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Research Article

Investigating the Properties of *Tympanostomus Fuscatus* in High Temperature Oil and Gas Well Cementing Operations

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Abstract

This study investigates the properties of Tympanostomus fuscatus (periwinkle) shell in high temperature oil and gas cementing operations. Tympanostomus fuscatus shell powder was tested in the laboratory for its potential use in well cementing operations. The shell was calcinated, pulverised and subjected to laboratory test following the API RP 10B recommended oilfield cement testing, with a cement slurry density of 15ppg at concentrations of 25%BWOC, 30%BWOC and 35%BWOC of periwinkle shell powder, with test temperatures of 2000C and 2500C. Characterization such as rheology, X-ray diffraction (XRD), X-ray fluorescence (XRF), API fluid loss, was conducted on the sample. The results showed that the periwinkle shell contained Al2O3, CaO, and SiO2, which is the elemental composition to prevent the strength retrogression of cement contraction. Tympanostomus fuscatus shell powder gave similar results with the silica flour based on its rheological properties. Tympanostomus fuscatus shell powder is a potential alternative for silica flour as additive and showed excellent properties for cement strength retrogression, and cement contraction for well cementing oil and gas operation.

Keywords: High Temperature, Cement Slurry, Tympanostomus Fuscatus, Rheological Properties

1. Introduction

Oil well cement is a special type of cement known as Portland cement [1]. Cement is used in oil wells for a variety of reasons [2]. The main purpose of oil well cement is to provide a continuous impermeable hydraulic seal in the annulus which provides zone isolation in the wellbore thus excluding the migration of wellbore fluids across zones. The hydraulic seal provides seal-off to loss circulation zones and also shuts off water production zones [3]. Aside from the sealing properties, oil well cement is used to provide structural integrity to the well, and plug off the existing well in the case of abandonment during the drilling of directional wells. Cementing also protects the casing from collapse under pressure and against corrosion [4]. The design of cement slurries for a particular well is perhaps the most important aspect of the oil well-cementing process. In the design stage, accurate characterization of the rheology of the cement slurry is critical [5]. Many factors affect the rheology of cement slurries. They include the type of cement (this includes, the size and shape of the cement grains, its chemical composition, and the relative distribution of its components at the surface of the slurry), the water/cement ratio, the chemical additives used (this includes the concentrations, quality, and quantity of the additives), interaction between cement and chemical additives, the temperature and pressure, mixing and testing procedure and settling time [6]. Noted the concentration of the chemical additives and the temperature and pressure of the well played the most profound roles in the rheology and mechanical properties of the cement slurry [7].

They further stated that chemical additives control the rheology of the cement slurry and its early mechanical properties. Cement slurries prepared with different additives types and concentrations using the same type of cement can exhibit large variations in flow and this variation becomes more profound when temperatures and pressures are elevated. Observed that high temperature also reduces the thickening time of the cement thus making the cement sheath set quicker than normal [8]. Reported that rheological properties of the cement slurry are affected by temperature, yield viscosity, and plastic viscosity declines with an increase in high temperature [9]. They further noted that the bottom-hole circulating temperature (the temperature at which the cement slurry is pumped into the wellbore) decreases with an increase in pressure. Therefore, the focus of this study is to investigate the properties of *Tympanostomus Fuscatus* (Periwinkle) shell powder in high temperature oil and gas well cementing operations.

2. Materials and Methods

2.1. Collection of the Sample

The periwinkle shell which is used as the local material was sourced at Ihiagwa market, Owerri as showed in Figure 1. The

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periwinkle shell was obtained with its edible part excluded. The periwinkle shell was washed with distilled water to remove particles that adhered to it. The washing was done using distilled water and then poured the periwinkle shell into it to ensure that the water covered it to the brim. The periwinkle shell was agitated to remove impurities. It was sundried and crushed into smaller particles and then sieve it to obtain the powdered form.

Figure 1: Periwinkle Shells (Tympanostomus Fuscatus)

2.2. Preparation of the Cement Slurry with Silica Flour and Periwinkle Shells Powder

Cement slurry was prepared with silica flour as cement retrogression additive with concentration of 25%, 30% and 35%. The same approach was applied for the periwinkle shell powder as the local material. The total additive composition of the cement slurry is shown in equation 1 and 2 while Table 1 and 2 showed the composition of the cement slurry additive with silica flour.

G cmt + 0.014gal/sk ASP-742+ 0.8%BWOC WE-UDS + 0.5287%BWOC MD-21S + 0.35gal/sk WFL-05 + 0.825gal/sk MICROBLOK + 0.4gal/sk WE-BON01+ SF ... (1)

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Additives	Batch No.	Gms	Mls	Concentration	Function
G CMT	601289	566.73	180.49		Cement
ASP-742	002/20WE27No-20	0.64	0.7	0.014gal/sk	Defoamer
WE-UDS	HC05DP22	4.53	2.87	0.8%BWOC	Dispersant
MD-21S	MM02K-01S398	3	2.44	0.5287%BWOC	Retarder
WFL05	2250560	19.69	17.58	0.35gal/sk	Fluid Loss Control
MICROBLOK	142017-000490	58.01	41.43	0.825gal/sk	Gas Check
WE-BON01	IITS101213RW	28.12	20.09	0.4gal/sk	Bonding Agent
WE-SF4	NIL20/06/2022	198.36	75.42	25%, 30%, 35%, 40%, BWOC	Strength Retrogression
FRESH WATER		258.98	258.98	5.157gal/sk	Mix Water
MIX FLUID EQUIREMENT		372.97	344.09	6.851gal/sk	Mix Fluid

Table 1: Cement Slurry Additives with Silica Flour

Additives	Batch No	Gms	Mls	Concentration	Function
G CMT	601289	566.73	180.49		Cement
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MICROBLOK	142017-000490	58.01	41.43	0.825gal/sk	Gas Check
WE-BON01	IITS101213RW	28.12	20.09	0.4gal/sk	Bonding Agent
PSP	PSP20/06/2022			25%, 30%, 35%, 40%, BWOC	Strength Retrogression
FRESH WATER		258.98	258.98	5.157gal/sk	Mix Water
MIX FLUID REQUIREMENT		372.97	344.09	6.851gal/sk	Mix Fluid

Table 2: Cement Slurry Additives with Periwinkle Shells (*Tympanostomus Fuscatus*)

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2.3. Characterization of the Periwinkle Shell Powder

The physical and compositional analyses of the PSP was conducted to determine the elemental and oxides of the periwinkle shell powder using X-ray diffraction (XRD) and X-ray fluorescence (XRF). In the X-ray diffraction analysis, the sample was done by powering the XRD device and setting the current and voltage of the panel at 45kV and 40 mA, and temperature was set at 21 ±2°C. The computer system was switched on and the XRD software was double clicked to initiate running. Periwinkle shell powder was poured into the sample holder and chamber door was closed. The computer system gave the signal of the elemental structure and oxides of the sample. Similar procedure followed for the XRF analysis.

2.4. Rheology Test

The rheology test for all cement slurry composition for both the silica flour and periwinkle powder was conducted at temperature of 250oF for revolution per minute of 300RPM, 200RPM, 100RPM, 60RPM, 30RPM, 6RPM and 3RPM. using Fann Model 35-viscometer.

2.5. API Fluid Loss Test

The conditioned cement slurry was poured into a 250 ml measuring cylinder and allowed to stand for 2 hours. Free water started to come out of the mixture with time. After 2 hours the amount of free water deposited at the top of the cement slurry was decanted and measured. The results were taken and recorded. The procedure was repeated for all concentrations of silica flour and PSP cement slurry preparations.

3. Results and Discussion

The X-ray diffraction (XRD) and X-ray fluorescence (XRF) is presented in Table 3 and 4

Element Number	Element Symbol	Element Name	Weight Concentration
20	Ca	Calcium	57
14	Si	Silicon	3.1
41	Nb	Niobium	0.013
26	Fe	Iron	3.71
19	K	Potassium	0.32
17	Cl	Chlorine	1.088
16	S	Sulphur	0.321
13	Al	Aluminium	1.75
8	O	Oxygen	30.0
6	C	Carbon	0.025
22	Ti	Titanium	0.251

Table 3: Elemental Composition of Periwinkle Shell Powder

Table 3, showed that Calcium and Silicon have the highest percentage weight concentration. The periwinkle shell powder (PSP) contained 57% by weight concentration Calcium and 3% of Silicon. These two elements are contained in Portland cement and are required for cement slurry retrogression strength.

Oxide	Periwinkle Shell powder (%)
CuO	0.007
FeO2	5.310
MnO	0.057
TiO2	0.420
CaO	80.7
Al2O3	3.3
ZnO	0.04
SiO2	6.7

Table 4: Oxides Composition of Periwinkle Shell Powder

Table 4 showed the oxides of periwinkle shell powder contained 80% of CaO%, SiO_2 of 7%, Al_2O_3 of 3.3% in the oxide composition. Periwinkle shells contained CaO, SiO_2 and Al_2O_3. However, CaO and Al_2O_3 prevents the contraction of cement sheath at high temperatures after setting while the SiO_2 helps in cement compressive retrogression strength. In addition, SiO_2 and Al_2O_3 are nanoparticles which helps to enhance the fluid loss control during and after cementing job operations.

3.1. Rheology Test Results

In Figure 2, it was observed that the plastic viscosity decreased as concentration increased from 25% BWOC to 30% BWOC for the silica flour additive and the periwinkle shell powder additive. It also showed that plastic viscosity remained constant when concentration increased from 30% BWOC to 35% BWOC. Furthermore, at 25% BWOC, the silica flour showed 5% higher in the plastic viscosity than periwinkle shell powder.

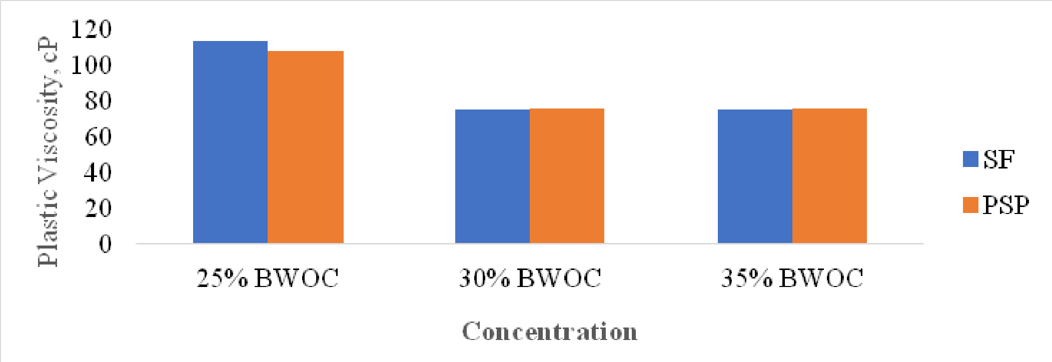

Figure 2: Plastic Viscosity of Various Concentrations of Silica Flour and Psp

Figure 3, it can be observed that the yield point of silica flour is not different from the periwinkle shell powder (PSP), the graph showed that for 25% BWOC and 35% BWOC, the yield point of the periwinkle shell powder (PSP) was noted to be higher than the silica flour, but for the 30% BWOC, the yield point of silica was higher than periwinkle shell powder. The results suggest that 25% and 35% BWOC samples may require higher circulating pressures for the cement samples with periwinkle shell powder than silica flour while 30% BWOC could require higher circulating pressures for silica flour than periwinkle shell powder.

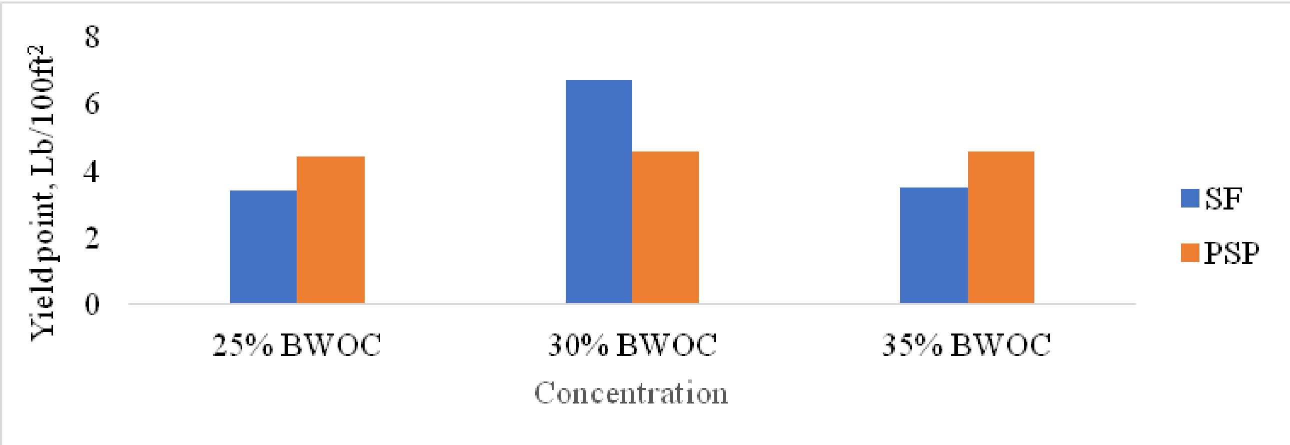

Figure 3: Yield Point for Silica Flour and Psp Cement Slurry Samples

Figure 4 showed the curve fitting of the rheological fluid models from 25% BWOC Silica Flour cement sample. It can be observed that Herschel-Bulkley model with the highest R2 value of 0.9998 gave the best fit curve to the experimental data of 25% BWOC silica flour cement sample, however, the Bingham Plastic and Power Law models have values of 0.9998 and 0.9873 respectively. The results suggest that the performance of the cement and the properties of the cement sample could be adequately determined using Herschel-Bulkley models.

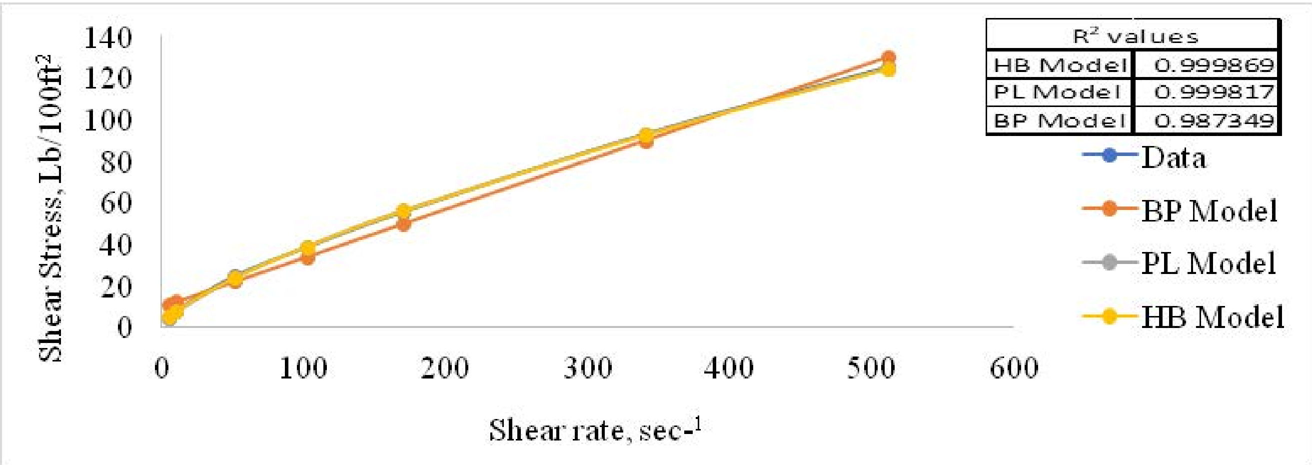

Figure 4: Curve Fitting of Rheological Models to 25% Bwoc Silica Flour

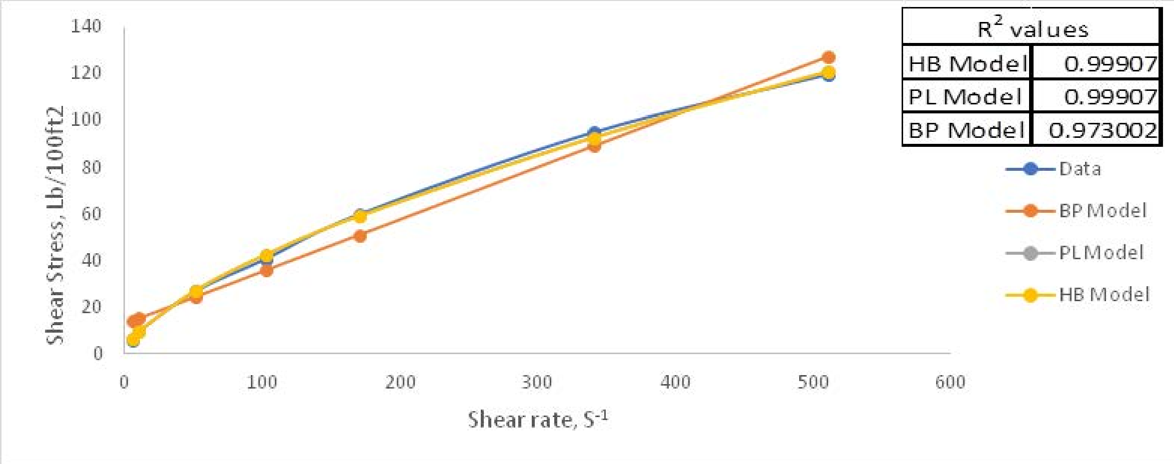

Figure 5: Curve Fitting of Rheological Models to 25% Bwoc Periwinkle Shell Powder

In Figure 5, Bingham plastic, Hershel-Bulkey and Power law models were fitted to the data to obtain the line of best fit. The Hershel-Bulkley and Power law model had R2 value of 0.9990 and while the Bingham Plastic value had 0.9730.

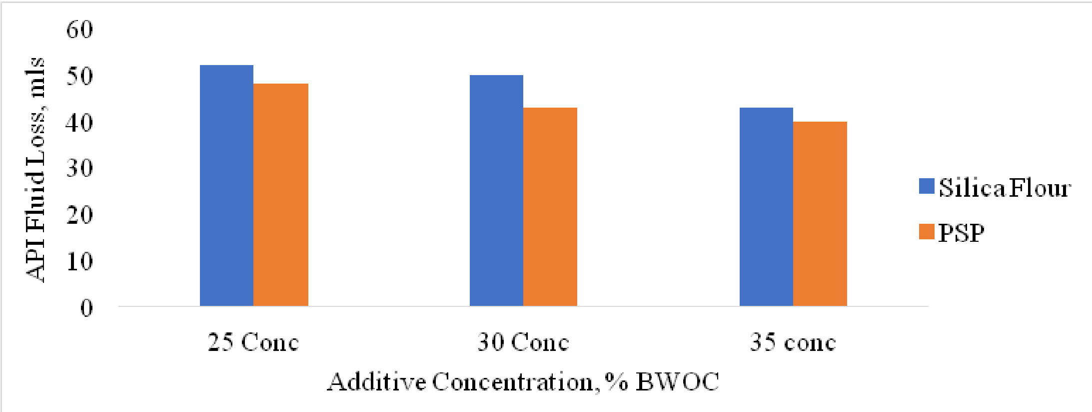

Figure 6: API Fluid Loss from Cement Samples

In Figure 6, the fluid loss was highest at 25% BWOC for both additives. The graph showed that periwinkle shell powder had better fluid loss control than silica flour. However, America Petroleum Institute recommend that fluid loss should not be more than 50ml/30mins. Both samples (silica flour and periwinkle shell powder) met the required criteria.

4. Conclusion

The following conclusions were drawn from the study:

• The periwinkle shell powder (PSP) contained 57% by weight concentration of Calcium and 3% of Silicon while the oxides of periwinkle shell powder contained 80% of CaO%, SiO_2 of 7%, Al_2O_3 of 3.3% in the oxide composition. Periwinkle shells contained CaO, SiO_2 and Al_2O_3. However, CaO and Al_2O_3 prevents the contraction of cement sheath at high temperatures after setting while the SiO_2 helps in cement compressive retrogression strength.

• The plastic viscosity decreased as concentration increased from 25% BWOC to 30% BWOC for the silica flour additive and the periwinkle shell powder additive while the yield point of the periwinkle shell powder (PSP) was noted to be higher than the silica flour. The results suggest that 25% and 35% BWOC samples may require higher circulating pressures for the cement slurry operation.

• The rheological models showed that the Herschel-Bulkley model had R2 value of 0.9998 while the Bingham Plastic and Power Law models have values of 0.9998 and 0.9873 respectively.

References

1. Umoh, A. A., & Femi, O. O. (2013). Comparative evaluation of concrete properties with varying proportions of periwinkle shell and bamboo leaf ashes replacing cement. *Ethiopian Journal of Environmental studies and management, 6*(5), 570-580.
2. Almabrok, A. A., Aliyu, A. M., Baba, Y. D., Ribeiro, J. X., Archibong-Eso, A., Lao, L., & Yeung, H. (2020, August). A comparative analysis of upward and downward pressure gradient behaviour in vertical gas-liquid two-phase flows in a large diameter pipe facility. *In SPE Nigeria Annual International Conference and Exhibition* (p. D013S014R003). SPE.
3. Orji, F., Egwuonwu, C., & Asoegwu, S. (2017). The investigation of periwinkle shell-rice husk composite as a replacement for granite in concrete. *Open Science Journal of Bioscience and Bioengineering, 4*(1), 1-5.
4. Ikpeka, P., Odo, J., & Uzuegbu, G. (2019). Effects of Additive concentrations on cement rheology at different temperature conditions. *International Journal of Engineering Works, 6*(3), 50-70.

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5. Arinkoola, A. O., Salam, K. K., Alagbe, S. O., Afolayan, A. S., Salawudeen, T. O., Jimoh, M. O., ... & Adeosun, T. A. (2021). Influence of Metakaolin and nano-clay on compressive strength and thickening time of class G oil well cement. *Songklanakarin Journal of Science & Technology, 43*(1).
6. Shahriar, A. (2011). *Investigation on rheology of oil well cement slurries.* The University of Western Ontario (Canada).
7. Shahriar, A., & Nehdi, M. L. (2012). Optimization of rheological properties of oil well cement slurries using experimental design. *Materials and structures, 45,* 1403-1423.
8. Ma, S., & Kawashima, S. (2019). A rheological approach to study the early-age hydration of oil well cement: Effect of temperature, pressure and nanoclay. *Construction and Building Materials, 215,* 119-127.
9. Zhang, Y. R., Kong, X. M., Lu, Z. B., Lu, Z. C., & Hou, S. S. (2015). Effects of the charge characteristics of polycarboxylate superplasticizers on the adsorption and the retardation in cement pastes. *Cement and Concrete Research, 67*, 184-196.