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Field Deployment of Nanomaterial Based Shale Inhibitors

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Agenda

- Introduction
- Challenges with Clays
- Swelling mechanisms
- A novel nanosilica based shale inhibitor
- A novel nanoplatelets based shale inhibitor
- Conclusions

Drilling Fluids History

- 1900-1920 – Dirt and water
- 1920s – Bentonite and Barite
- 1924 – Blowout preventer (BOP)
- 1930 – Fluid loss control
  - 1939 – Starch for FLA
- 1940 – Lime gypsum, silicate mud
  - Lignosulfonate/lignite mud
- 1950s – Invert emulsion mud (OBM)
- 1970s – Polymers
- 1980s – Synthetic mud (SBM)
- 2000s – Solids free system
  - Waste management

First 50 years only WBM, now 50:50

Why WBM?

1. Transport cuttings to surface - rheology
2. Prevent well-control issues
   - Maintain mud density at all temperature - rheology
3. Preserve wellbore stability
4. Minimize formation damage
5. Cool and lubricate the drillstring
6. Provide information about the wellbore
7. Cost effective
8. Minimize risk to personnel, the environment, and drilling equipment

Nanosilica based shale Inhibitor

Successfully field trialed in 3 wells

SPE-185950

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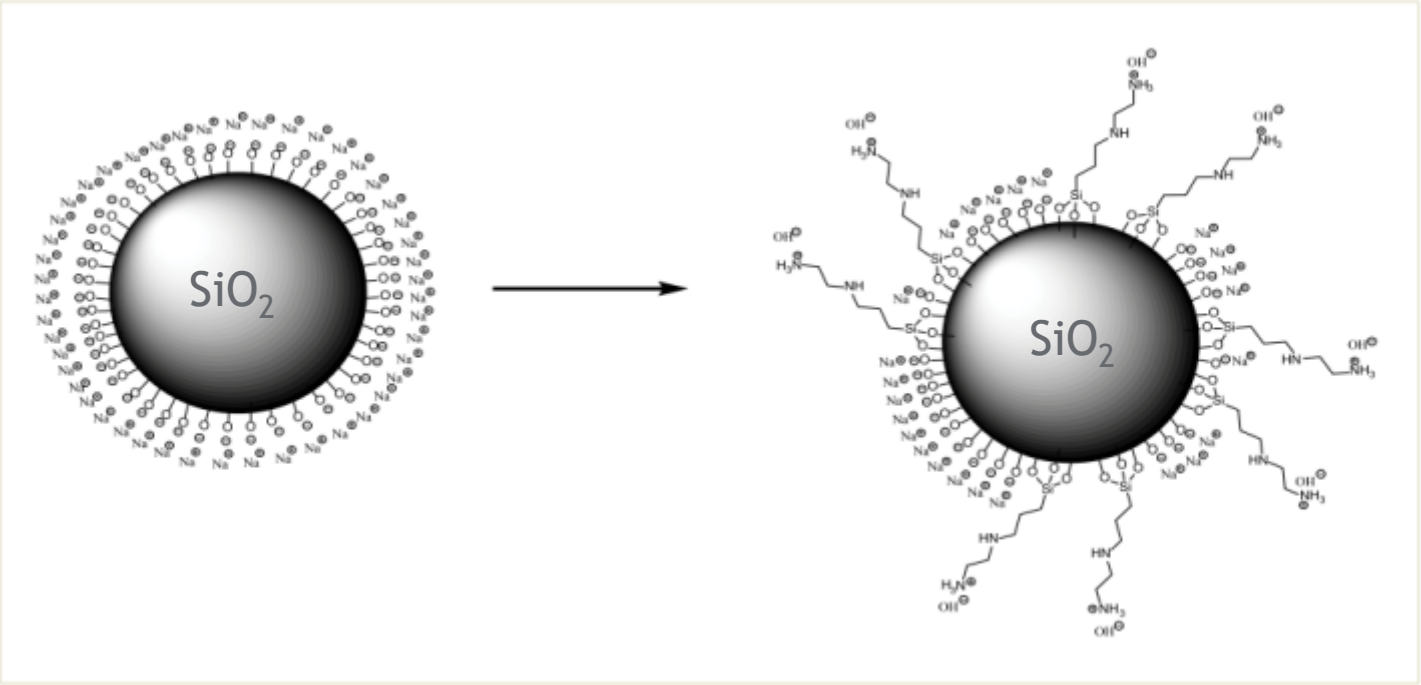
Shale Inhibition at the Nanoscale



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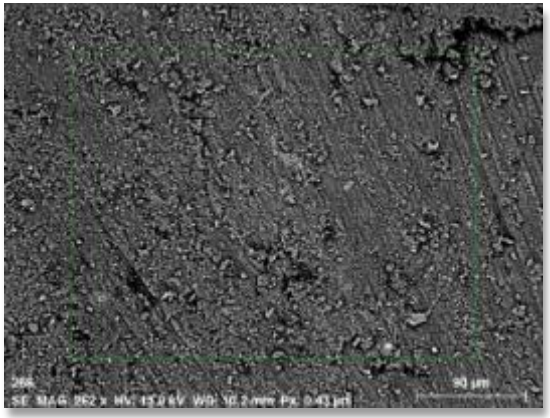
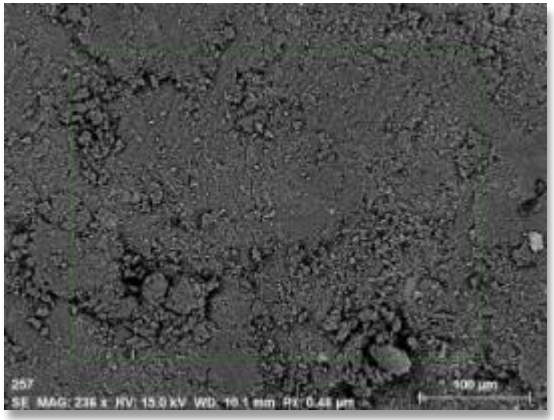
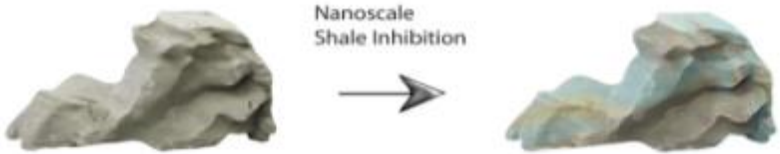
Nanosilica Shale Inhibition Advantages





- Bridging chemical design with nano-particulate design - cementation
- Green chemistries can be targeted with a lower environmental footprint
- Higher inhibiting activity at lower concentrations than conventional shale inhibitors

Nanosilicas as green additives for shale inhibition



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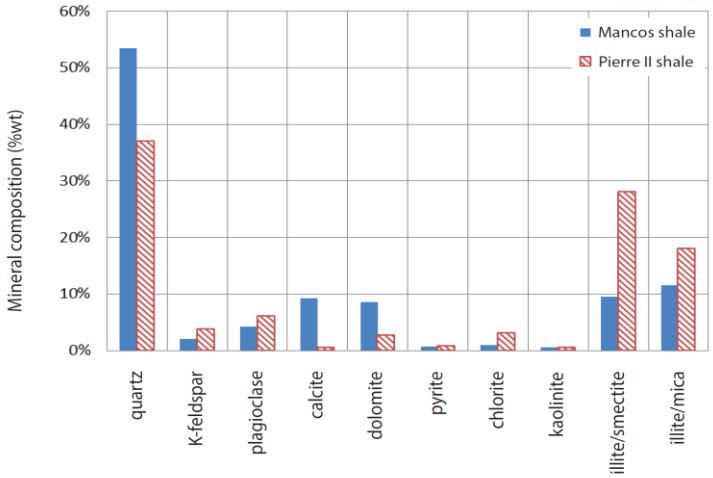
Functionalized Nanosilica: Dispersion Test (Pierre II Shale)



91%

82%

25%

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Functionalized Nanosilica - Swelling Test

Material	Amount (lb/bbl)	Amount (lb/bbl)	Amount (lb/bbl)
Water	324	324	324
NaCl	36	36	36
Xanthan gum	1	1	1
Starch	4	4	4
Modified Cellulose	1	1	1
NaOH	0.1	0.1	0.1
Nanosilica	3	0	0
Additive 1	0	3	0
Additive 2	0	0	3

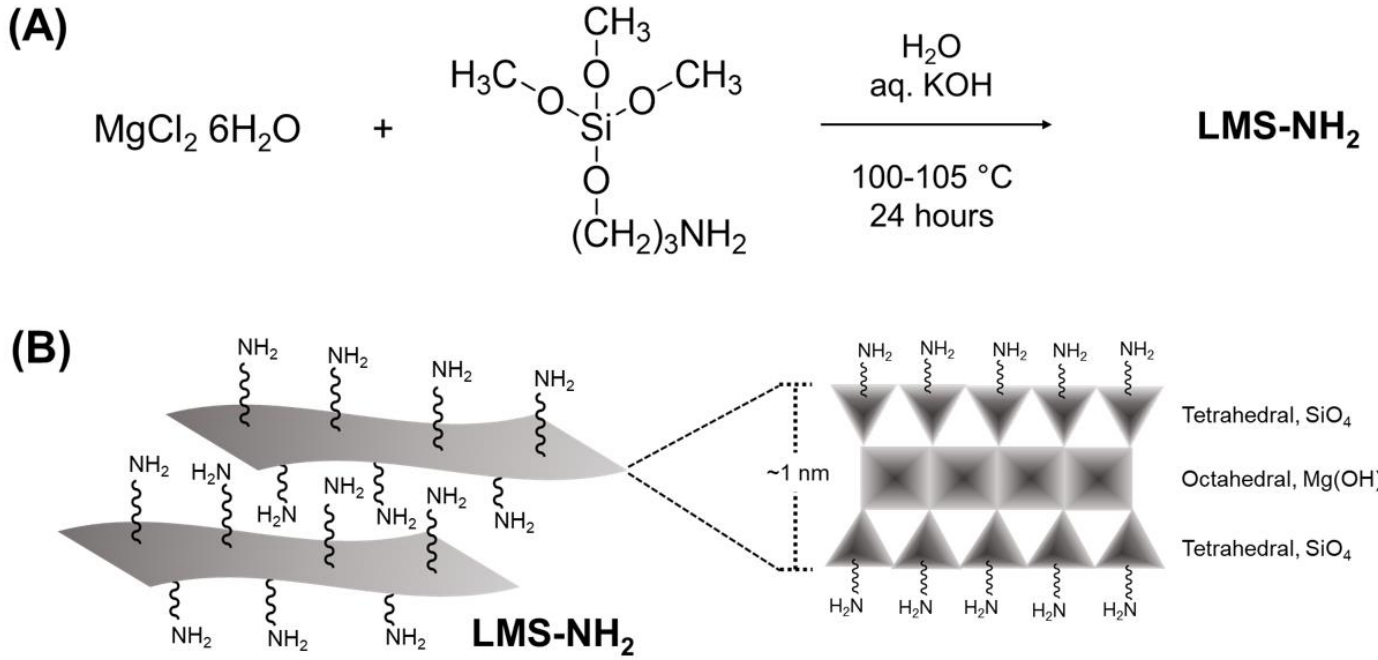
Clay inhibitor name	Final Swell %
Nanosilica	41.5%
Additive 1	43%
Additive 2	43%

Nano-platelets based Shale Inhibitor

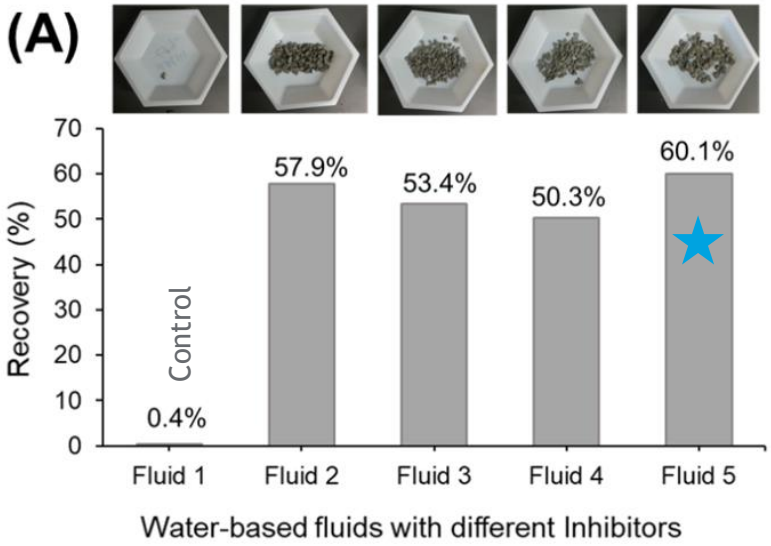
Ready for field trials

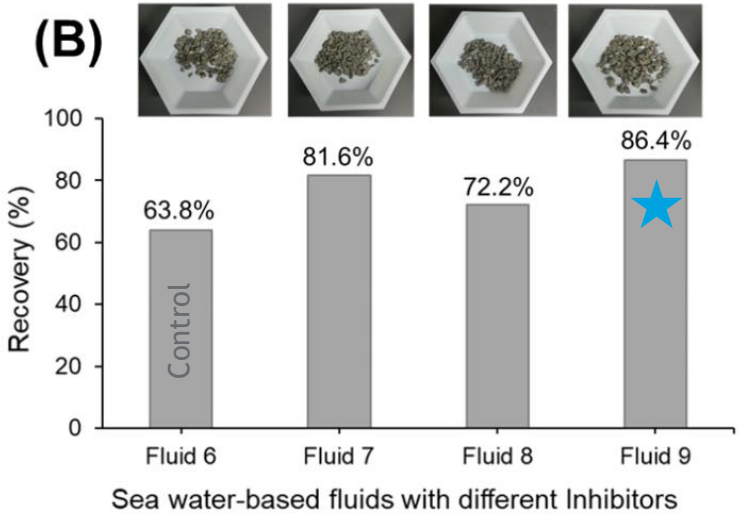
IPTC-20014

Functionalized Nano-platelets



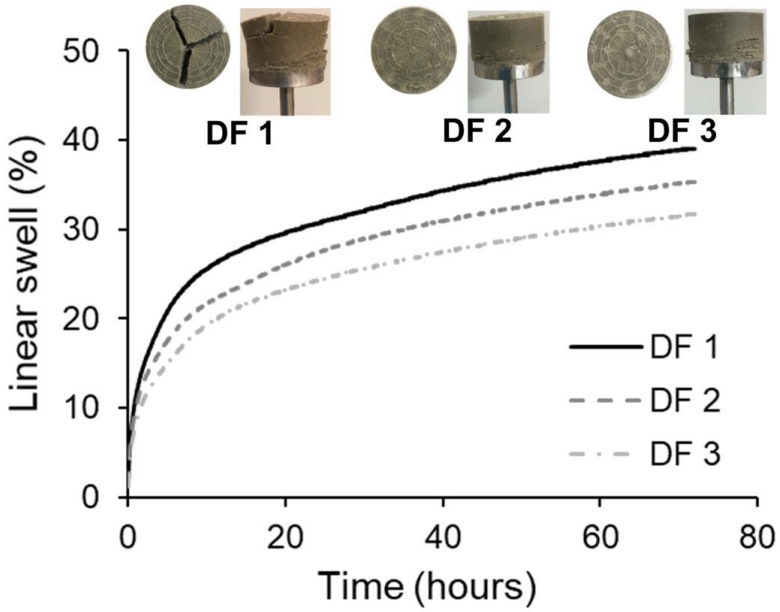
Functionalized Nano-platelets: Dispersion Test (Pierre II Shale)



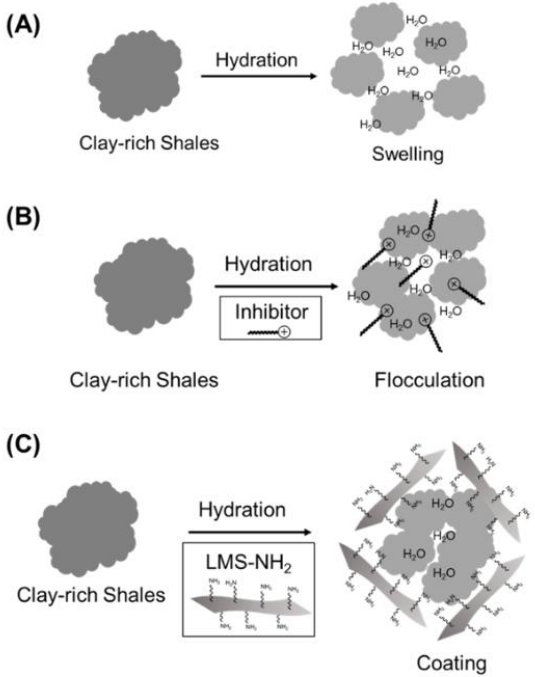


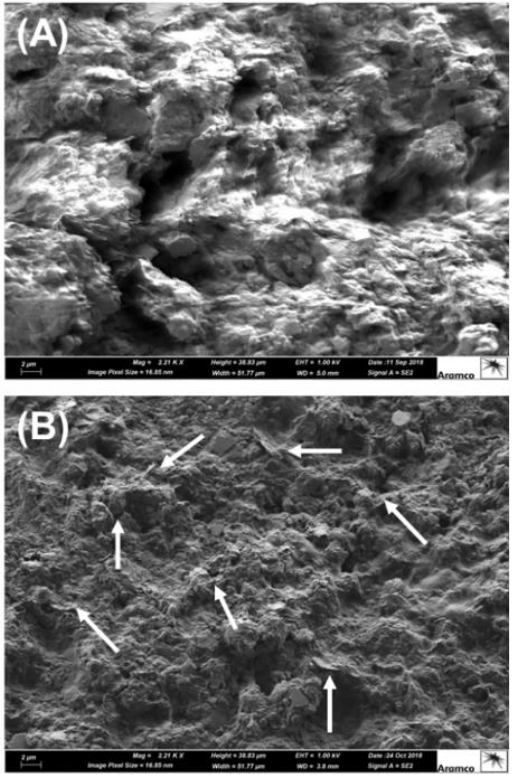
Functionalized Nano-platelets: Swelling Test

Formulations	DF 1	DF 2	DF 3
Water (tap), g	324	324	324
NaCl, g	36	36	36
Xanthan gum, g	1	1	1
Starch, g	4	4	4
Modified cellulose, g	1	1	1
NaOH, g	0.1	0.1	0.1
LMS-NH_2, g	-	2	4



Mechanism – formation of Inorganic coating





Conclusions

- Both Nanosilica and Nano-platelet based shale inhibitors have demonstrated enhanced shale stability:
  - by formic protective layer
  - reducing the permeability
  - cementation

- Both are environmentally friendly

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