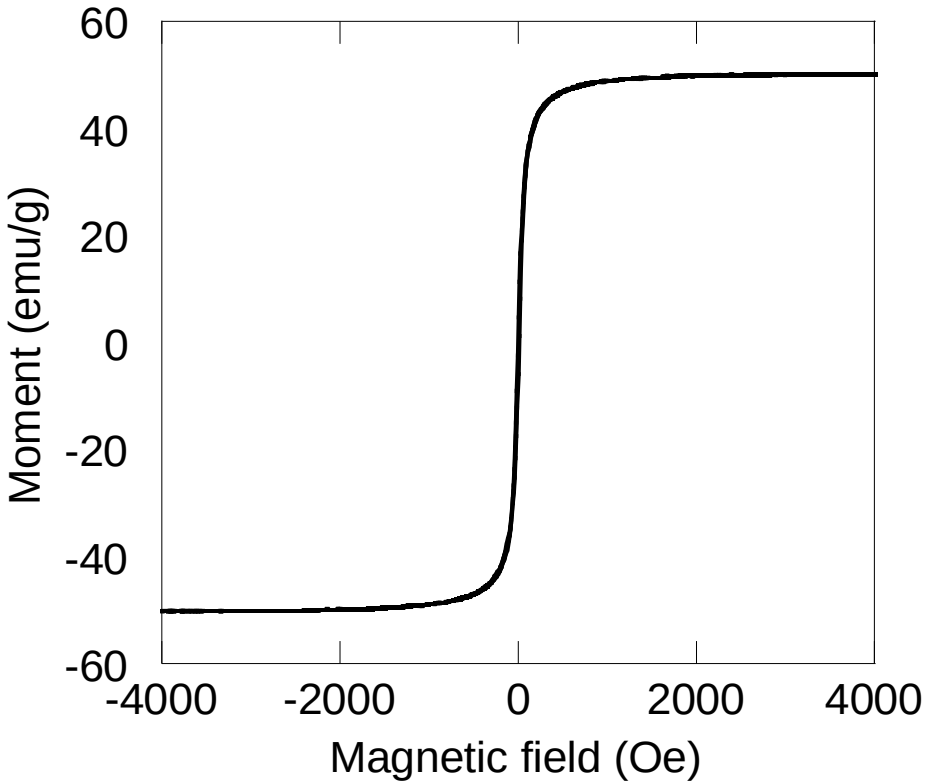
Potential problem: Aggregation of small Pt nanoparticles

Iron oxide support

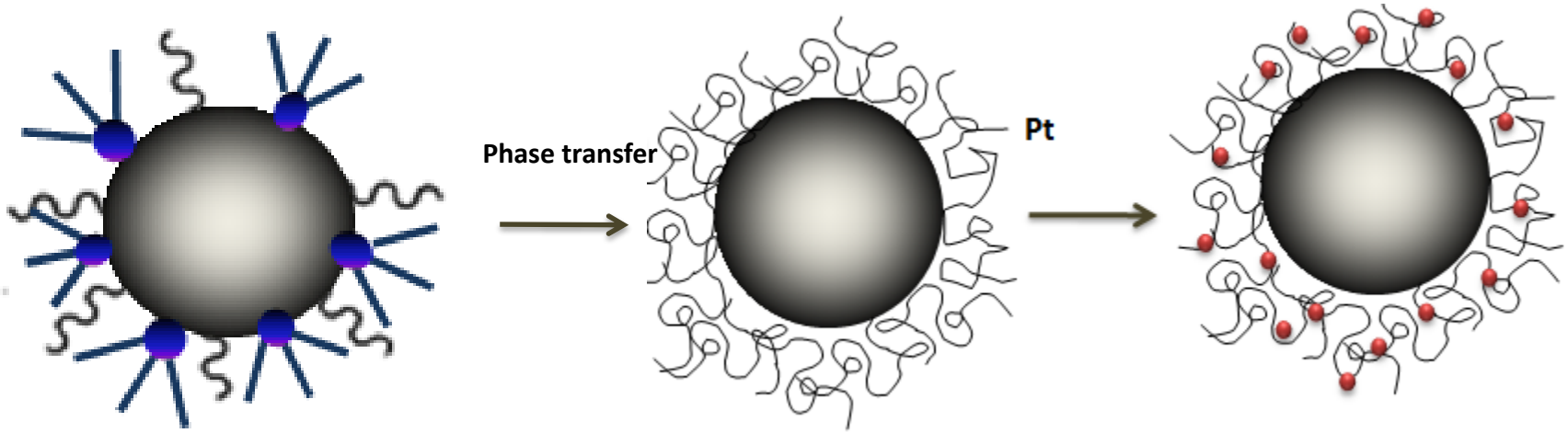


Iron Oxide Nanoparticles: Modified “Heat-Up” Method





Approach for Multiple Pt Attachment: Aqueous Phase

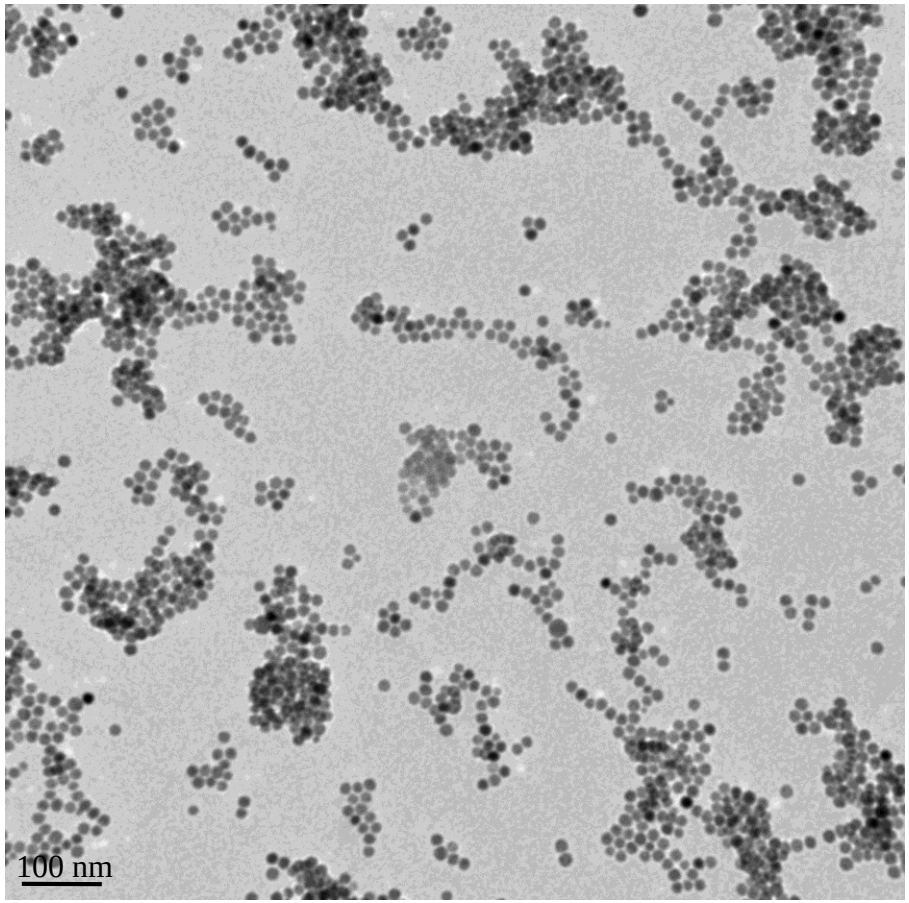


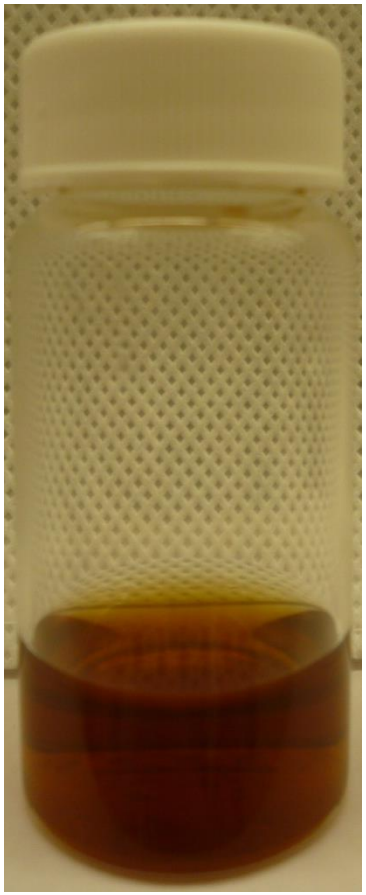
Iron oxide Nanoparticle

- Biocompatible ligand: Polyacrylic acid (PAA, M_w 100,000)
- Platinum salt: Chloroplatinic acid (H_2PtCl_6)
- Reducing agent: Ultraviolet radiation (UV)
- Solvent: Water

Xu, Y.; Qin, Y.; **Palchoudhury, S**.; Bao, Y. Water-soluble iron oxide nanoparticles with high stability and selective surface functionality. Langmuir, 2011, 27, 8990-8997.

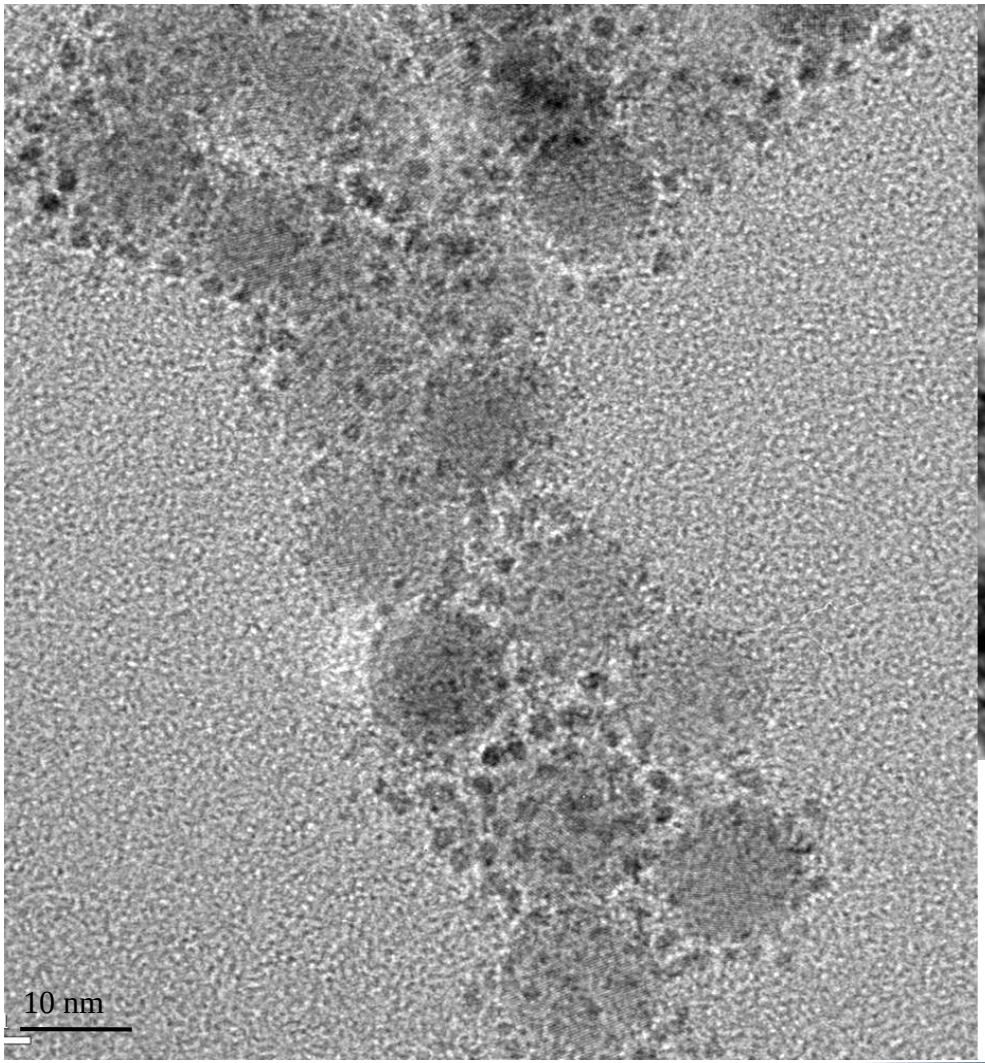
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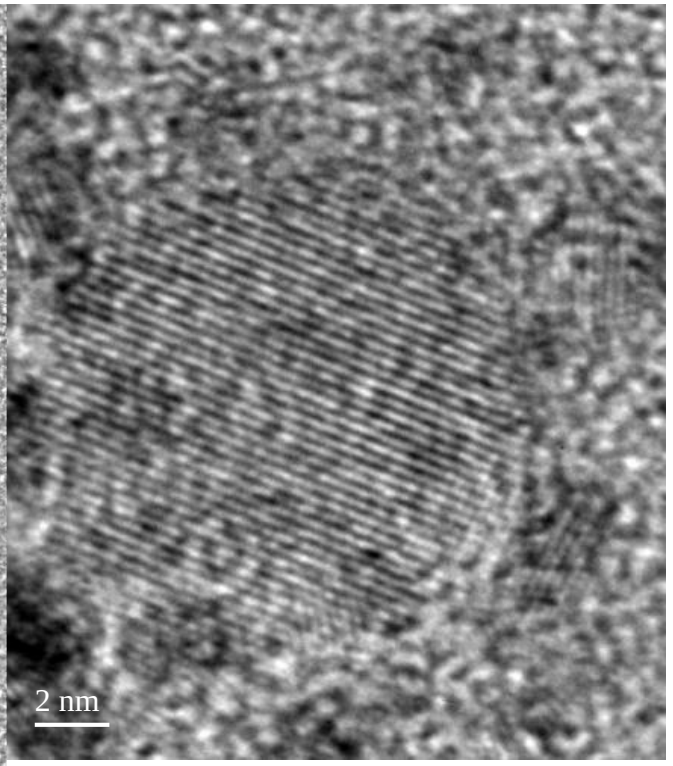




Xu, Y.; Qin, Y.; **Palchoudhury, S**.; Bao, Y. Water-soluble iron oxide nanoparticles with high stability and selective surface functionality. Langmuir, 2011, 27, 8990-8997.

Pt-Attached Iron Oxide Nanoparticles : Aqueous Phase

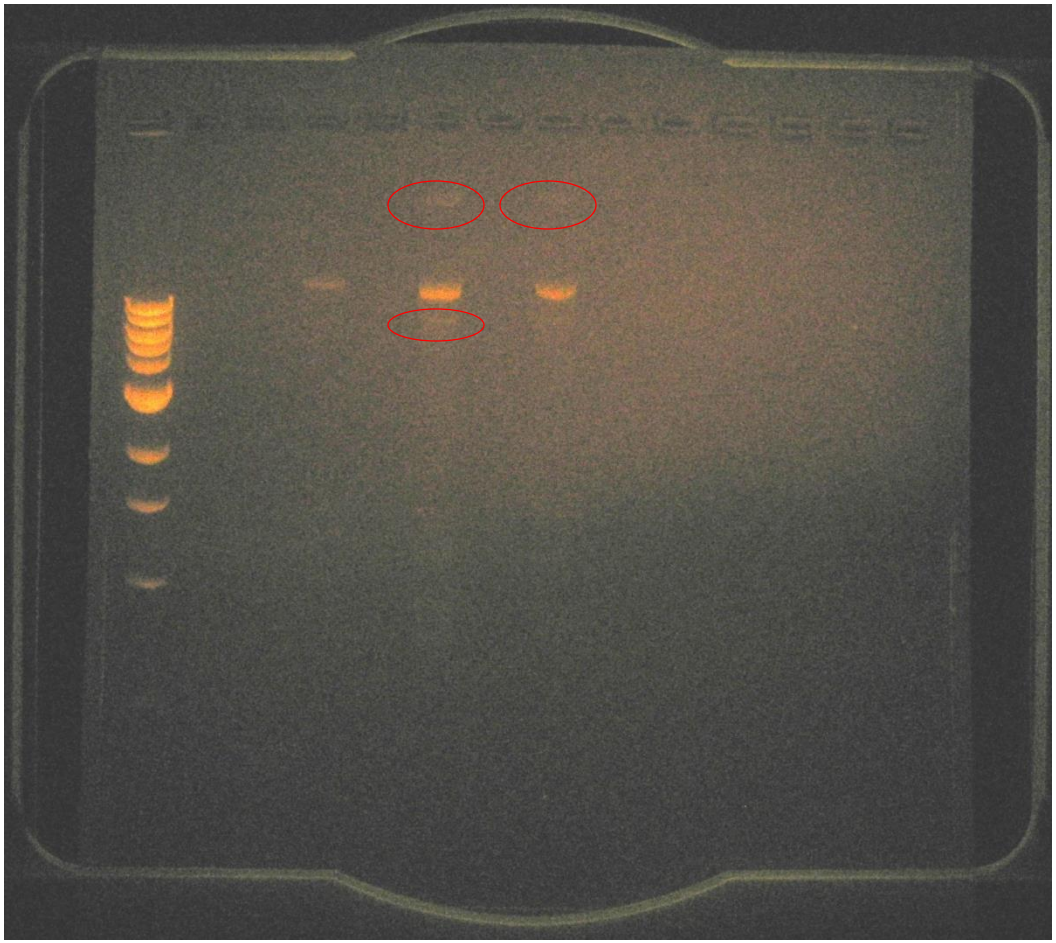




Palchoudhury, S.; Xu, Y.; Goodwin, J.; Bao, Y. Synthesis of multiple platinum attached iron oxide nanoparticles. J. Mater. Chem. 2011, 21, 3966-3970.

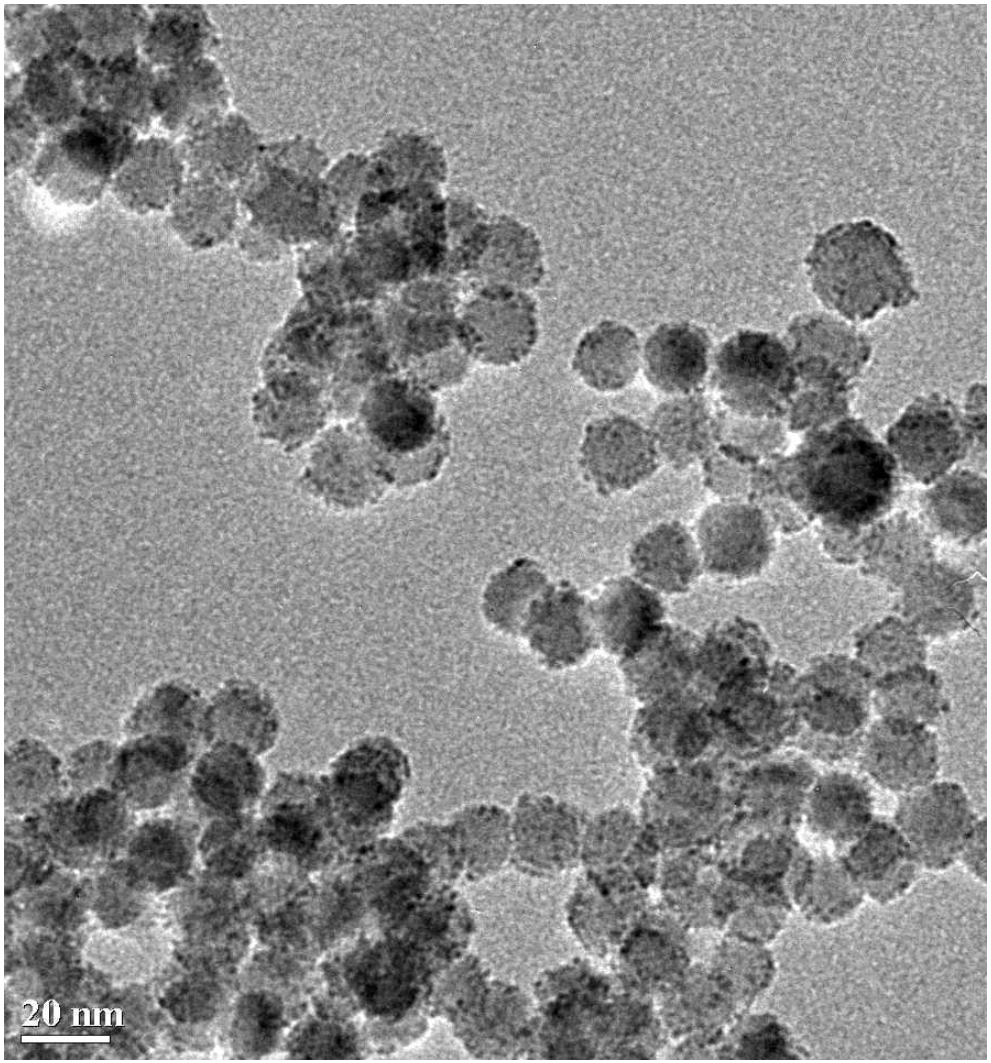
DNA Interaction: Gel Electrophoresis

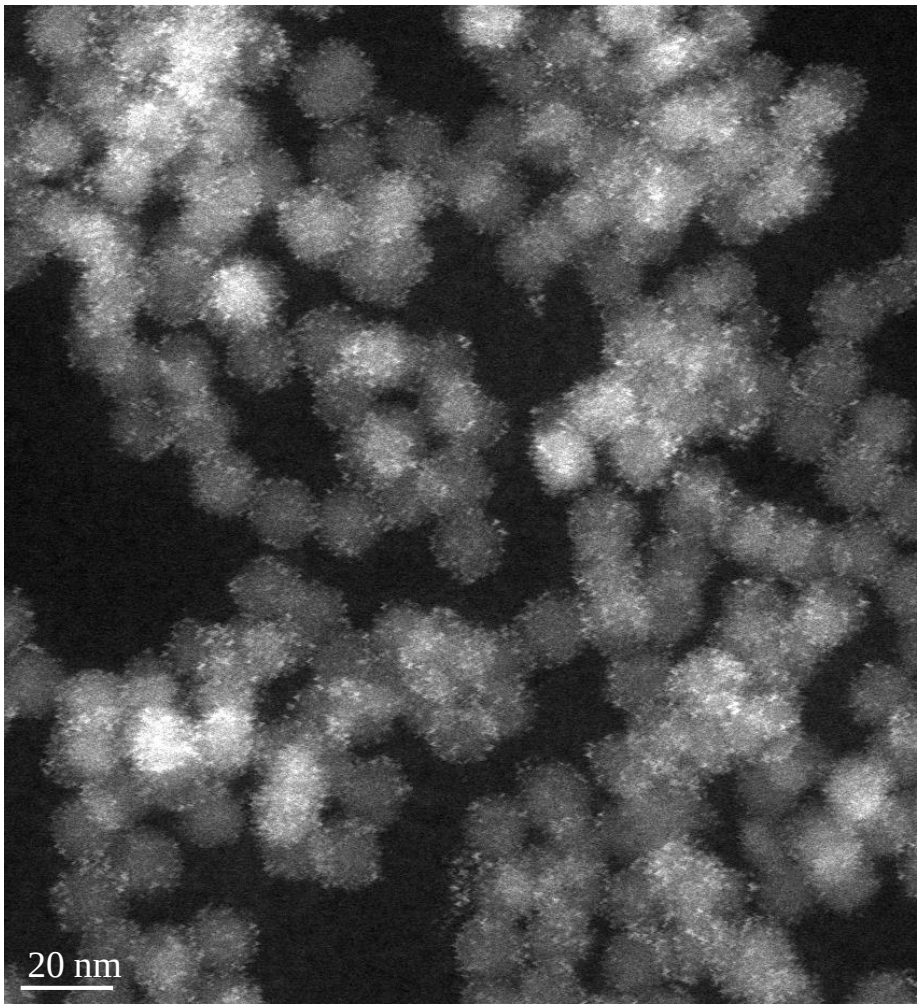
Ladder | Control DNA | NP-DNA (4 h) | NP-DNA (30 min)



Palchoudhury, S.; Xu, Y.; Rushdie, A.; Bao, Y. DNA interaction of multiple Pt attached iron oxide nanoparticles. IEEE Trans. Magnetics 2013.

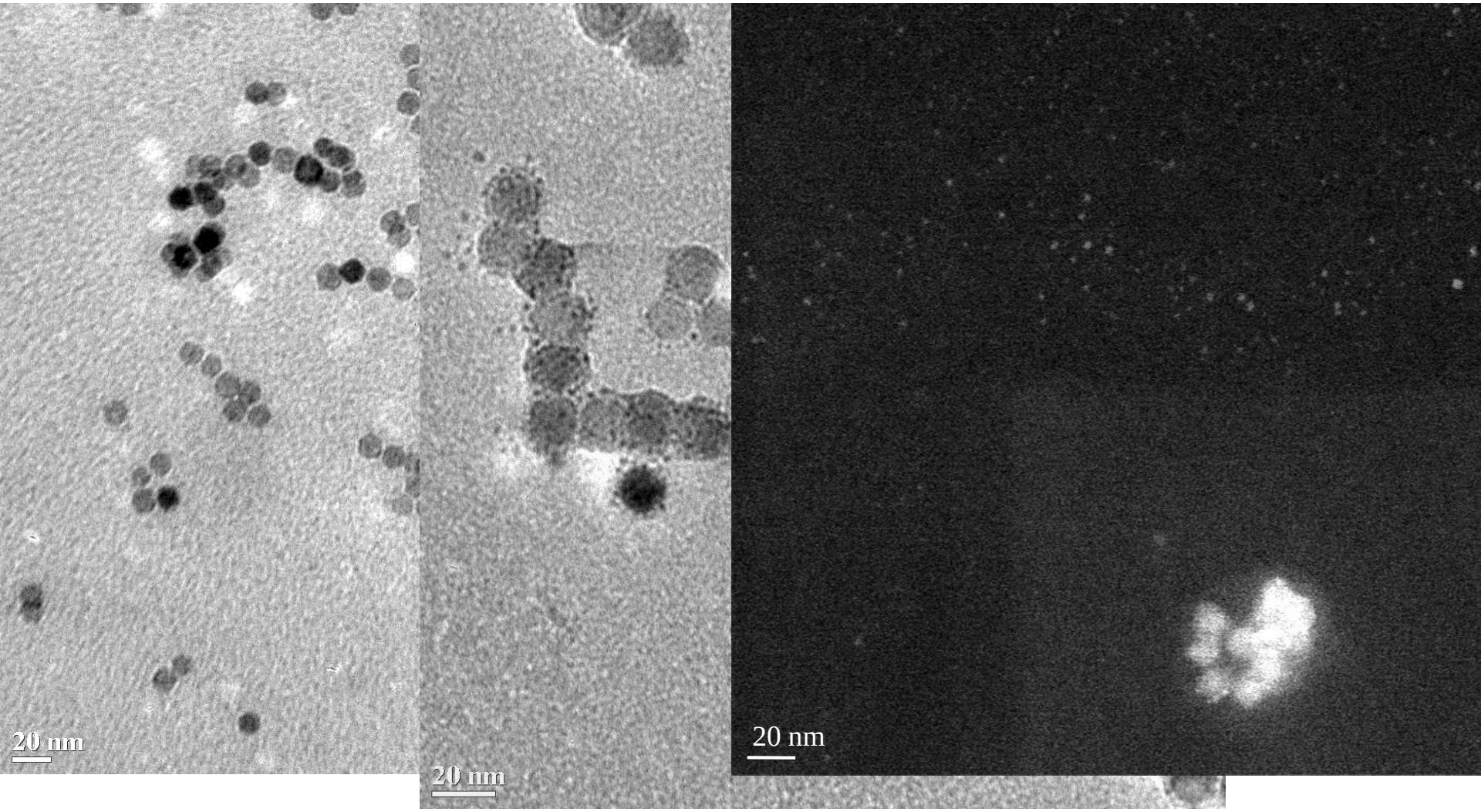
DNA Interaction: Transmission Electron Microscopy





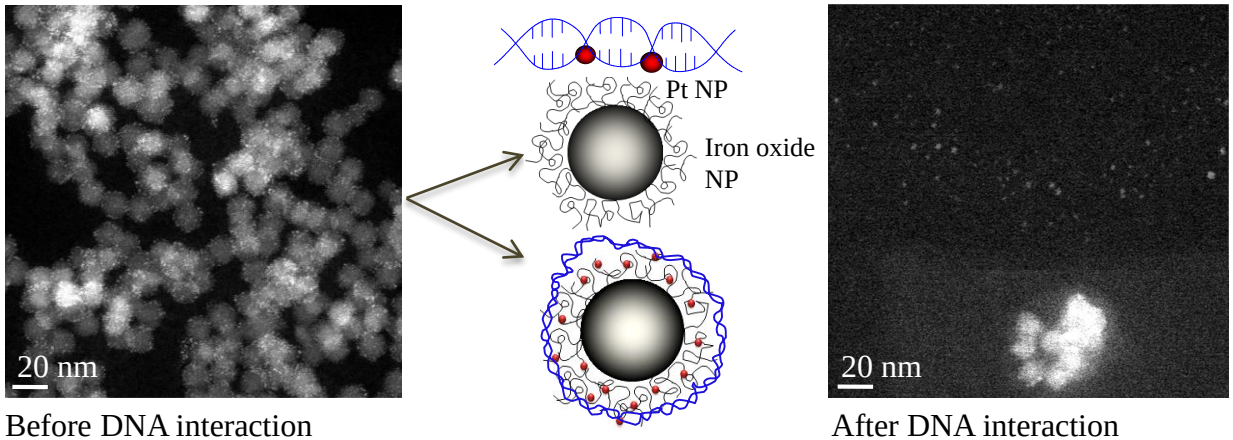
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DNA Interaction: Transmission Electron Microscopy



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DNA Interaction of Pt-Attached Iron Oxide Nanoparticles



Before DNA interaction

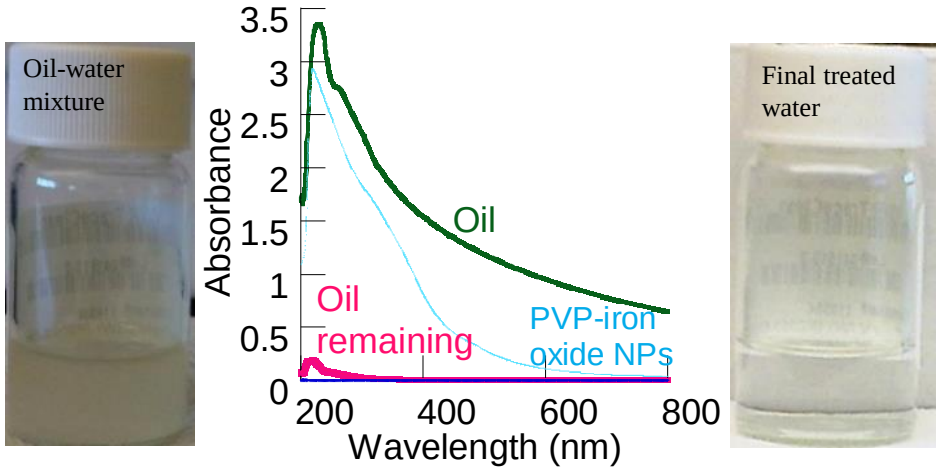
After DNA interaction

Palchoudhury, S.; Xu, Y.; Rushdie, A.; Bao, Y. DNA interaction of multiple Pt attached iron oxide nanoparticles. IEEE Trans. Magnetics 2013.

Conclusion

- Monodisperse and shape-controlled iron oxide nanoparticles using “modified heat-up” method
- Pt-attached iron oxide nanoparticles
- Successful demonstration of DNA interaction of Pt-iron oxide nanoparticles
- **Future Work: New therapeutics**

New Materials for Oil Spill Remediation



Oil removal with magnetic nanoparticles

Motivation





- **Catastrophic oil spills (e.g., Exxon Valdez (1989), MC252 (BP, 2010))**
- **Cause huge environmental concern**

Deepwater Horizon Disaster, *Nature*, Image credit: Daniel Beltra/Greenpeace; Wikipedia; www.theguardian.com

Motivation

- **Limitations of current oil remediation routes**



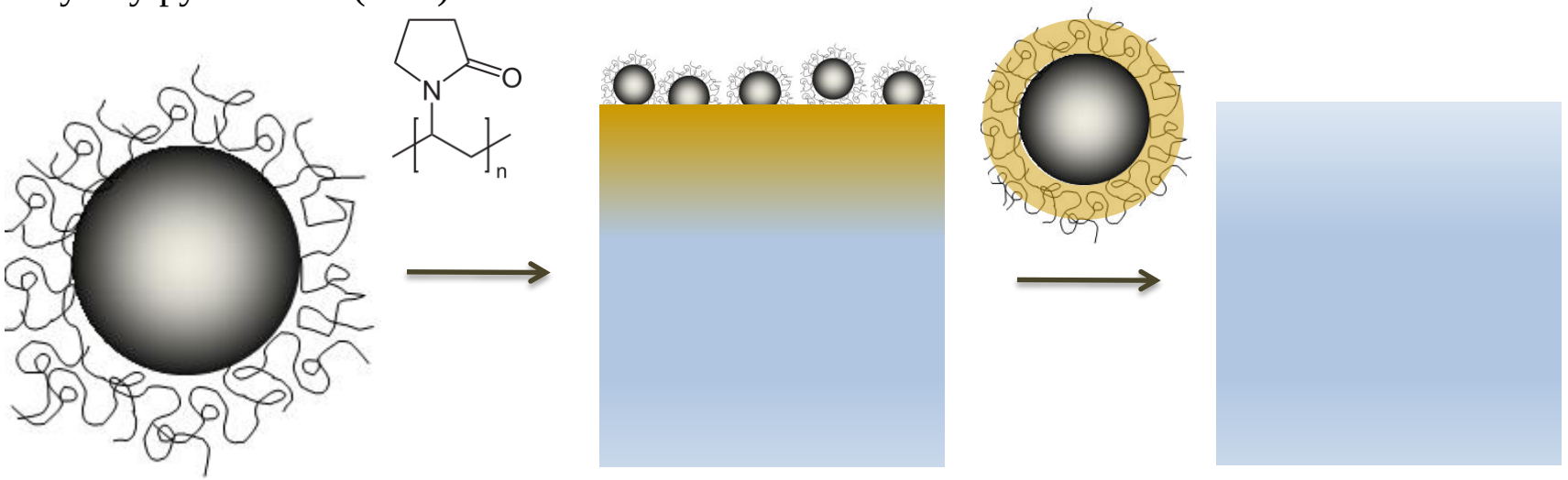




www.theguardian.com
www.cleveland.com
National Geography

Hypothesis

Polyvinylpyrrolidone (PVP)



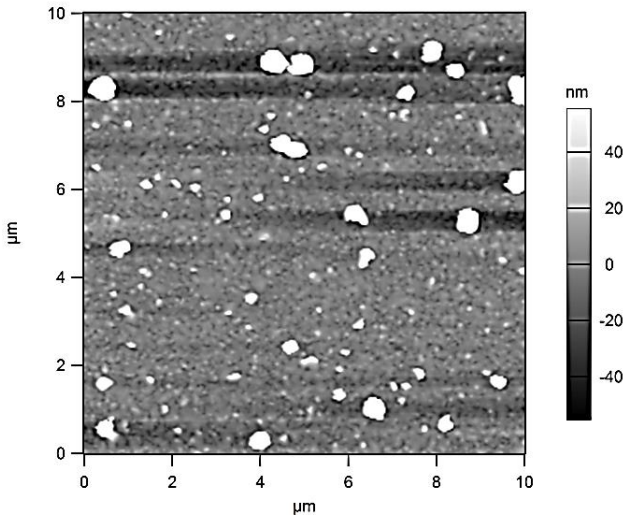
Hydrophilic iron oxide nanoparticles

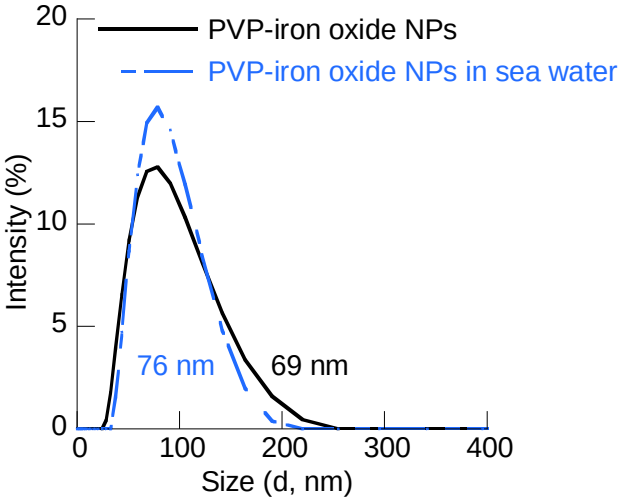
Oil spill

Clean water

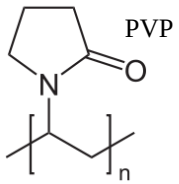
Palchoudhury, S.; Lead, J. A facile and cost-effective method for separation of oil-water mixtures using polymer-coated iron oxide nanoparticles. *Environ. Sci. Technol.*, 2014.

Polyvinylpyrrolidone-Coated Magnetic Nanoparticles



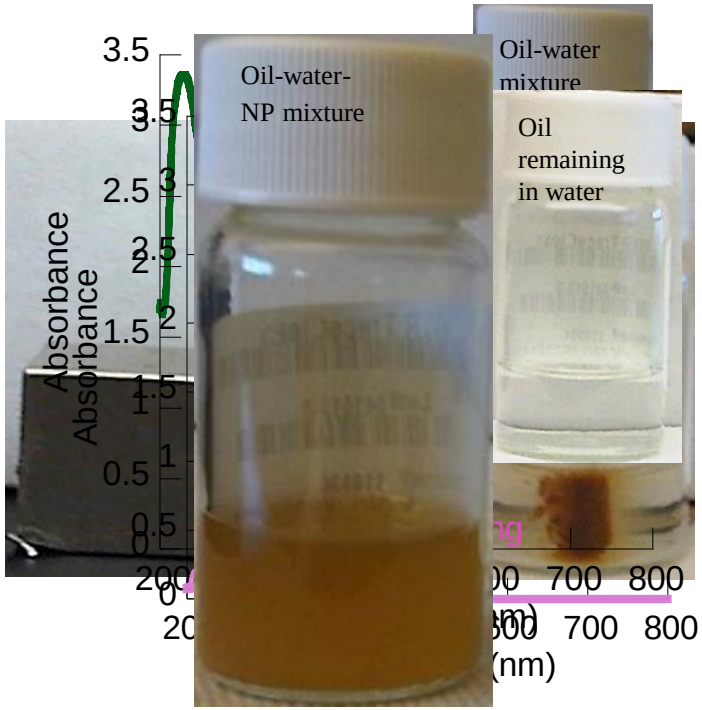


- Water-soluble iron oxide nanoparticles synthesized in one-step using “modified polyol method”
- Solvent: Triethyleneglycol (TREG)
- Capping agent: Polyvinylpyrrolidone (PVP)
- Precursor: Iron (III) acetylacetonate
- Reaction temperature: 260 °C



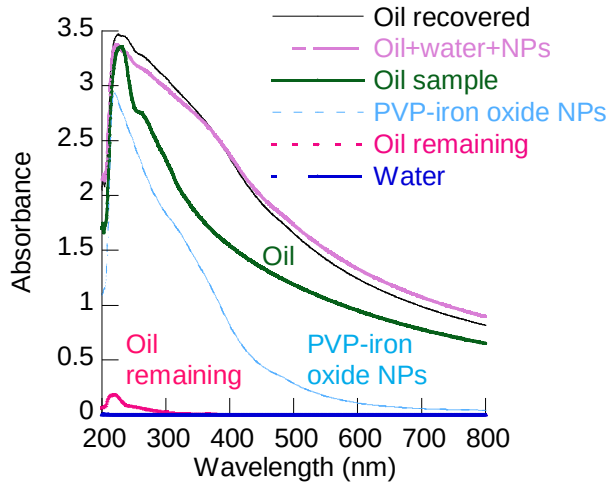
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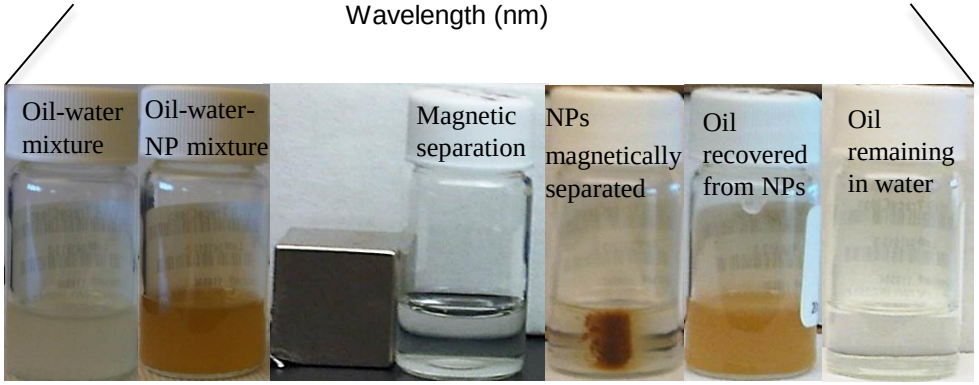
Analyzing the Oil-Water Separation via UV-vis Spectroscopy



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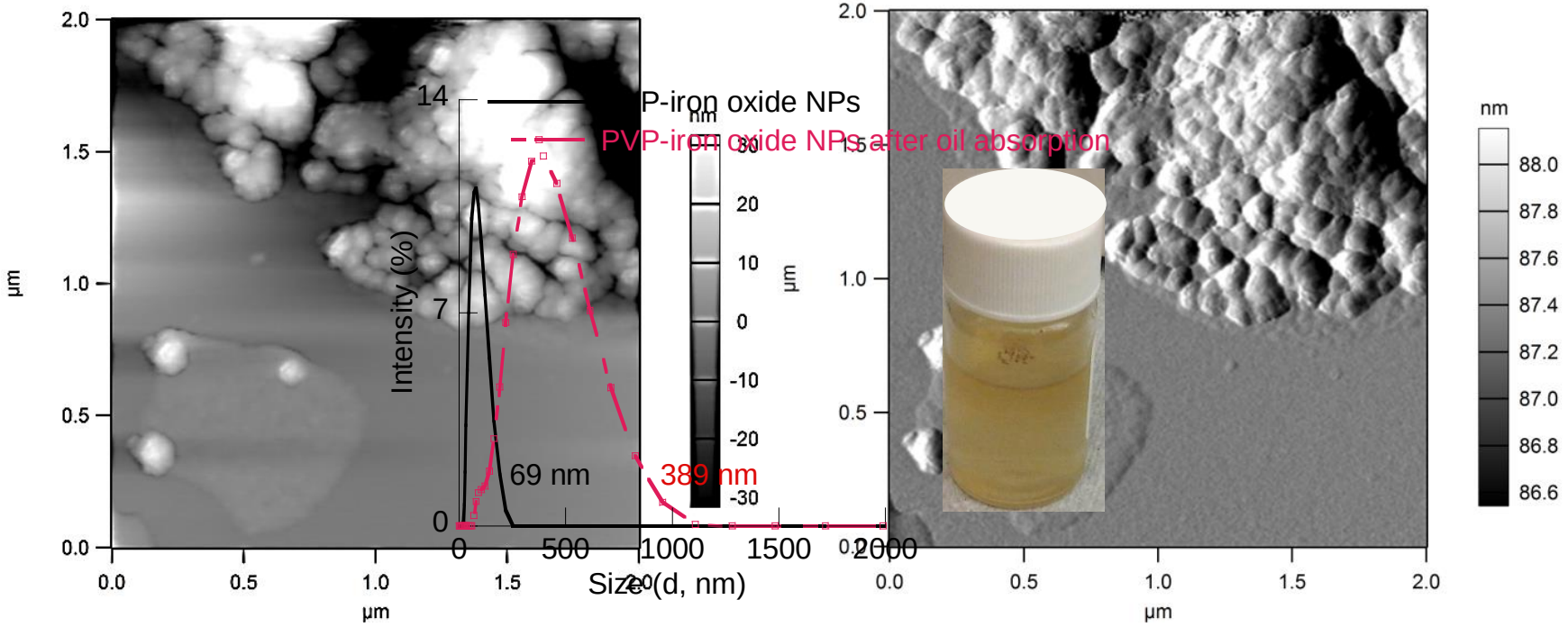




- Deepwater Horizon oil sample used
- Near 100 % oil removal in 12 h

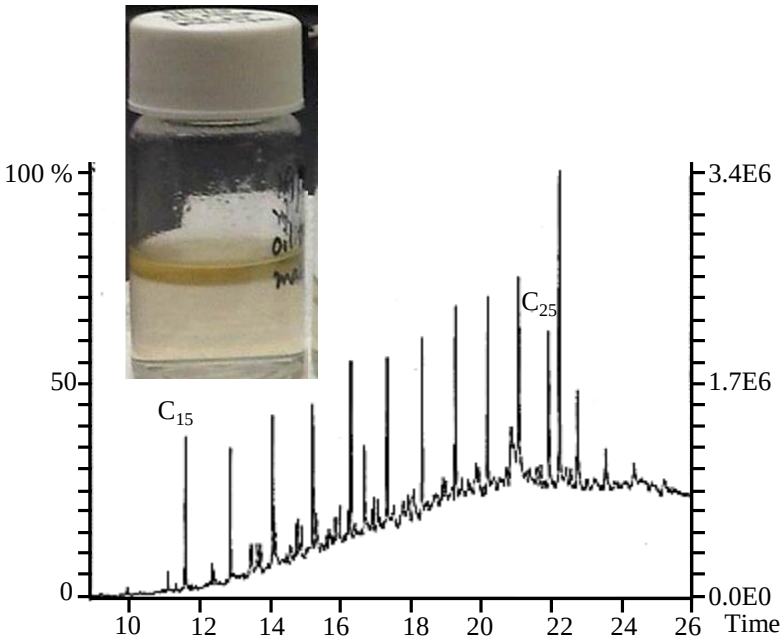
Palchoudhury, S.; Lead, J. A facile and cost-effective method for separation of oil-water mixtures using polymer-coated iron oxide nanoparticles. *Environ. Sci. Technol.*, 2014.

Oil-Coated Iron Oxide Nanoparticles: Characterization

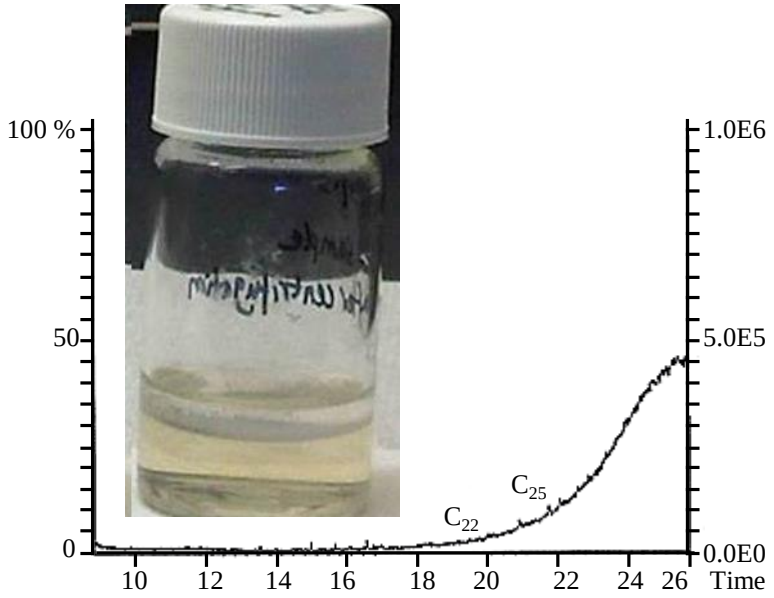


Palchoudhury, S.; Lead, J. A facile and cost-effective method for separation of oil-water mixtures using polymer-coated iron oxide nanoparticles. *Environ. Sci. Technol.*, 2014.

Gas Chromatography-Mass Spectroscopy Analysis



Crude oil sample



Sample after treatment with nanoparticles

Palchoudhury, S.; Lead, J. A facile and cost-effective method for separation of oil-water mixtures using polymer-coated iron oxide nanoparticles. *Environ. Sci. Technol.*, 2014.

Conclusion

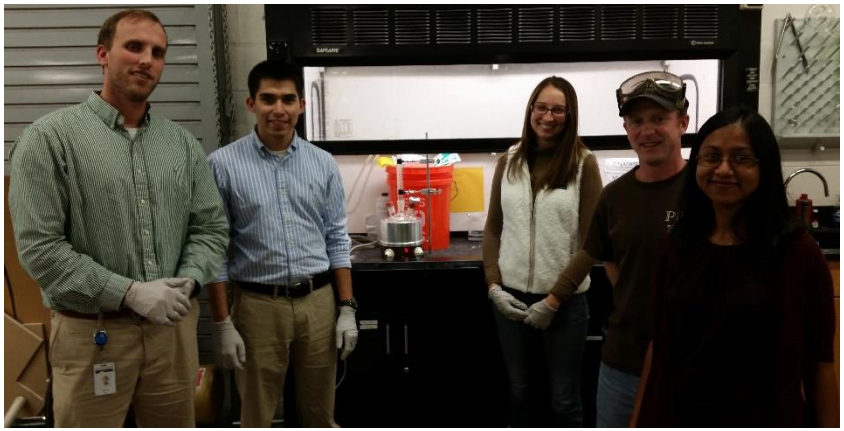
- Near 100% separation of BP crude oil-water mixture using PVP-iron oxide nanoparticles
- Nanoparticles absorbed ~178 times their own volume of oil
- Easy scale-up, cost-effective, and environment-friendly
- Future Work: **Practical application in remediation**

ACKNOWLEDGEMENTS

Collaborators:

Prof. Arunava Gupta, MINT Center, The University of Alabama
Prof. Frank Jones, University of Tennessee Chattanooga
Dr. Bryan Ennis, University of Tennessee Chattanooga
Dr. Bradley Harris, University of Tennessee Chattanooga
Dean Daniel Pack, University of Tennessee Chattanooga

Students



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