HYDROPHOBIC POLYMER-MODIFIED NANOSILICA AS EFFECTIVE ENVIRONMENT-FRIENDLY SHALE INHIBITOR FOR WATER-BASED DRILLING MUD

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Overview

Introduction

- Shale hydration and dispersion is a major cause of wellbore instability in oil and gas drilling industry
- Types of drilling muds
 - *Oil-based muds (OBMs)*
 - *Synthetic based muds (SBMs)*
 - *Water-based muds (WBM)*
- The drilling muds are employed for
 - *Cleaning the wellbore*
 - *Conveying the drill cuttings*
 - *Chilling and greasing the drill bit*
 - *Monitoring the formation pressure*
 - *Avoiding reservoir fluid loss*
 - *Formation of thin and impermeable filter cakes*
 - *Sustaining wellbore stability*

- Rana A, Arfaj MK, Saleh TA (2019) Advanced developments in shale inhibitors for oil production with low environmental footprints – A review. Fuel 247:237–249.
- Afolabi RO, Orodu OD, Efeovbokhan VE (2017) Properties and application of Nigerian bentonite clay deposits for drilling mud formulation: Recent advances and future prospects. Appl Clay Sci 143:39–49.

Clay Swelling

- Swelling mechanism of the clays that can be divided into three key steps.
 - *The water molecule enter the space between the sheets of the clay minerals and the clay swelling was observed to be the same as the diameter of the water molecules.*
 - *The next stage is known as hydration swelling in which the interlayer ions are hydrated and dehydrated.*
 - *Lastly, free swelling happens, where the interlayer forces of attraction such as van der Waal's and the electrostatic forces play a crucial role. At this level of swelling, the clay sheets are far enough apart that the interlayer forces cannot hold them together.*

- Rana A, Arfaj MK, Saleh TA (2019) Advanced developments in shale inhibitors for oil production with low environmental footprints – A review. Fuel 247:237–249.
- Xie G, Xiao Y, Deng M, et al (2020) Low Molecular Weight Branched Polyamine as a Clay Swelling Inhibitor and Its Inhibition Mechanism: Experiment and Density Functional Theory Simulation. Energy & Fuels 34:2169–2177.

Polymer based nanocomposites

- Conventional water based drilling fluids can cause sloughing, tight hole, and pipe struck
- Polymers are widely used for the improvement of rheological features and shale inhibition
- Example of polymer based shale inhibitors include such as xanthan gum, partial hydrolytic polyacrylamide, polyethyleneimine
- Nanocomposites of polymer attract the attention due to unstable nature of polymer in WBM
- Example of polymer based nanocomposite additives for WBM
 - *Polyethylene glycol grafted nano-silica composite*
 - *Amphiphilic polymer/nano-silica composite*
- In current study we utilized a novel polyacrylamide modified nanosilica (PAM-SiO₂NPs) as shale inhibitor

- Xu J, Qiu Z, Zhao X, et al (2018) Synthesis and characterization of shale stabilizer based on polyethylene glycol grafted nano-silica composite in water-based drilling fluids. J Pet Sci Eng 163:371–377.
- Qiu Z, Xu J, Yang P, et al (2018) Effect of Amphiphilic Polymer/Nano-Silica Composite on Shale Stability for Water-Based Muds. Appl Sci 8:1839.

Objectives

- Synthesis of polyacrylamide modified nanosilica (PAM-SiO₂NPs)
- Characterization of the enhanced nanomaterials
- While developing new shale inhibitor materials, we kept in mind
 - Efficient
 - Cost-effective
 - Environmental profile
- Inhibition efficiency and inhibition durability were compared with the unmodified inhibitive mud, KCl and commercial shale inhibitor

Results and Discussion

Characterization

Less pores on the surface of shale after addition of PAM-SiO₂NPs

FE-SEM images of shale (a), PAM-SiO₂NPs (b), and shale modified with PAM-SiO₂NPs (c).

FTIR spectra of graphene, shale, PAM-SiO₂NPs, and shale modified with PAM-SiO₂NPs

TGA data of PAM-SiO₂NPs, shale, and shale modified with PAM-SiO₂NPs

Rheological Study

Bentonite	Resinex
KCl	Water
XC-Polymer	PAC-L
Na ₂ SO ₃	Inhibitor

100°C, 500 Psi

Hot rolling

16h

Viscometer

Table 3. Rheological properties at 120°F and 14.7 psi

Mud formulation					
	PV (cp)	AV (cp)	YP (lb/ft ²)	Gel _{10sec} (lb/ft ²)	Gel _{10min} (lb/ft ²)
Unmodified mud Pre hot rolling	12	20.5	8.5	8	15
Unmodified mud Post hot rolling	10	18	8	6	9
PAM-SiO ₂ NPs- WBM Post hot rolling	7	11.5	5.5	4	5

Improvement in the rheological features

Linear Swelling test

Linear swelling test of bentonite in the presence of various aqueous solution

Conclusion

Better
inhibition
features of
the PAM-
SiO₂NPs-WBM

PAM-SiO₂NPs-
WBM plugs
the pores of
the shale and
hinder the
water
molecules to
invade the
surface

Surface of
shale become
hydrophobic

PAM-SiO₂NPs-
WBM helps to
maintain the
rheological
properties at
higher
temperature

Low-cost,
efficient, and
better
environmental
features

Thankyou