Ester-Based Drilling Fluids Toward Improved Filtration Properties Performance

Azmi Kamis, Abdul Razak Ismail, Issham Ismail &
Khor Siak Foo
Faculty of Chemical & Natural Resources Eng.
Universiti Teknologi Malaysia
81310 UTM Skudai, Johor

Keywords: drilling fluid; ester; hydrolysis; filter cake.

ABSTRACT

Synthetic based drilling fluids have been developed to meet difficult drilling targets with reduced environmental impact. Vegetable oils have been extensively studied as an alternative to common oil-based drilling fluids. However most of the vegetable oils are chemically reactive and can undergo alkaline hydrolysis at high temperature, which will increase the thickness of the filter cake and the filtrate loss volume. The development of an ester-base drilling fluid system with low filtration loss volume is the central focus of this research. It was found that Malaysian palm oil derivative could be used for the formulation of a suitable drilling fluid, which performed acceptable rheological properties compared to commercially available drilling fluid system. Under similar formulation, isopropyl laureate (IPL) demonstrated an acceptable low permeability filter cake and less filtrate loss volume compared to methyl laureate (ML). Result showed that filtrate loss property can be further enhanced by increasing the quantity of fluid loss control agent as well as reducing the water content in the emulsion system.

INTRODUCTION

Permeability refers to the ability of fluids to flow through porous formations. In order to prevent formation fluids from entering the wellbore, the hydrostatic pressure of the drilling fluid column must

be greater than the pressure of the fluids in the pores of the formation. Consequently, drilling fluid tends to invade the permeable formations and a filter cake of drilling fluid solids will be deposited on the wall of the wellbore. Excessive filter cake thickness and high filtrate loss may cause some problems such as 'tight' hole conditions, poor log quality, increased torque and drag, stuck pipe, lost circulation, and formation damage (Simpson *et al.*, 1974). Hence drilling fluid systems should be designed to deposit a thin, low-permeability filter cake on the formation to limit the invasion of drilling fluid filtrate into the wellbore.

Over the past several years, the use of oil-based drilling fluids in the petroleum drilling industry has increased significantly. The increased usage of these invert-emulsion systems is due to their stability and effectiveness in troublesome drilling cases especially water sensitive shales, extended hole or high temperature wells. However environmental constraints have led to the development of biodegradable invert emulsion drilling fluid systems which have excellent health and safety aspects. As an alternative to common oil based drilling fluids, the petroleum exploration industry is trying to substitute these conventional oil based fluids with biodegradable esters derived from vegetable oils (Peresich *et al.*, 1991). However, these esters are more reactive chemically compared to conventional mineral oils and most importantly can undergo alkaline hydrolysis at high temperature which will increase the thickness of the filter cake and the filtrate loss volume while applying in drilling operations. These drawbacks have limited the applications of the ester oil-based drilling fluids.

In order for palm oil derivatives to be used, this hydrolysis reaction must be minimized. This can be achieved by careful selection of the oil types (Khor *et al.*, 1999) and the proper control of the fluid's alkalinity (Hodder *et al.*, 1991). In this study, Malaysian palm oil derivative ester oils, methyl laureate ester and isopropyl laureate ester which have high stability against alkaline hydrolysis were tested on their effect on filtration properties.

EXPERIMENTAL PROCEDURES

Invert emulsion ML and IPL ester oil-based drilling fluid systems were formulated by mixing the weighed amount of ester, emulsifiers,

lime, brine water, viscosifier, fluid loss control agent (Versatrol), oil wetting agent and barite into a 350 cc scale sequentially at intervals of two minutes. Stirring of the oil bases was maintained throughout the addition of all additives involved. Selected formulation of each ester-based systems which performed acceptable rheological properties were compared to Sarapar, a commercially available synthetic oil-based system, for their high temperature-high pressure (HTHP) filtration loss property. This was done by heating the drilling fluid at 250°F under a pressure of 500 psi and filtrate collected in 30 minutes were recorded. These procedures were repeated by varying the Versatrol concentration from 0, 4, 6, 8 and 10 g for the oil/water ratio (OWR) of 90/10, 80/20, and 75/25 respectively.

RESULTS AND DISCUSSION

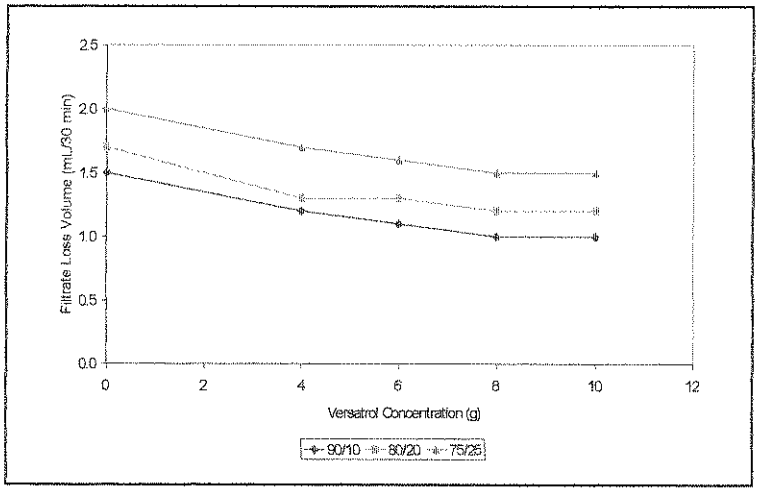
Table 1 shows that the physical properties of the prepared ester-based systems are similar compared to the Sarapar based system. Therefore, it can be concluded that drilling fluid systems prepared from this formulation mimic those of the commercially available system and can be used to study filtration property performance.

Table 1: The Properties of Inverted Emulsion Drilling Fluids (OWR: 90/10)

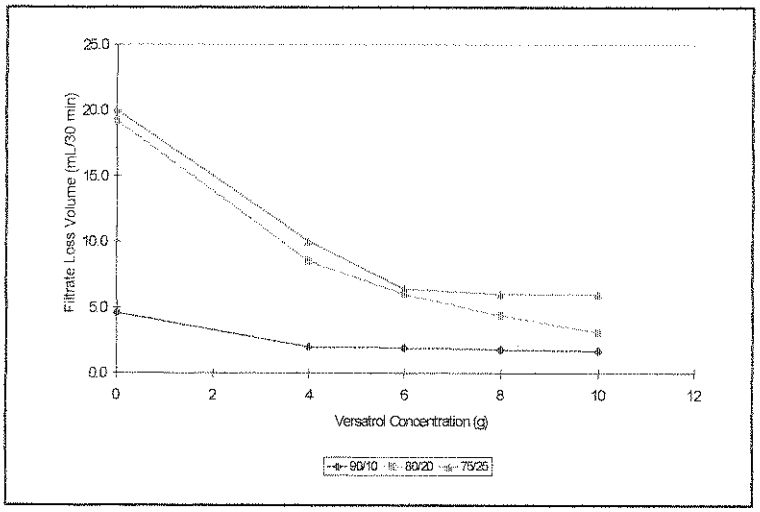
Drilling Fluid	Sarapar	ML	IPL
Plastic viscosity, cP	16	16	21
Yield point, lb/100 ft^2	13	11	7
10s/10min Gel Strength, lb/100 ft^2	16/21	9/12	9/12
Electrical stability, volt	1021	962	847

As can be seen in Figures 1 (a) and 1 (b), the increase in Versatrol concentration decreases the collected filtrate loss volume in 30 minutes. This pattern is expected as increasing the Versatrol concentration resulted in an increase in available binding sites on the fluid loss control agent. These active sites react with the oil base to form a homogeneous system, which further reduce the porosity of the filter cake formed. Figure 1 (c) shows IPL ester based system has a

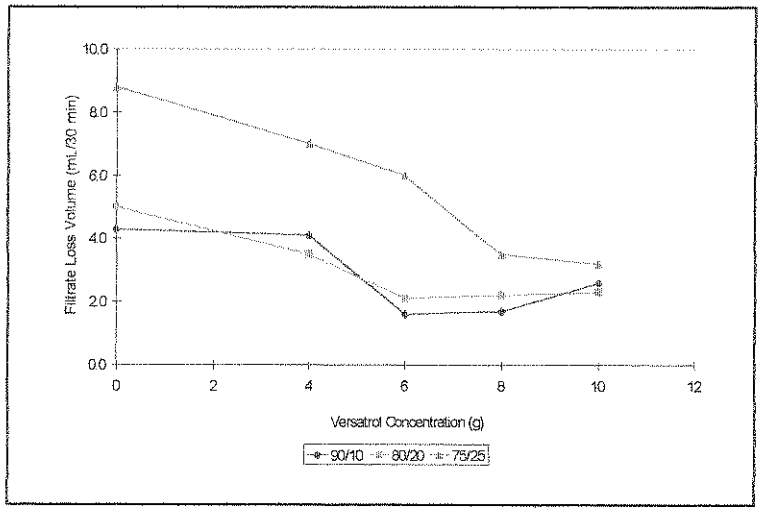
similar trend to that of Sarapar and ML ester based systems. However an increase in filtrate loss volume was observed when the Versatrol concentration increased from 8.0 g onward especially for the oil water ratios of 90/10 and 80/20. This probably due to the over dosage of the fluid loss control agent, which had increased the porosity of the filter cake instead of reducing as expected.



(a) Effect of Versatrol on Filtrate Loss Property (Sarapar)



(b) Effect of Versatrol on Filtrate Loss Property (ML)



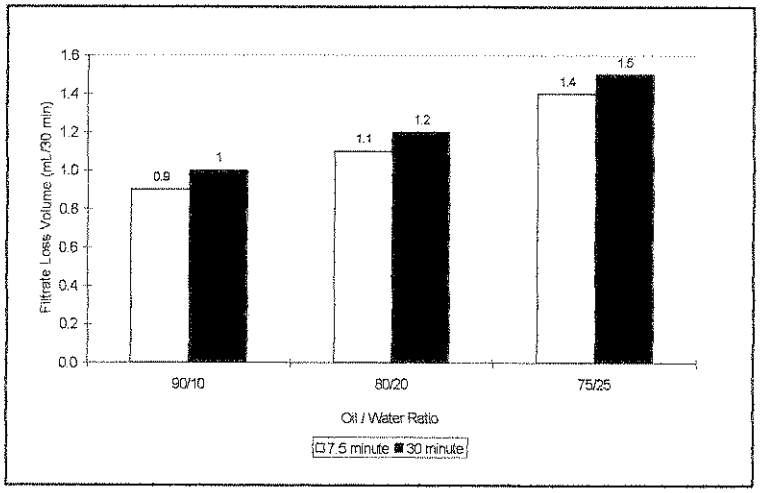
(c) Effect of Versatrol on Filtrate Loss Property (IPL)

Figure 1: Effect of Versatrol Contamination on Filtrate Loss Property Conditions: Different Versatrol Concentration (g/350 cc drilling fluid) for OWR of 90/10, 80/20 and 75/25.

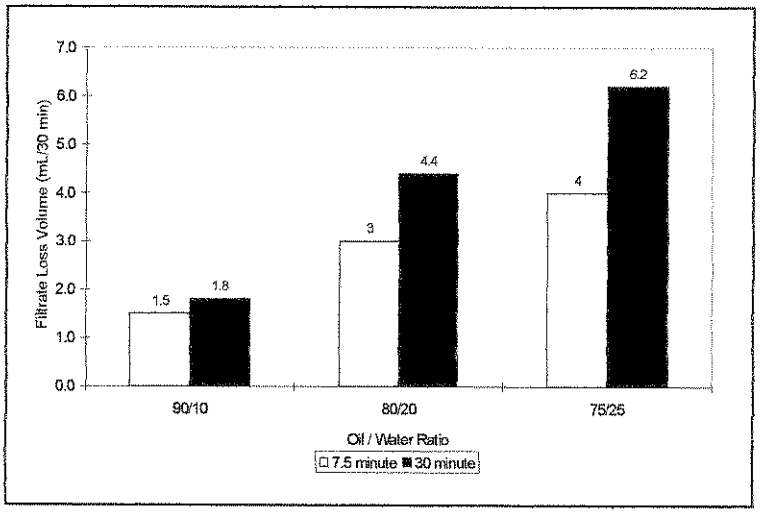
High pressure-high temperature filtration characteristics of Sarapar, ML and IPL oil-based drilling fluid systems were compared by varying the oil-water ratio in each of the systems. Figures 2 (a), 2 (b) and 2 (c) illustrate the results of filtrate loss volume of all three drilling fluid against time for oil-water ratio of 90/10, 80/20 and 75/25 respectively. Sarapar oil-based drilling fluid system displayed lowest filtrate volume over 30 minutes for all oil-water ratios under investigation. On the other hand, IPL ester based oil system demonstrated moderate filtrate loss whereas ML has poorest filtrate loss property among the oil based drilling fluid systems. The better filtration property of IPL oil-based drilling fluid compared to ML oil-based drilling fluid is partly due to the filter cake property. The larger molecular size of IPL compared to the latter is also a contributing factor, with less IPL molecules passing through the filter cake. However filtrate volumes of IPL and ML are considered low and establish the fact that these esters are suitable to be used as base fluids in drilling fluid formulation.

Results clearly illustrate the increase in filtrate loss volume with increasing water content in the emulsion system. When water

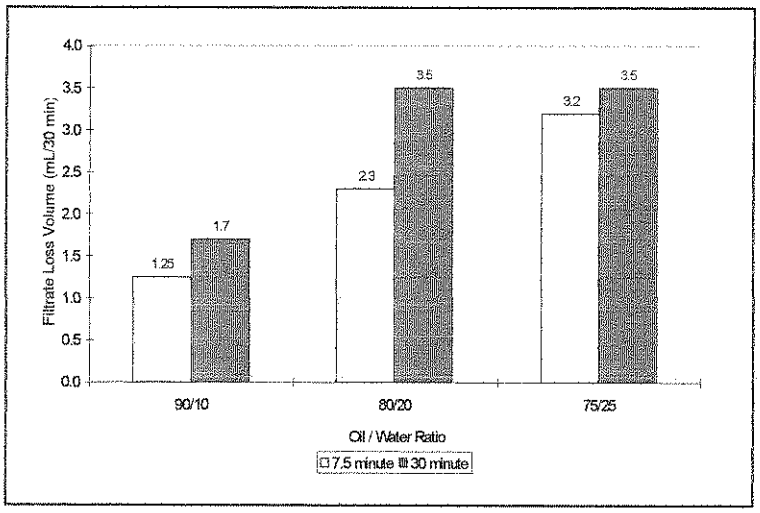
content increases, water droplets in the invert emulsion system are within the vicinity of each other and associate to form larger water droplets in the system. Since the filter cake is partly formed by the water droplets, an increase in water droplet size increases the pore volume and permeability of the filter cake.



(a) Effect of OWR on Sarapar



(b) Effect of OWR on ML



(c) Effect of OWR on IPL

Figure 2: Effect of OWR on Filtrate Loss Property
Conditions: Different OWR (%v/v) and 8 g Versatrol in 350 cc drilling fluid

CONCLUSIONS

Study showed that Malaysian ester derivative oils, ML and IPL can be easily formulated to perform the basic rhelogical properties of commercial drilling fluid system such as Sarapar oil-based drilling fluid

Based on the results obtained from HTHP filtration test, it can be concluded that IPL ester oil appears to be a suitable alternative oil to be used as oil base in drilling fluid formulation. This is due to its ability to form a low permeability filter cake and has larger molecule size compared to ML ester oil. Filtrate loss volume can be reduced by increasing Versatrol concentration to an optimum level, which can result in an increase in available binding sites on the fluid loss control agent. Since higher water content will increase filtrate loss volume, formulation of a low OWR drilling fluid system is recommended in order to maintain the superior performance of IPL

ester-based drilling fluid. However further studies on IPL are needed to determine the potential of this ester oil to become an alternative for the conventional mineral oil-based drilling fluids. These studies included the effect of the oil on formation damage and contaminants tolerance test.

ACKNOWLEDGEMENTS

The authors wish to thank the Malaysian Ministry of Science, Technology & Environment for sponsoring this work under project IRPA 02-02-06-0029. Special grateful to Kota Mineral & Chemical Sdn. Bhd. for providing the additives needed in formulation the drilling fluids.

REFERENCES

Hodder, M. H., et al. 1991 Palm Oil Derived Systems for Use in the Petroleum Industry as Drilling Fluids, PORIM Intl. *Palm Oil Conf,* 186 – 192.

Khor, S. F., et al. 1999. New Approaches in Minimizing the High Temperature Hydrolysis of Esters Based Drilling Fluids, Reg. Sym. of Chem. Eng., Songkla, Thailand, 22 - 24 Nov. 1999.

Peresich, R.L., et al,. 1991. Development and Field Trial of a Biodegradable Invert Emulsion Fluid, *SPE/IADC Drilling Conf.*, Amsterdam, March. 11 – 14, 1991: 333 – 340.

Simpson, J. P. 1974. Drilling Fluid Filtration Under Simulated Downhole Conditions, SPE 4779.