

Rheological Behavior of Eco-accommodating Drilling Fluids from Biopolymers

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Abstract: The rheological properties of drilling liquids adjusted with two biopolymers – lignin, and polyanionic cellulose (PAC-R) have been contemplated. The impact of centralization of the biopolymers on the boring liquid was additionally reported. The altered boring liquids were found to obey Herschel Bulkley rheological model. The liquids were additionally observed to be pseudo-plastic with shear diminishing conduct. Polyanionic cellulose demonstrated the most astounding shear rate and shear stress than lignin. This can be ascribed to the straight open long chain structure of PAC-R and its capacity to associate with water, solids and with itself. It likewise went about as a superior viscosifier due to the more negative charge it conveys. Likewise, the plan of biopolymer boring liquid with bentonite has demonstrated to enhance the consistency than that experienced in typical traditional drilling liquids.

Keywords: rheology, biopolymers, drilling fluids, natural polymers, Herschel-Bulkley model

1. Introduction :

Drilling liquids properties are imperative for the achievement of any boring operation. The liquids were initially intended to guarantee that turning boring of underground developments is conceivable and prudent. The drilling liquids accomplish this by (i) moving drill cuttings to the surface, (ii) cooling and cleaning the bore, (iii) decreasing erosion, (iv) keeping up wellbore dependability, and (v) keeping pore liquids from rashly streaming into the wellbore. Also, the boring liquids are basically intended to fabricate a channel cake, which is essentially expected to diminish filtrate misfortune to the arrangement, be thin and hold the drilling liquid in the wellbore [1]. A standout amongst the most basic elements of boring liquids is to minimize the measure of drilling liquid filtrate entering the hydrocarbon bearing development which can prompt arrangement harm in view of rock wettability changes, fines movement, boring liquid solids stopping and development water science incompatibilities [2]. Rheological conduct of drilling liquids is imperative in their appropriate choice for any well. Rheological properties of boring muds are vital on the grounds that they are utilized to describe properties of the mud, for example, its well purifies, disintegration conservation, cutting material expulsion, water powered count, and pump framework [3]. The rheological standards can be utilized to decide the dynamic execution of a boring liquid conduct in taking care of issues of cleaning gap, suspension of cuttings, water driven counts and mud treatment [4]. The accomplishment of any boring operation depends essentially on the execution and cost viability of the boring liquid utilized [5,6,7]. As indicated by Douglas et al [8,9,10], boring liquids are for the most part ordered into: (i) air or froth based liquids which are utilized where fluid drilling liquid is not the most attractive coursing medium; (ii) oil-based liquid, and (iii) water-based liquid. In light of ecological and cost contemplations, water-based liquids offer properties that are for the most part favored over that of oil-based liquids [11]. Drilling liquids ought to be ecologically amicable and contain the most reduced conceivable measure of contaminations. Subsequently, care ought to be taken in the choice and definition of crude materials [12]. These days, different polymers, which can be as normal (e.g. starch), engineered, and/or adjusted (e.g. carboxymethyl cellulose or) polymers, are utilized as a part of request to control the liquid misfortune and thickness of drilling liquids. In oil-drilling, these polymers decrease filtrate, alter rheological properties, balance out shale and diminish drag, and can be utilized as a part of cutting edge oil recuperation (EOR) forms [13,14]. The deluge of the fluid stage, known as filtrate, in beneficial zones can bring about a noteworthy decrease of porousness and henceforth bring down well profitability [15,16]. The consolidation of normal gums and starch-based materials in boring liquids structures was the essential answer for control this wonder [6]. Various studies on polymers and their utilization in water-based drilling liquids have been done [6,17,18,19]. Dim and Darly, [6] examined the utilization of polymers like guar gum, carboxymethyl cellulose, and hydroxypropylstarch as filtration control operators and as boring liquids. They inferred that filtration parameters like sorptivity and diffusivity of these polymers are subject to temperature. Sorptivity is a measure of the resistance against the liquid coursing through the channel cake, while diffusivity is a measure of the rate of stream of liquid [20]. The impact of polymers on the rheological properties of KC1/polymer-sort boring liquids was concentrated on by Kok and Alikaya, [19]. This study concentrated on the impact of expansion of polymers on consistency file, stream conduct list, and shear stress. The creators watched that consistency record expanded as polymer focus expanded. Consistency list is a measure of the general thickness of a liquid, while stream list is a measure of the level of stream conduct of a liquid [17,21]. The resistance of the liquid to the connected rate of shear or compel is known as the shear stress, which in oil field terms is closely resembling the pump weight [19,22,23]. In the present paper, the impacts of including

different amounts of various biopolymers (Polyanionic cellulose, carboxymethyl cellulose and lignin) to a boring mud test containing bentonite will be accounted for. The rheological properties of the boring liquids will be resolved and examination made. Xanthan gum is an anionic polysaccharide polymer with high sub-atomic weight produced by starch after aging of xanthomonas campestris. Carboxymethyl cellulose is a semi-adaptable anionic cellulose ether polymer [27] that is created by responding antacid cellulose with sodium monochloroacetate under inflexibly controlled conditions. It is a concoction subsidiary of cellulose where a portion of the hydroxyl bunches (- OH) are substituted with carboxymethyl bunches (- CH₂COOH) while polyanionic cellulose (PAC) is a sort of anionic cellulose ether of high virtue and high level of substitution, arranged with characteristic cellulose through synthetic adjustment. Its sodium salt is regularly used. The essential distinction amongst the and PAC generation procedures is in the radicalization step and the high level of substitution in PAC. The structures of the biopolymers utilized are shown beneath. As is surely understood for , PAC and other cellulose ethers, the attributes of these materials can be changed by having diverse normal quantities of substituents per glucose unit and distinctive atomic weights [28].

2. Theory:

The ideas of shear stretch and shear rate and their estimation empower the scientific depiction of the stream of drilling muds. The measure of power connected to a liquid decides the shear rate, which in oil field terms is controlled by the stream rate of the liquid through a specific geometric design. Stream models are plots both of stream weight versus stream rate or of shear anxiety versus shear rate. The Power law and Herschel –Bulkley models are portrayed here and utilized for the portrayal of the boring liquids concentrated on.

2.1. Power Law Model

Power law is a two – parameter model that relates shear stress to shear rate in a nonlinear manner [17,23]. The model does not consider an excess yield stress and states the relation as:

$$\tau = K \dot{\gamma}^n \quad (1)$$

where k , and n are consistency and flow indices respectively, τ is the shear stress, and $\dot{\gamma}$ is the shear rate. Taking the logarithm of the equation, the following term is obtained:

$$\log \tau = \log k + n \log \dot{\gamma} \quad (2)$$

Thus, n = slope and k = intercept.

2.2. Herschel-Bulkley Model

Herschel-Bulkley is a three-parameter model that describes the behaviour of yield-pseudoplastics fluids [21].

$$\tau = \tau_0 + k \dot{\gamma}^n \quad (3)$$

where τ is the shear stress, τ_0 is the yield stress, k is the consistency index, $\dot{\gamma}$ is the shear rate, and n is the flow index.

3. Materials

The lignin utilized for this study was gotten from Baker Hughes Houston USA under the exchange name of XAN-PLEX™. Polyanionic cellulose consistent under the exchange name DRISPAC from Yu Long Chemicals China was among the normal polymers utilized as a part of this study. Bentonite and were acquired from Global Oil Company Nigeria Limited. The hardware/mechanical assembly utilized as a part of this study include: Fan V-G meter 8 speed model viscometer; hamilton shoreline blender; stop watch; electronic measuring parity; spatula, viscometer glass and hamilton shoreline blender container; institutionalized measuring plate and thermometer.

3.1. Experimental Procedure:

The suspension of bentonite tests were set up by submerging 15g of bentonite clay into 350cm³ of deionized water. The blend was mixed vivaciously for 15 minutes to accomplish homogeneity while discontinuously dislodging any bentonite sticking to the mass of the blending holder. The bentonite suspension was then put away at room temperature in a fixed holder for 24 hours to give space for maturing. Polyanionic cellulose Regular (PAC-R) was added to the Bentonite suspension at different fixations (0.50 g, 0.75g, 1.0g) and the viscometric studies did to decide its rheological conduct on the boring liquid. Reasonable amounts of sodium hydroxide (NaOH) and Potassium chloride (KCl) were added to the examples and blended to alter the pH and for hindrance separately. The technique was then rehashed for and lignin biopolymers separately. The shear-anxiety was resolved utilizing the force law model which accept that all liquids are pseudoplastic.

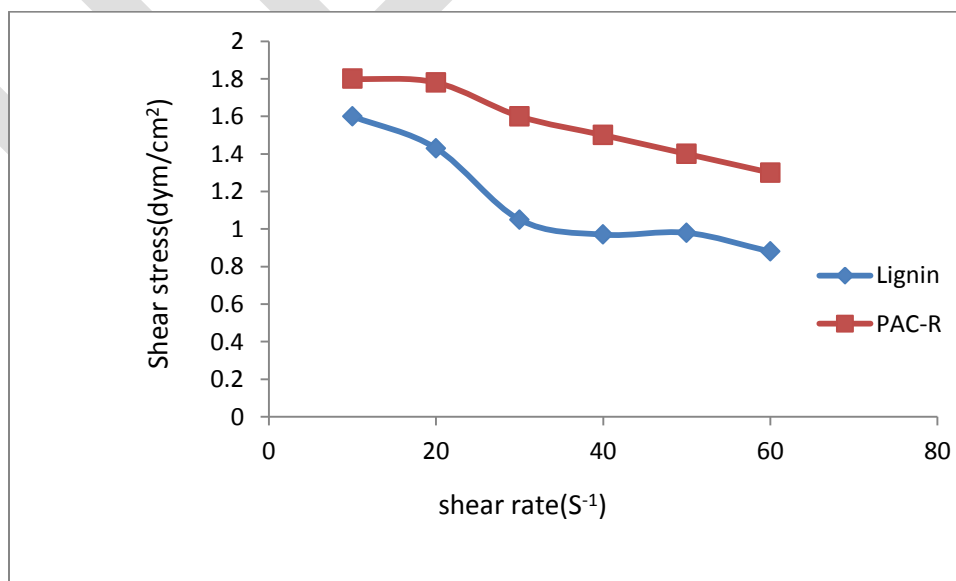
4. Results and Discussion:

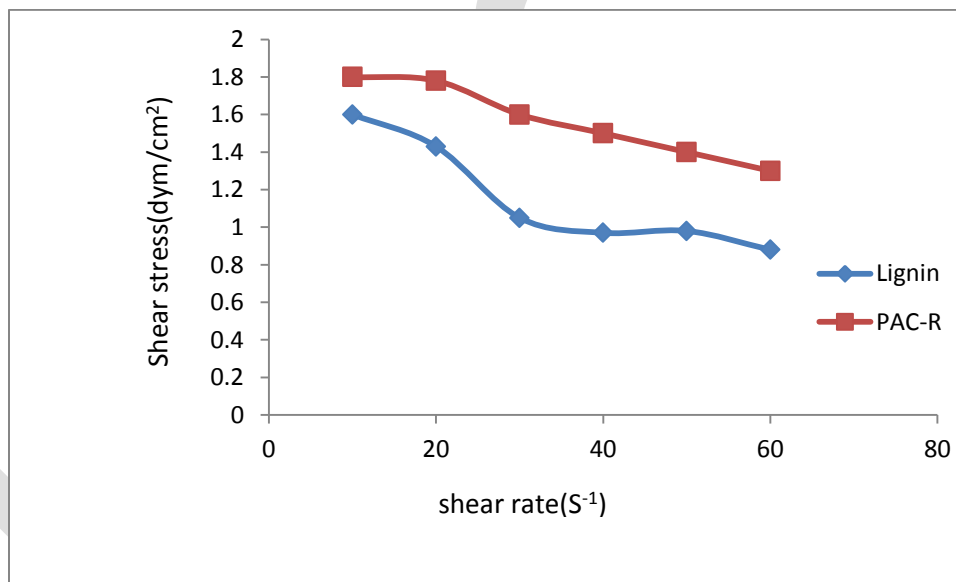
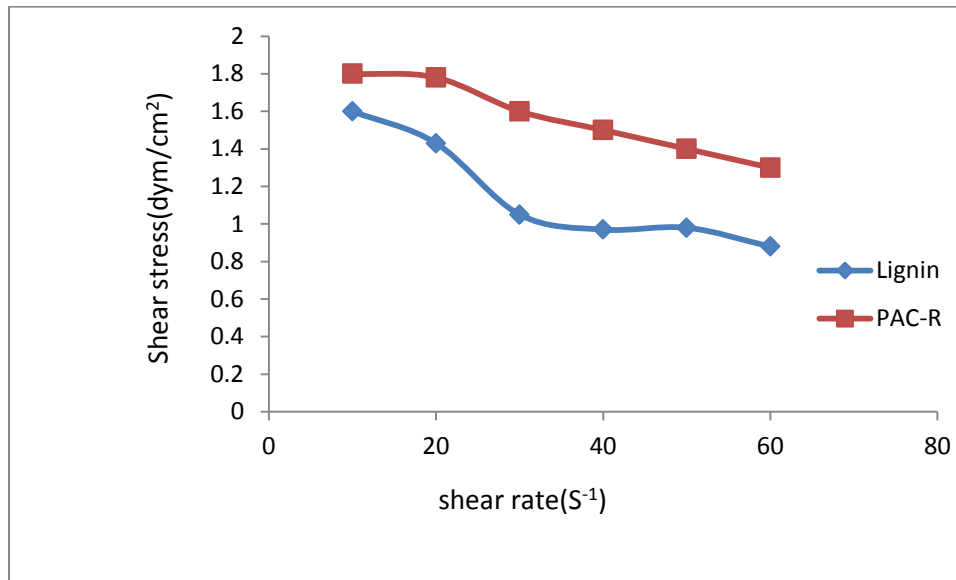
The rheological parameters such as plastic viscosity, yield stress, and apparent viscosity of all of the drilling fluids were calculated and presented in Table 1. Figures 1 – 3 illustrates the relationship between shear stress, and shear rate of the non-Newtonian fluids at different concentration of the biopolymers.

The example of these bends demonstrated an underlying high stretch after which there was a less push with expanding shear. This demonstrates the liquids are pseudoplastics and comply with the Herschel-Bulkley model. As per Hemphill et al. [24], Herschel-Bulkley liquid model requires a specific anxiety to start stream, yet less with expanding shear. The three parameters of Herschel-Bulkley model, i.e., yield stress, liquid consistency, and liquid file were figured by fitting the trial information of shear anxiety as an element of rate of shear to the model in Equation 3. The outcomes demonstrate that the augmentation of the measure of biopolymers, expand the yield anxiety of the last boring liquid as the stream resistance is expanded. This finding is in concurrence with the aftereffects of Khalil and Jan [25]. The expansion in yield stress with focus came about because of an expansion in shear stress required to

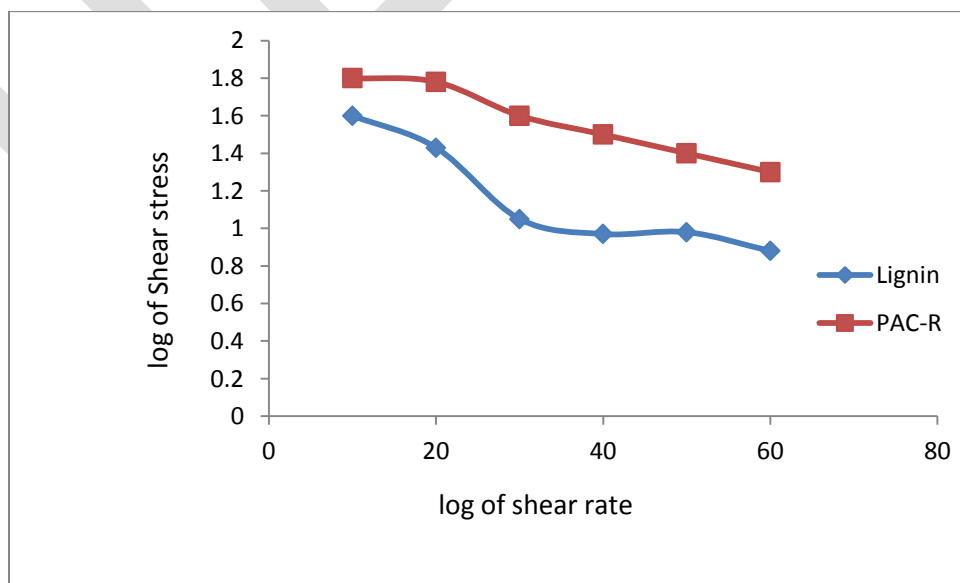
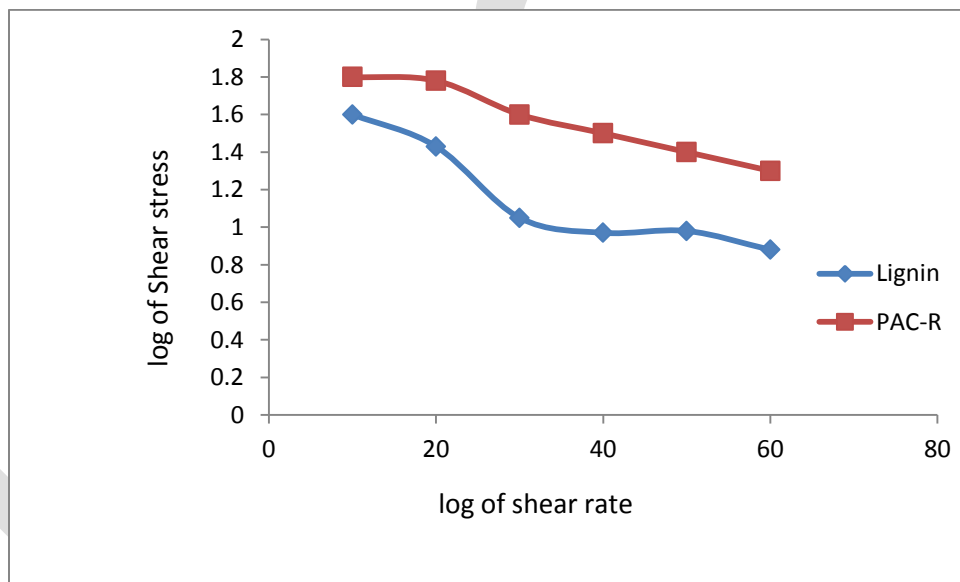
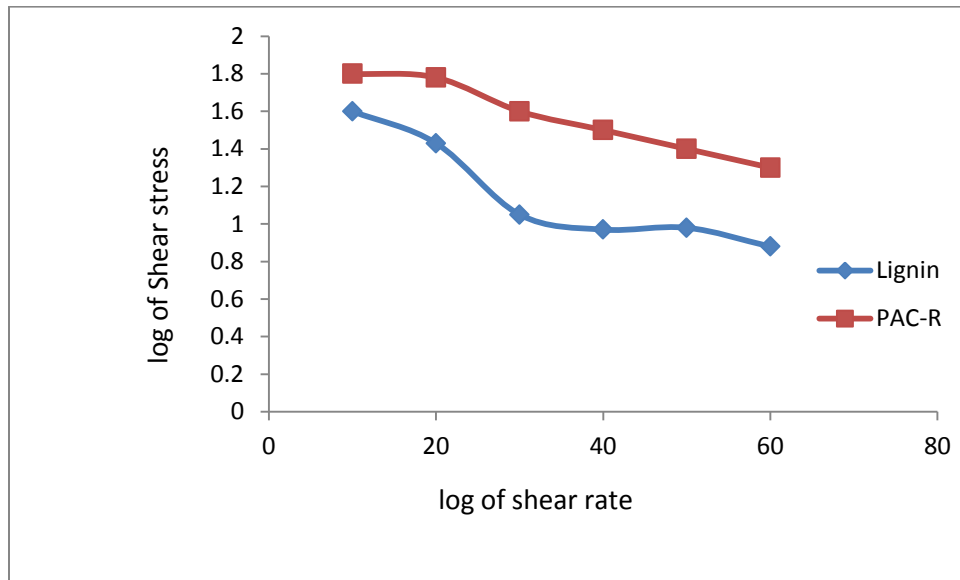
Fluid Reference	PAC R			LIGNIN		
	0.50g	0.75g	1.0g	0.5g	0.75	1.0g
Plastic viscosity(P)	1.6	1.9	2.6	1.02	1.02	1.5
Apparent viscosity(P)	9.55	14.35	25.7	8.13	12.09	18.91
Yield Stress(dyn/cm ³)	15.4	24.1	44.3	14.2	17.3	20.3
Flow Index, n	0.419	0.391	0.281	0.327	0.218	0.248
Consistency Index, K	5.813	9.312	19.853	4.813	9.829	9.328

break the gel structure of the mud before stream began. Besides, it could be viewed as that, very still, the mud's chains were trapped and the gel development came about because of the polymer system framed by the physical conglomeration with area of nearby request going about as system intersections. The stream file, n, and consistency list, k, of the boring liquids were investigated utilizing Equation 2 and this relationship is shown graphically in Figure 4 – Figure 6. The n values displayed in Table 1 demonstrates that the stream record, n, is under 1 for every drilling liquid at the different groupings of the biopolymers contemplated showing a shear diminishing conduct. As indicated by Mewis et al. [21], a liquid for which n value is under 1 ($n < 1$) is said to have pseudo plastic stream conduct. Further examination of the table uncovers that the stream file n, of the drilling liquid diminished with expanding grouping of polyanionic cellulose.

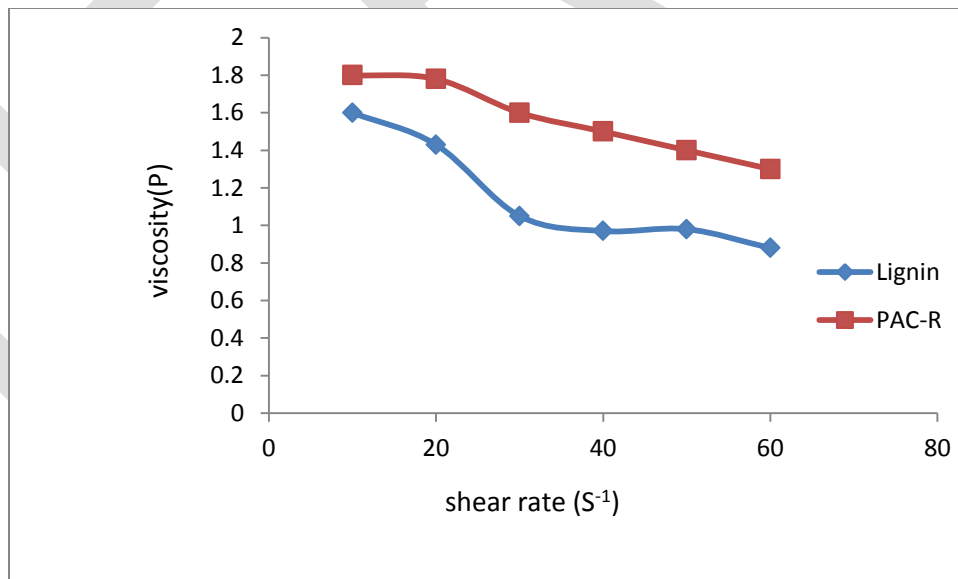
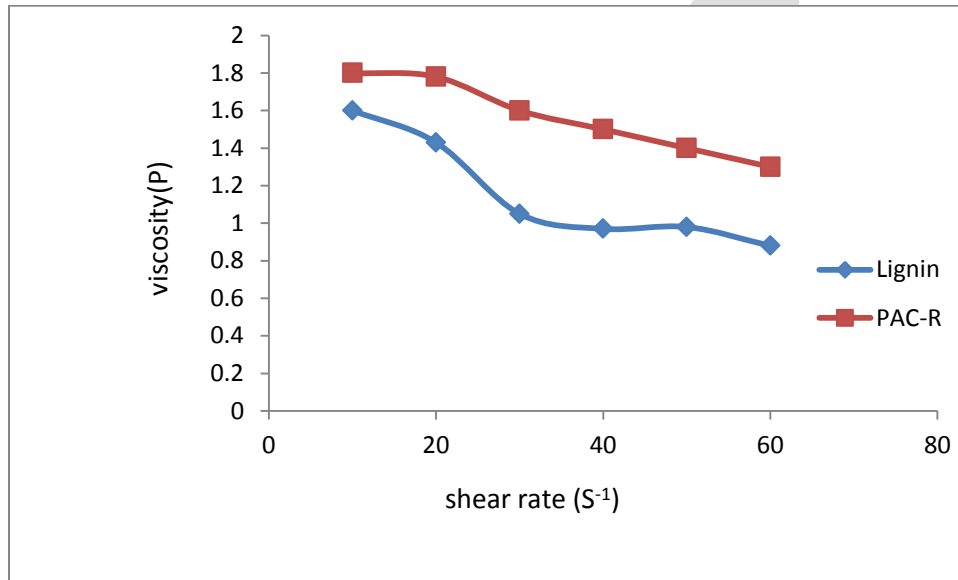


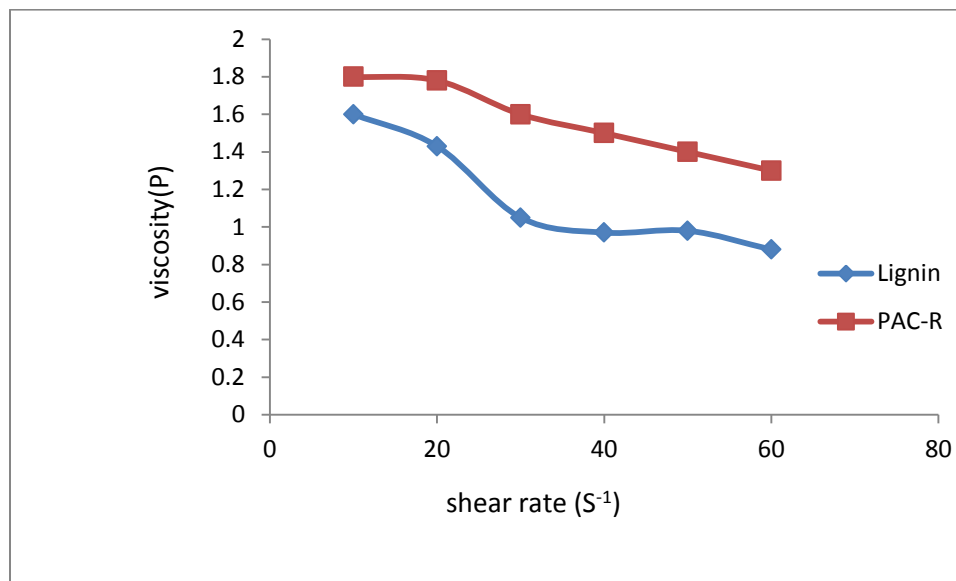


This is as opposed to the discoveries of Chike-Onyegbula et al [26] who contemplated biodegradable polymer boring mud arranged from Guinea corn starch. The consistency list, k , for the polyanionic cellulose altered boring liquid was found to increment with expansion in the convergence of the polymer in the liquid. The expansion in consistency record, k , with polyanionic cellulose focus came about because of the expansion in the general thickness of the liquid. On account of boring liquids adjusted with lignin and caboxymethyl cellulose, the consistency file, K and stream file, n shows up not to be influenced by the amount of the biopolymer. Oppositely, Khalil and Jan [25], found that the ascertained liquid consistency of their boring liquids gives off an impression of being unequivocally subject to the nearness of glass air pockets, xanthan gum, and mud. Be that as it may, their liquid consistency shows up not to be influenced by the nearness of starch.



The plot of shear rate as a capacity of viscosity is appeared in Figure 7 – Figure 9. It is seen from these assumes that the consistency of the boring liquids diminished with expanding shear rate. This came about because of the way that the ensnarement of the liquid's chain at low shear rate blocked shear stream and the thickness was high. The thickness diminished as shear rate was expanded, demonstrating shear diminishing conduct of the drilling liquids. The thickness of a polymer arrangement is identified with the polymer focus, the degree of polymer-dissolvable collaboration, and the polymer structure, for example, atomic weight, shap, sub-atomic adaptability, and sub-atomic compliance [29].





Pseudo-plastics are known not stream with diminishing rate of shear anxiety. It was further watched that the centralization of lignin and caboxymethyl cellulose in the boring liquids did not have any impact on its thickness while; expanding grouping of polyanionic cellulose expanded the consistency of the boring liquid. Hence expanding the grouping of polyanionic cellulose will build its imperviousness to stream under specific levels of connected anxiety.

5. Conclusion :

The Rheological properties of boring liquids can't be overemphasized on account of their conspicuous commitment to the general fruitful boring operations. This study has shown the utilization of earth benevolent biopolymers in the creation of boring liquids. The boring liquids were observed to be non-Newtonian and show pseudo-plastic conduct. The shear stress, yield anxiety, and consistency of the eco-accommodating liquids are subject to focus and have higher qualities indicating higher gel quality and flocculation for the new liquid than for the generally utilized liquids. The consistency of the liquids diminishes with expanding shear rate; accordingly, the new liquids have a shear diminishing conduct. The new biopolymer liquids are along these lines more appropriate for investigation and abuse of oil and gas in naturally delicate zones because of its high effectiveness and immaculateness. Polyanionic cellulose (PAC-R) demonstrated the most noteworthy shear rate and shear stress than carboxyl methyl cellulose and xanplex D. This was a direct result of the straight open long chain structure of PAC-R and its capacity to associate with water, solids and with themselves. It additionally went about as a superior viscosifier as a result of the more negative charge it conveys. Likewise, the plan of polymeric drilling liquid with Bentonite has demonstrated to enhance the consistency than that experienced in typical traditional boring liquids.

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