Functional Nanoparticle-Augmented Surfactant Fluid for Enhanced Oil Recovery in Williston Basin

Presented to Oil & Gas Research Council

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Outline

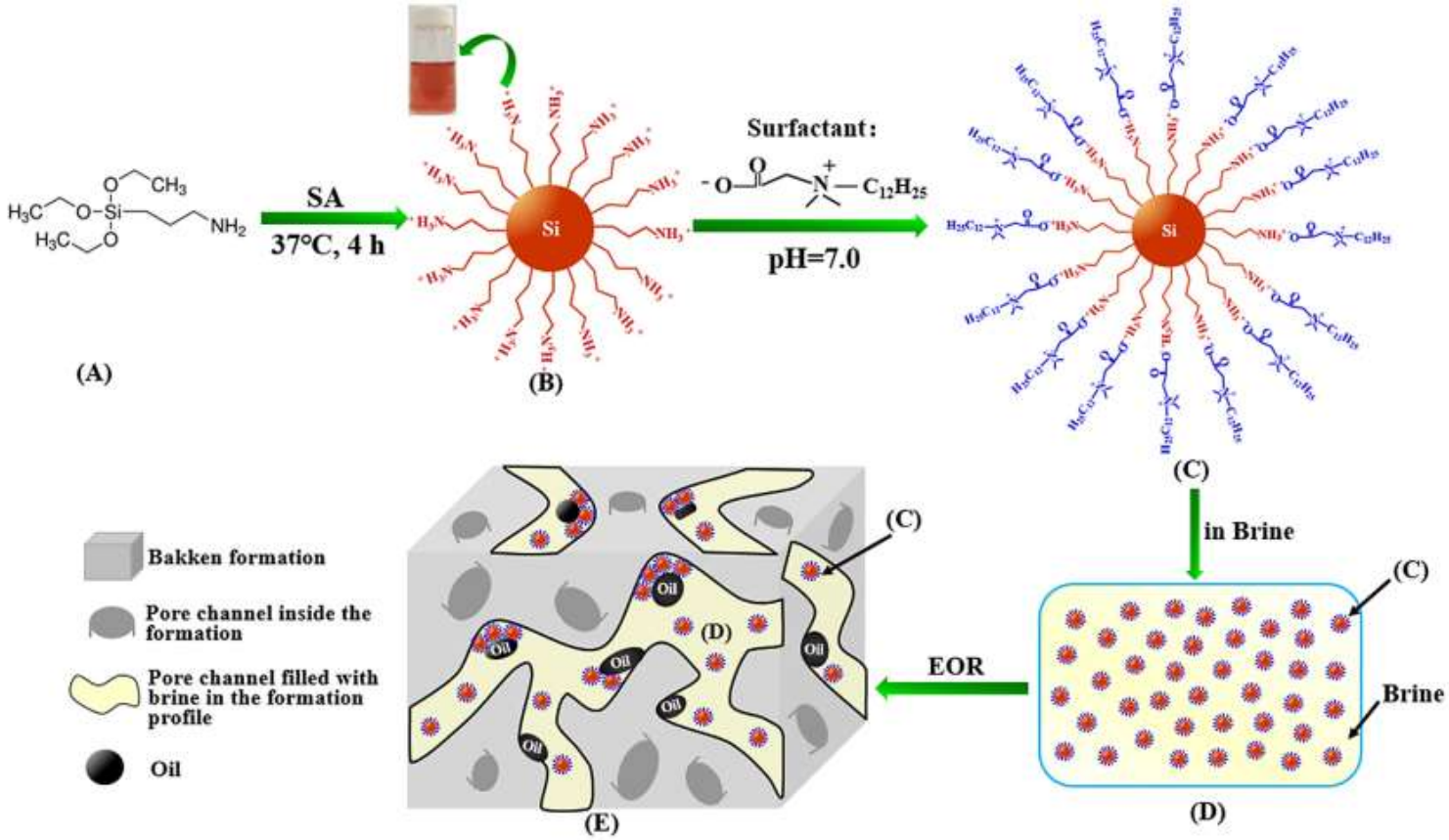
- Nano EOR Highlights
- Research Results
- Conclusions
- Budget
- Publications and Patent
- Team
- Acknowledgement

Nano EOR – Highlights

- **Synthesized three types of nanofluids in UND lab**
  - Silica nanofluid
  - Polymer nanofluid
  - Silicon Quantum Dots (SiQDs) nanofluid
- **Conducted surface modification on commercial nanoparticles (NPs)**
  - SiNPs modified by GLYMO and zwitterionic surfactant
  - SiNPs modified by nonionic surfactant
- **Static adsorption of surfactants on Bakken samples**
- **Experimental and numerical studies of spontaneous imbibition in Bakken samples**
- **Molecular dynamics simulation and numerical simulation studies of NPs and/or Surfactants**

Research Results

Silica Quantum Dots (SiQDs) Nanofluid for EOR



Schematic diagram of the designed nanofluid. (A) APTES. (B) SiQDs. (C) SiQDs-augmented surfactant nano-composite. (D) Nano-fluid prepared by synthetic brine. (E) The application of the nano-fluid on Bakken formation to recover oil.

Research Results

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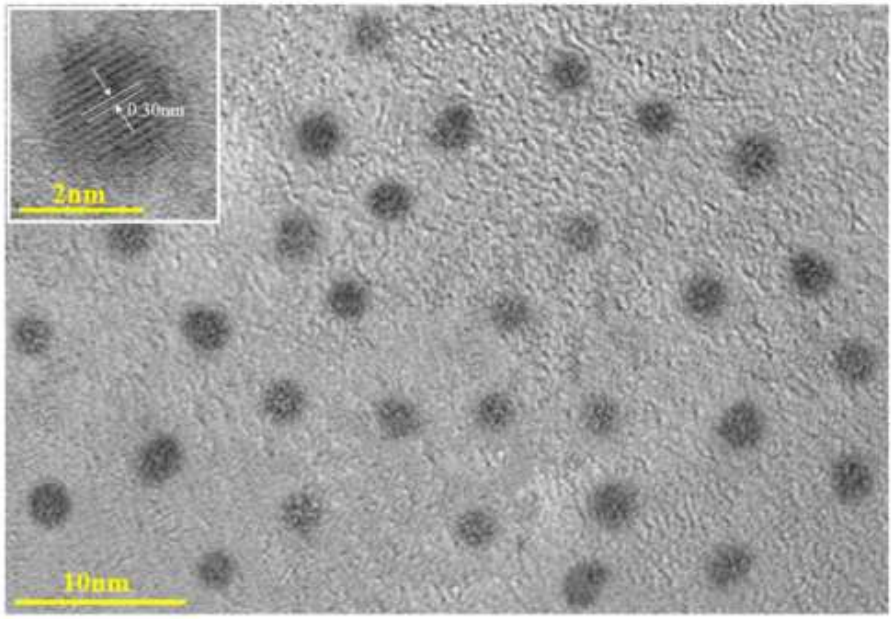
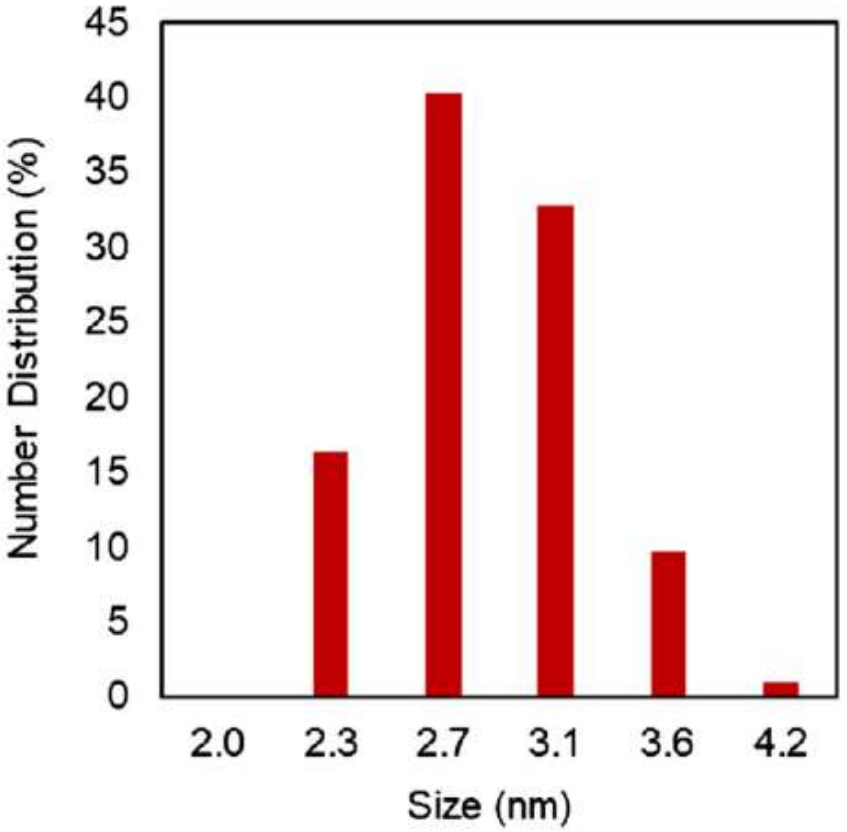


(A)



(B)

Characterization of SiQDs. (A) TEM image of SiQDs; (B) SiQDs size distribution based on the DLS method

Research Results

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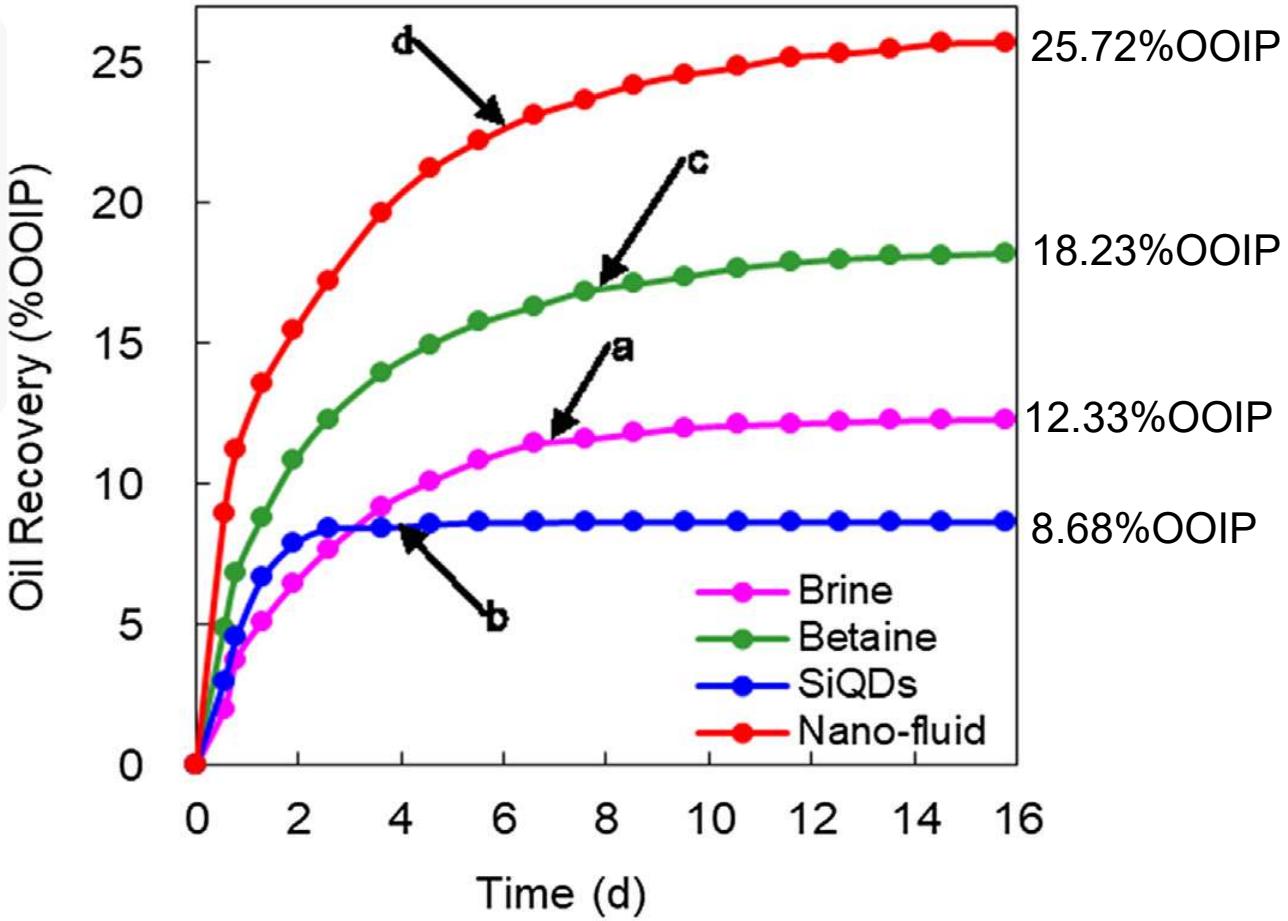
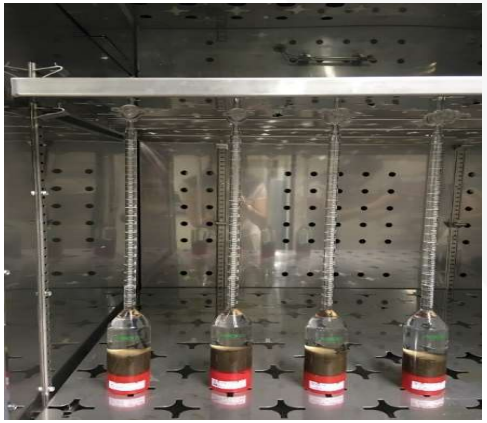


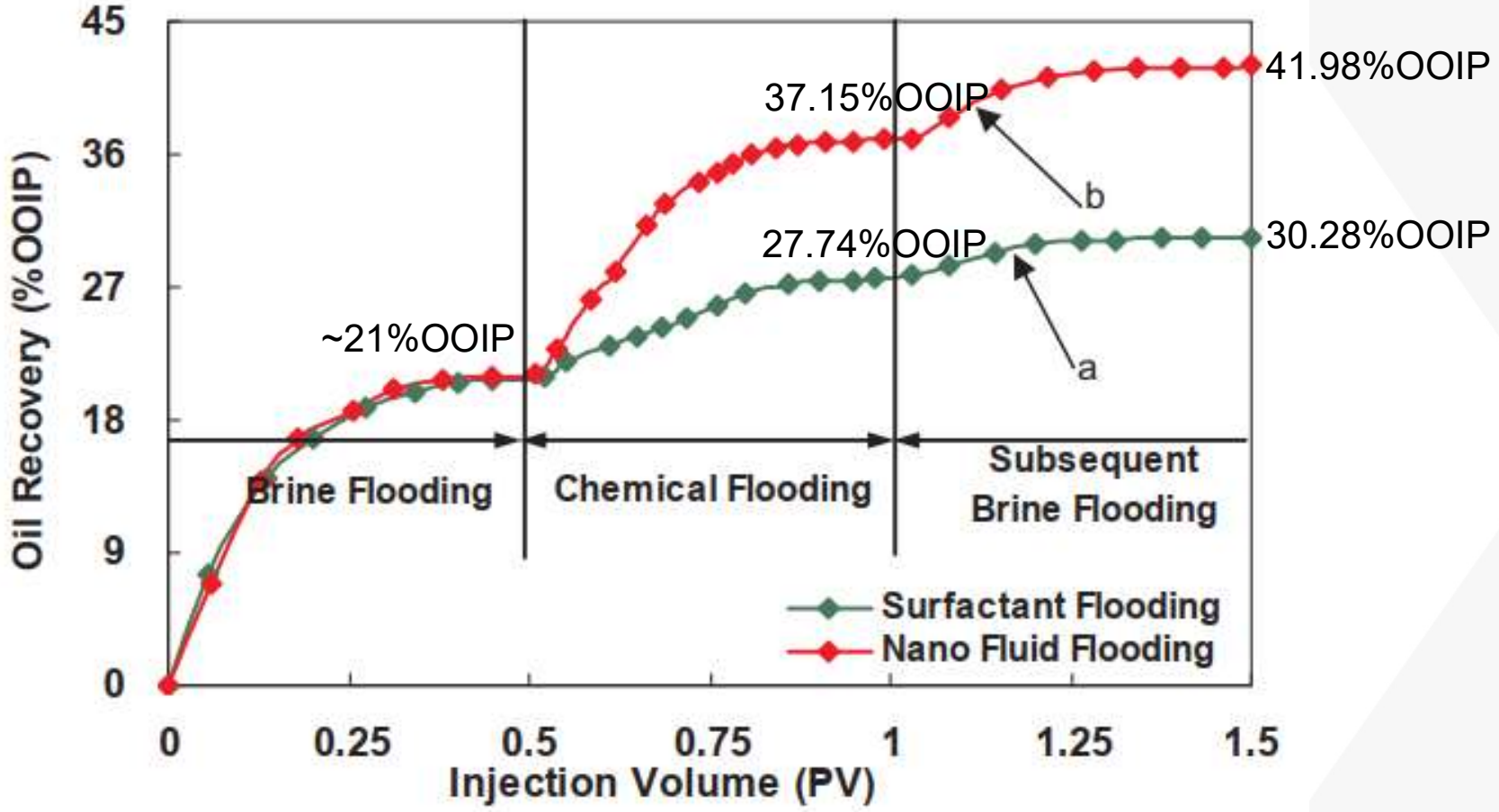


Spontaneous imbibition experiment

Spontaneous imbibition experiments on Bakken cores at 80 °C.

Research Results

Silica Quantum Dots (SiQDs) Nanofluid for EOR



Oil recovery of coreflooding on Bakken cores at 80 °C.

Conclusions

- SiQDs nanofluid yielded 25.72 %OOIP recovery in spontaneous imbibition, which was 7.49 %OOIP higher than that of the surfactant (betaine) imbibition test.
- A total recovery of 41.98 %OOIP by SiQDs nanofluid in core flooding test was achieved. The result was 9.13 %OOIP higher than the surfactant flooding.
- This project lays a solid foundation for the further nano EOR technology development and transfer.

Budget

Petroleum Engineering

	4 months (May 1-Aug. 31, 2020), NDIC	
EXPENSES, Personnel	Salary	Benefits
Hui Pu, PI	27,533	6,883
Research assistants	16,000	
Subtotal salary and benefits	43,533	6,883
Total	$50,417	
EXPENSES, Nonpersonnel		
Supply/Materials	4,804	
Travel, Conferences	0	
Total Nonpersonnel	4,804	
Total Direct Expenses	55,221	
F&A	0	
TOTAL EXPENSES	$55,221	

Chemistry

	4 months (May 1-Aug. 31, 2020), NDIC	
EXPENSES, Personnel	Salary	Benefits
Julia Zhao, Co-PI	23,450	4,690
Research assistant	3,670	30
Subtotal salary and benefits	27,120	4,720
Total	$31,840	
EXPENSES, Nonpersonnel		
Office supplies	798	
Total Nonpersonnel	798	
Total Direct Expenses	32,638	
F&A	0	
TOTAL EXPENSES	$32,638	

Total: $87,859

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Publications

—Peer-Reviewed Journal Articles

1. Shaojie Zhang, Hui Pu, Julia Xiaojun Zhao. Experimental and Numerical Studies of Spontaneous Imbibition with Different Boundary Conditions: Case Studies of Middle Bakken and Berea Cores. *Energy & Fuels* **2019**, 33(6): 5135-5146. (Impact Factor: 3.42)

2. Xun Zhong, Chuncheng Li, Hui Pu, Yanxia Zhou, Julia Xiaojun Zhao. Increased Nonionic Surfactant Efficiency in Oil Recovery by Integrating with Hydrophilic Silica Nanoparticle. *Energy & Fuels* **2019**, 33(9):8522-8529.

3. Xun Zhong, Hui Pu, Yanxia Zhou, Julia Zhao, *Comparative Study on the Static Adsorption Behavior of Zwitterionic Surfactants on Minerals in Middle Bakken Formation*, *Energy & Fuels* **2019**, 33(2):1007-1015.

4. Chuncheng Li, Hui Pu, Julia Xiaojun Zhao. Molecular Simulation Study on the Volume Swelling and the Viscosity Reduction of n-Alkane/CO_2 Systems. *Industrial & Engineering Chemistry Research* **2019**, 58(20): 8871-8877.

5. Yanxia Zhou, Xu Wu, Xun Zhong, Wen Sun, Hui Pu, Julia Zhao. *Surfactant-Augmented Functional Silica Nanoparticle Based Nanofluid for Enhanced Oil Recovery at High Temperature and Salinity. ACS Applied Materials & Interfaces* **2019**, 11, 49, 45763-45775. (Impact Factor: 8.75)

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Publications

—Peer-Reviewed Journal Articles

6. Runxuan Sun, Hui Pu, Wei Yu, Jijun Miao, Julia Xiaojun Zhao. Simulation-based enhanced oil recovery predictions from wettability alteration in the Middle Bakken tight reservoir with hydraulic fractures. *Fuel* **2019**, 253, 229-237. (Impact Factor: 5.12)

7. Shaojie Zhang, Yinghui Li, Hui Pu. Studies of the storage and transport of water and oil in organic-rich shale using vacuum imbibition method. *Fuel* **2020**, 266, 117096.

8 Xun Zhong, Chuncheng Li, Yinghui Li, Hui Pu, Yanxia Zhou, Julia Xiaojun Zhao. Enhanced Oil Recovery in High Salinity and High Temperature Conditions with Zwitterionic Surfactant and Silica Nanoparticles Acting in Synergy, *Energy & Fuels* **2020**, 34, 3, 2893-2902.

9. Yanxia Zhou, Xu Wu, Xun Zhong, Julia Zhao, Hui Pu, *Polymer Nanoparticles Based Nano-fluid for Enhanced Oil Recovery at Harsh Formation Conditions*, *Fuel* **2020,** 267, 117251.

10. Yanxia Zhou, Xu Wu, Shaojie Zhang, Xun Zhong, Hui Pu, Julia Xiaojun Zhao. Development of Silicon Quantum Dots Based Nano-fluid for Enhanced Oil Recovery on the Tight Formation of Bakken Cores. *Fuel* **2020,** 277, 118203.

Publications

—Conference Papers

1. Xun Zhong, Hui Pu, Yanxia Zhou, Julia Zhao, *SPE-193589 Static Adsorption of Surfactants on Bakken Rock Surfaces in High Temperature, High Salinity Conditions*, *SPE International Conference on Oilfield Chemistry*, 8 - 9 Apr **2019**, Galveston, Texas.

2. Chuncheng Li, Hui Pu, Shaojie Zhang, Julia Zhao, *Effect of Nanoparticles and Surfactants on Oil/Water Interfacial Tension: a Coarse-Grained Molecular Dynamics Simulation Study*, 2019 Unconventional Resources Technology Conference (URTeC), Denver, CO, 22-24 July 2019.

3. Shaojie Zhang, Chuncheng Li, Hui Pu, Kegang Ling, Runxuan Sun, Julia Xiaojun Zhao. Experimental Study of Surfactant-Assisted Oil Recovery in the Middle Bakken Cores. 2019 SPE Liquid-Rich Basins North American, Odessa, TX, 7-8 November 2019.

—Presentations

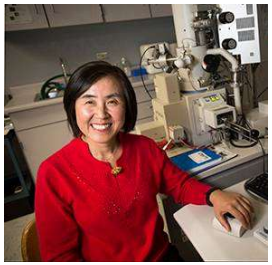
1. Chuncheng Li presented "*Nanoparticle-Surfactant Flooding Driven Oil-Detachment in Calcite Nanochannels: A Molecular Dynamics Simulation Study*" at The Bakken Conference & Expo, Bismarck, ND, July 16-17, 2019,

2. Shaojie Zhang presented "*Measuring capillary pressure and relative permeability of Bakken Rocks using spontaneous imbibition*" at Bakken Oil Product & Service Show, Williston, ND, Oct 2-3, 2019

Patent

Yanxia Zhou, Xu Wu, Hui Pu, Julia Xiaojun Zhao. Quantum Dots based Nanofluid for Enhanced Oil Recovery in Tight Oil Reservoir. Application filed on December 31,2019.

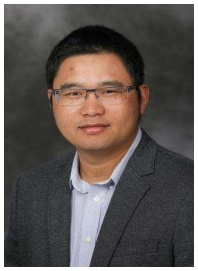
Team



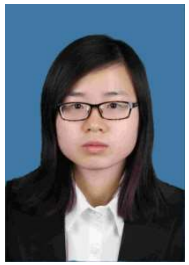
Dr. Julia Zhao

Dr. Hui Pu

Dr. Yanxia Zhou



Dr. Xu Wu



Xun Zhong

Shaojie Zhang

Chuncheng Li

Runxuan Sun

Wen Sun

Sarah Reagen

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- **Bakken core samples**

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Department of Mineral Resources

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- **Bakken crude oil samples**

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Thank You!
Questions?

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