Cellulose nanofibers facilitate heavy particle suspension in drilling fluids

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Introduction

As drilling fluid rheological characterization is an evolving knowledge, the need to go further in understanding the drilling fluids viscoelasticity and yield stress, relates to the way in which the material yields under different types of stresses.

To suspend heavy particles, the yield strength of a drilling fluid must be tailored by rheological methods. Yield strength determination with modern rheometers provides accurate results in comparison to oil industry traditional dynamic yield strength calculation using a Model 35A viscometer.

The purpose of this work is to analyse the suspension capability of a water-based drilling fluid containing cellulose nanofibers at different temperatures.

Experimental

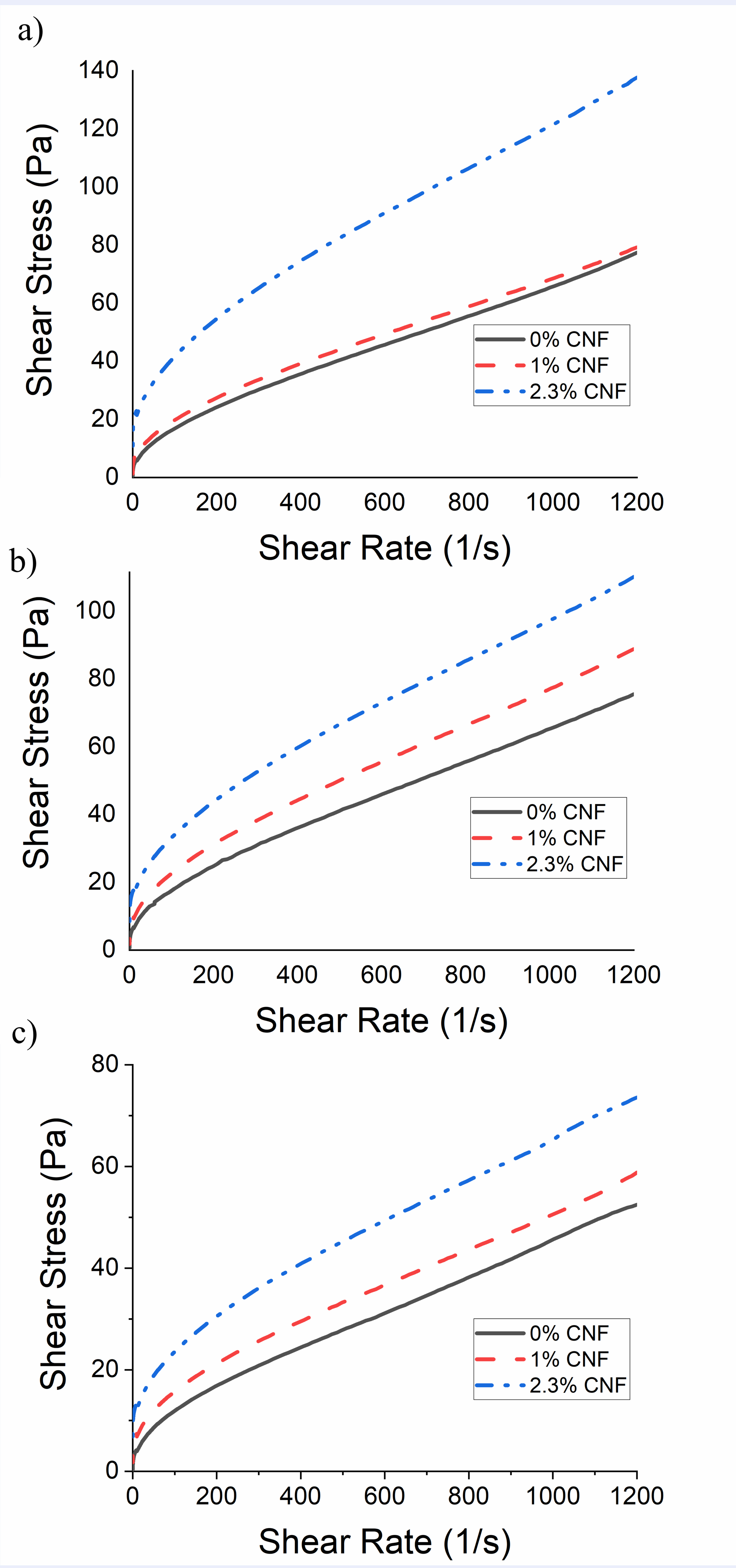
The materials used in this study were a standard water-based drilling fluid with density of 1.68 g/cm3 containing KCl, soda ash, polyanionic cellulose, starch, xanthan gum, barite, and a commercial Cellulose Nanofibrils (CNF) which was obtained from Borregaard. CNF was added to the drilling fluid in different w/w percentages.

Flow curve protocol		
Pre-shearing	1000	seconds
1st stage	1200-60	100 steps
2nd stage	60-10	5 steps
3rd stage	10-0,1	100 steps

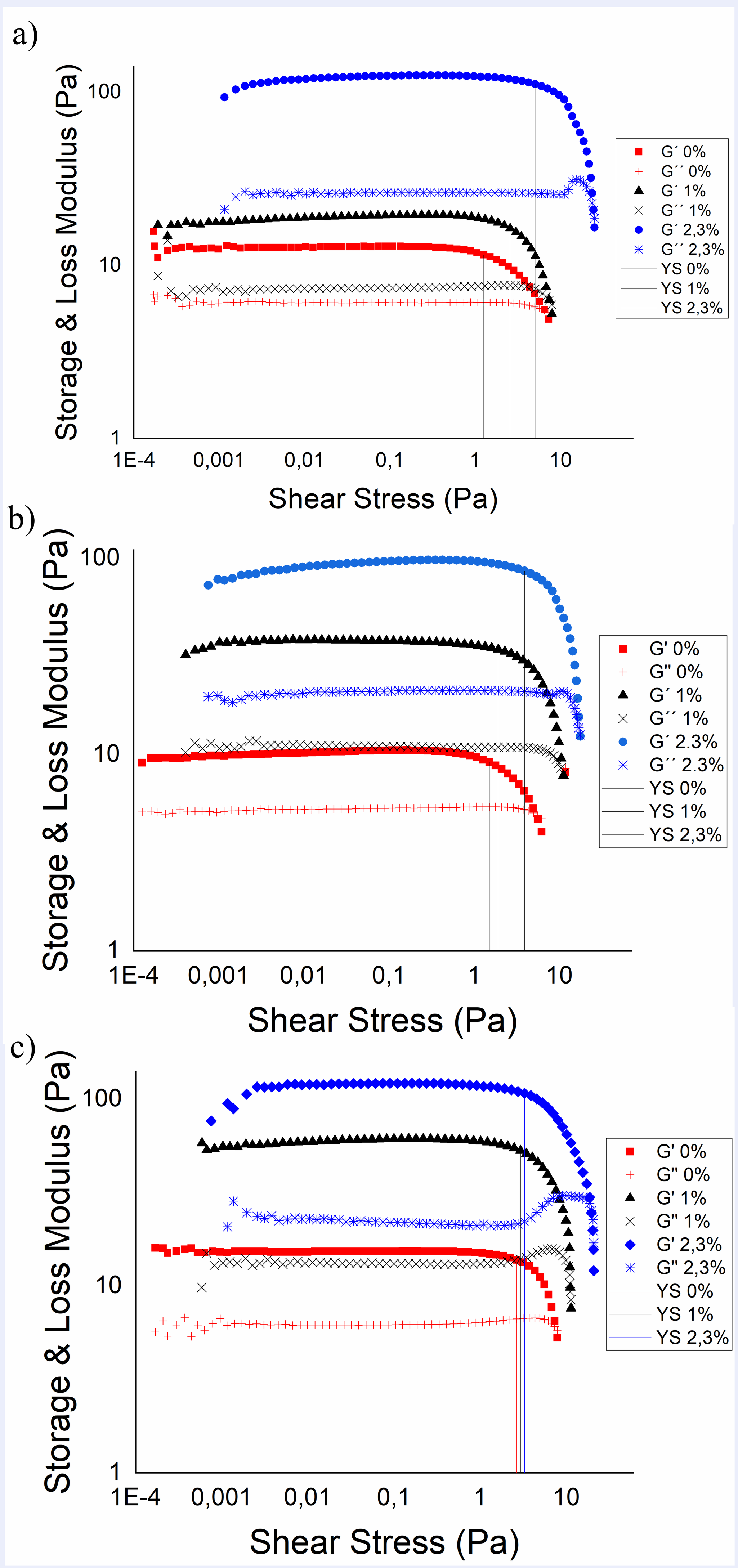
Oscillatory protocol		
Freq. (Hz)	Strain (%)	Meas. points
1	0,01-100	60

3 iTT Protocol		
Rest interval		
Strain 0,1%	Freq. 10Hz	10 meas. Points
Load interval		
Shear rate 10 s-1		10 meas. Points
Recovery interval		
Strain 0,1%	Freq. 10Hz	1000 meas. Points

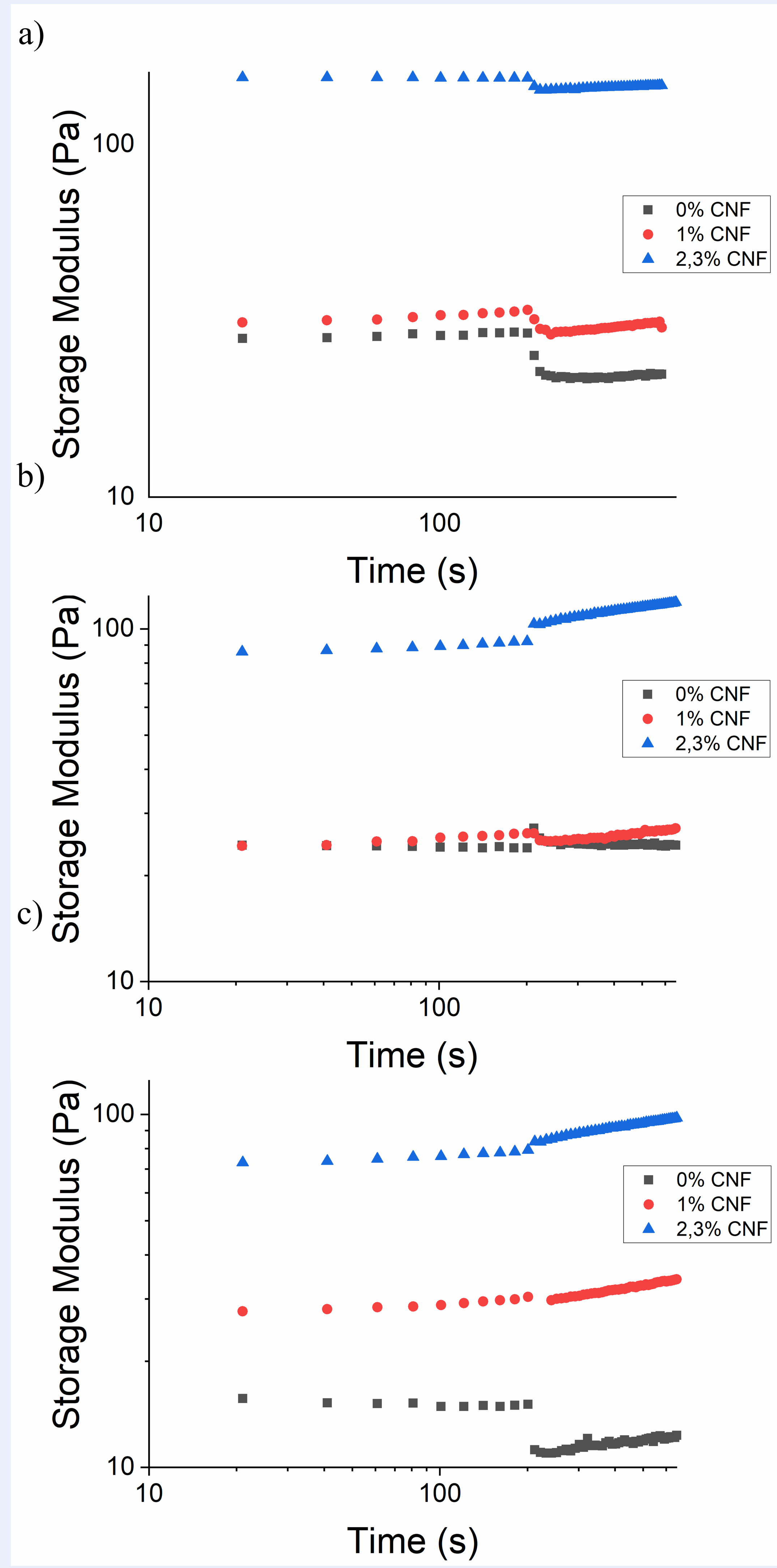
Results



Drilling fluids shear flow profile with 0, 1, and 2.3 wt% of CNF at different temperatures (a) 25°C, (b) 30°C and (c) 50°C.



Drilling fluids storage modulus (G') and loss (G'') modulus, and yield strength (YS) with 0, 1, and 2.3 wt% of CNF at different temperatures (a) 25°C, (b) 30°C and (c) 50°C.



Drilling fluids thixotropy test with 0, 1, and 2.3 wt% of CNF at the different temperatures (a) 25°C, (b) 30°C and (c) 50°C.

Conclusions

The highly entangled structure of CNF causes a 3D network that increases the resistance to flow, which could explain the shear stress increment during variable shearing flow, and also the necessity of extended periods of time for the 2.3% CNF concentration in drilling fluids to reach steady state during the 3iTT and was not affected by the higher shear applied during the same experiment.

CNF addition to drilling fluids improves certain fluid properties, such as the elastic modulus during quiescent state, becoming a great possibility to enhance heavy particle suspensions to help with the drilling cuttings removal and to avoid barite sagging.

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