FEASIBILITY STUDY OF PALM OIL ESTERS AS BASED FLUID IN DRILLING OPERATION

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ABSTRACT

Drilling oil and gas wells requires special drilling fluid, which are usually called mud. For normal drilling operation, the based fluids such as seawater or treated water are usually used for drilling job. However, special oil based fluid such as mineral oil, diesel or synthetic oil are required to avoid drilling problems such as shale swelling, high temperature wells, highly deviated or horizontal wells, etc. Unfortunately, the oil based drilling fluids are usually expensive, highly toxic and will cause pollution to the environment. This paper will discuss the feasibility study of using Malaysian palm oil esters as based drilling fluid since it is environmental friendly and have huge supply of raw material. Esters such as isopropyl laureate and methyl laureate are selected for this study. The performance and characteristics of these esters will be evaluated and compared to see their suitability as compared to the oil and water based fluids. The preliminary results showed that Malaysian palm oil ester has a potential to be used as based drilling fluid.

Keywords: drilling fluid, ester

INTRODUCTION

Drilling fluids were introduced with rotary drilling in 1900. The American Petroleum Institute (API) defines a drilling fluid as a circulating fluid used in rotary drilling to perform any or all of the various functions required in a drilling operation. The main component of drilling fluid can be gas, water or oil. To date, the application of oil-based drilling fluid increases significantly due to its superior performance in lubricating behavior for extended and directional drilling operation, minimal maintenance, high temperature stability and tolerance to contamination. Although the cost of oil-based drilling fluid may claim about two or three time more higher than water-based system, their use is justified by better performances and savings on fluid maintenance (Digouy *et al.*, 1993).

Drilling fluid is used primarily to maintain downhole pressure, carry and transport the drill cuttings from the wellbore, transfer the generated heat of the drill pipe and facilitate the drilling operations. The efficiency of the drilling fluid to perform such functions is based on the flow behavior or rheological properties of the fluid system.

The rheological behavior is the indication of the ability of drilling fluid in (i) hole cleaning and hole erosion, (ii) suspension of drill cuttings, (iii) hydraulic calculations, and (iv) requirement of drilling fluid treatment (Chilingarian *et al.*, 1983). The rheological properties of drilling fluid are basically represented by plastic viscosity, yield point and gel strength. The yield point is a measure of electrical attractive forces in the drilling fluid system under flowing conditions. No bulk movement of the fluid occurs until the applied stress exceeds the yield point. Plastic viscosity indicates the drilled cuttings suspension and hole cleaning abilities under dynamic condition. On the other hand, the fluid thickening effect and suspension capabilities under static condition are controlled by gel strength. The adjustable and flexibility of the rheological properties of drilling fluids play a very important role in determining the success of overall drilling operations. In order to obtain a properly functioning drilling fluid, rheological properties should be continuously measured and modified if necessary.

Ester-based drilling fluids are gradually getting more acceptance due to their readily biodegradable in both aerobic and anaerobic environments (Peresich et al., 1991). In this study, the potential of local vegetable oils as the oil-based in drilling fluid formulation is evaluated. Methyl laureate ester-based (MLB) isopropyl laureate ester-based (IPLB) drilling fluids are derived from Malaysian palm oil derivatives, methyl laureate and isopropyl laureate respectively. The characteristics and rheological properties of the both ester-based systems were modified and compared with the commercially water-based (WB) and oil-based (OB) drilling fluids.

EXPERIMENTAL

Mud samples with density of 10.0 ppg were prepared for all the tests in this research. The components used in the formulation of the commercially available water-based and oil-based systems as well as the evaluated ester-based systems are listed in Table 1.

The drilling fluid was formulated on a 350-cc scale using a Silverson Mixer. The continuous base was measured into a suitably sized container. Whilst stirring, weighed amount of each of the additives was added into the system sequentially at intervals of five minutes. The mixture was stirred continuously for a further five minutes until a homogeneous system was obtained. Density, rheological properties, (plastic viscosity, yield point and 10 seconds/10 minutes gel strength) and electrical stability voltage of the prepared invert emulsion mud systems were recorded at room temperature, 80°F.

Table 1. The components of drilling fluid formulation

Water-based Drilling Fluid (WB)	*Oil-based Drilling Fluid (OB), Methyl Laureate-based Drilling Fluid (MLB) or Isopropyl Laureate-based Drilling Fluid (IPLB)*
• Water • KCl (inhibitor) • NaOH (pH controller) • Filtrate loss control agent • Gel forming agent • Weighting agent	• Mineral oil, methyl laureate or isopropyl laureate • Primary emulsifier • secondary emulsifier • Brine water • Filtrate loss control agent • Gel forming agent • Wetting agent • Weighting agent

RESULTS AND DISCUSSION

Stability of the invert emulsion systems for oil-based, and both ester based drilling fluids is critical indicator for the consistency performance of the systems. Table 2 reveals the electrical stability voltage of the invert emulsion systems. The higher voltage value of both ester-based systems compared to commercially oil-based drilling fluid system convinces the effectiveness of the emulsifiers used to reduce the interfacial tension within the systems. Result also shows that when the brine water content increases from oil/water ratio of 90/10 to 80/20, water droplets in the invert emulsion system are within the vicinity of each other and associate to from larger water droplets which substantially reduces the stability voltage value.

Table 2. Electrical stability voltage for different invert emulsion drilling fluid systems

Invert Emulsion System	*Electrical Stability Voltage, V*	
	Oil/water Ratio = 90/10	*Oil/water Ratio = 80/20*
Oil-based	801	604
Methyl Laureate-based	962	607
Isopropyl Laureate-based	847	716

Rheological analysis of the drilling fluid systems displayed similar results for plastic viscosity value for all the fluid systems as shown in Fig. 1. The representative bar for water-based system in Fig. 1 appears individually and differently from those invert emulsion systems since its contains only water phase in the formulation. The larger molecule of isopropyl causes greater plastic viscosity than methyl laureate system. However, both esters are compatible to the commercially systems in the sense of drilled cuttings suspension and hole cleaning capability.

Fig. 2 shows plots of yield point for the formulated drilling fluid systems. Both ester-based systems demonstrate lower yield point values than the water-based and oil-based systems. This incorporates the limitation of the ester-based systems in drilled cuttings removal especially at low shear rate. Results also suggest that increases of the brine water content in the systems can increase the yield point. However such approach is not recommended practice since the additional water content would increase the plastic viscosity to some extend which eventually will cause severe pressure loss throughout the drilling fluid circulating process. Application of suitable gelling agent or increases the dosage of the gelling agent is more practical and effective method to improve the yield point of the ester-based systems.

Gel strength which is reported in 10 seconds-10 minutes measurement represents the gelling effect of the drilling fluid systems during motionless. The gel building up property is significant to suspend the drilled cuttings and drill pipe when the drilling is temporary ceases for particular drilling operations such as drill pipe stripping and casing. Data in Fig. 3 illustrates the gel strength for oil water ratio of 90/10 and 80/20 for each of the drilling fluids systems. Mild increases of the gel strength with time confirm the thixotropic property of all the drilling fluid systems (Brown *et al.*, 1991). Again the ester-based systems show an acceptable gelling effect compared those commercially available systems.

Better performance of gelling can be obtained by increasing the water content which behaves as pseudo particles and aid in suspension capability of the fluid systems.

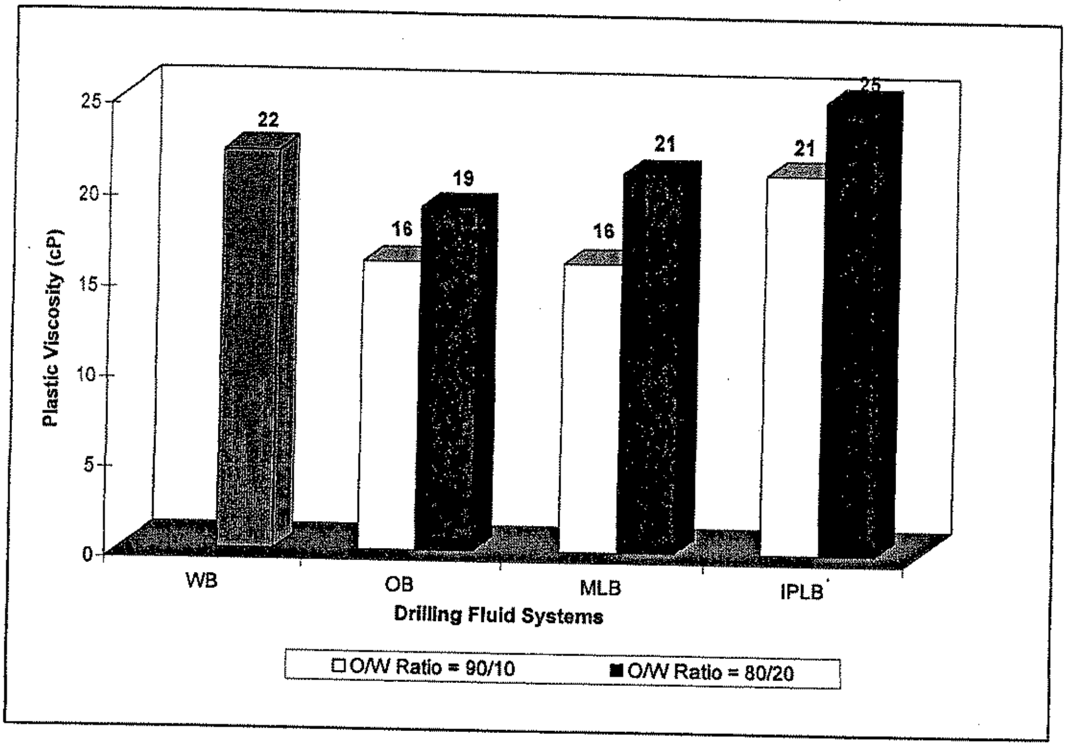


Fig.1 Plastic viscosity of drilling fluid systems for oil/water ratio of 90/10 and 80/20

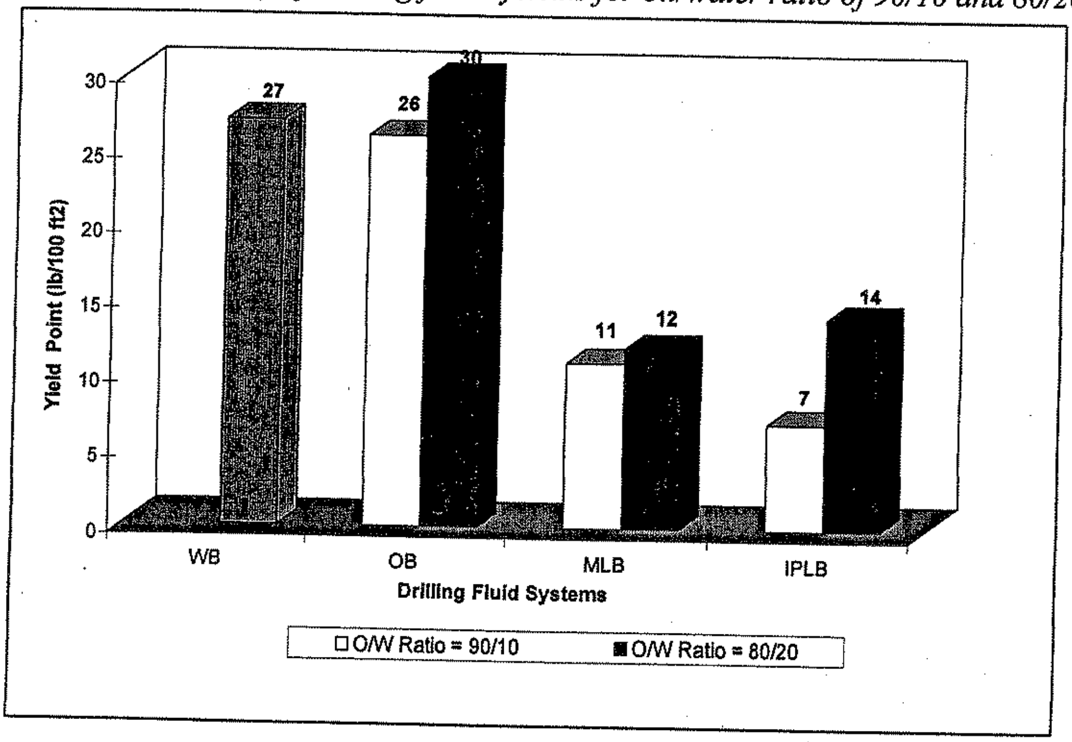
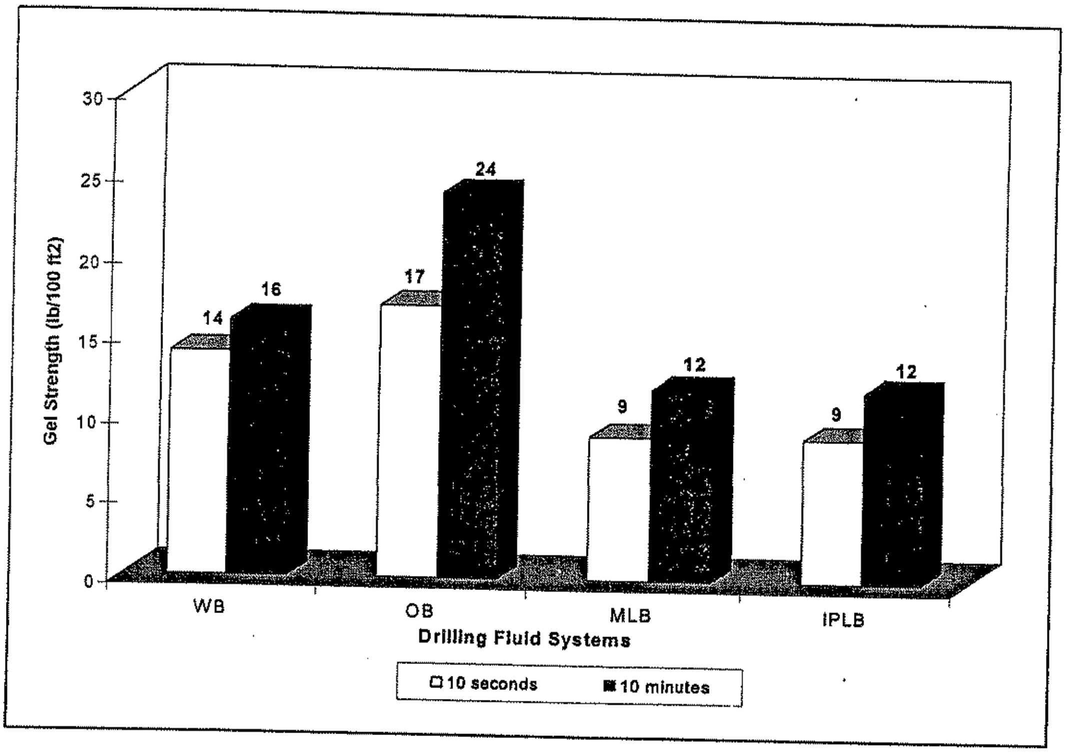
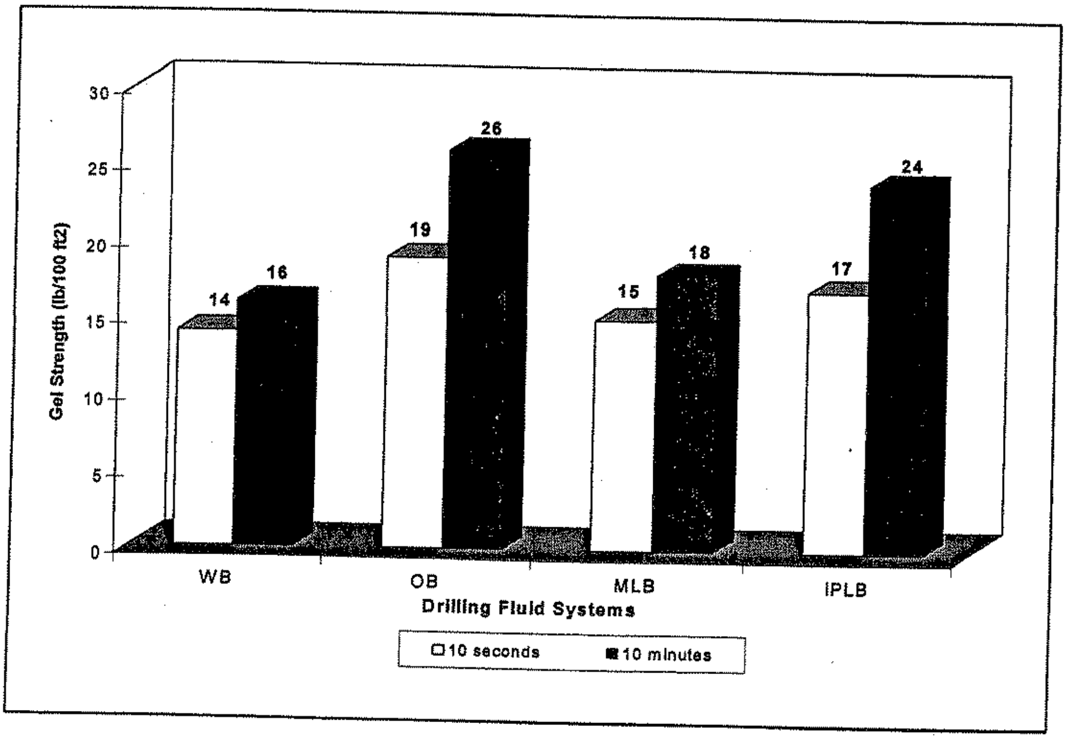


Fig.2 Yield point of drilling fluid systems for oil/water ratio of 90/10 and 80/20



(a). Oil/water ratio = 90/10



(b). Oil/water ratio = 80/20

Fig. 3 Gel strength of drilling fluid systems for oil/water ratio of 90/10 and 80/20

CONCLUSION

This study exhibits that Malaysian palm oil derivative, methyl laureate and isopropyl laureate ester can be used to develop drilling fluid systems. The presence of the plastic viscosity, yield point and gel strength of both ester-based systems suggests the non-Newtonian behavior of the fluid systems (EXLOG, 1985). The rheological properties of the ester-based systems are depending on the ester type as well as the water content in the systems. Although exceptional lower yield point was observed for the ester-based systems, the authors strongly believe that this can be improved by the use of others suitable additives. Additional study should be conducted to investigate the rheological properties of the fluid systems at bottom hole conditions, which is at high pressure and high temperature since the properties will be altered at that curious environment.

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