THE EFFECTS OF VISCOSIFIERS ON TERENGGANU K-SHALE HYDRATION

Abdul Razak Ismail & Ng Chong Yeow
Faculty of Chemical and Natural Resources Engineering,
Universiti Teknologi Malaysia
81310 UTM Skudai, Malaysia.

ABSTRACT

Operational experience showed that drilling through reactive and sensitive shale formations will result in well bore instability problems. Borehole instability can result from erosion, swelling and dispersion of formation clays. It will cause many problems such as stuck pipe, high torque and drag, bridging and hole enlargement. In general, the well bore stability can be achieved by using oil-based drilling fluids. However, due to the environmental reasons, a need for a better understanding of drilling fluids and shale interaction are very important to formulate an environmental friendly drilling fluid. This study focused on the effects of selected viscosifiers and its concentrations on Terengganu K-shale hydration. The characteristics of K-shale was identified using methylene blue test (MBT). The effects of several viscosifiers such as xantham gum, PAC-R, polyplus-dry and hydroxyl ethyl cellulose (HEC) on shale hydration were studied using hot-rolling dispersion test. The results showed that viscosifiers can be used to prevent shale hydration. Besides, an increase of viscosifiers concentration can reduce shale hydration and dispersion. The results also showed that xanthan gum and polyplus-dry are more efficient to prevent the shale hydration in comparison with the other two viscosifiers. The study also revealed that xanthan gum gives an optimum rheological properties of KCl-polymer system.

Keywords: shale, hydration, viscosifier

INTRODUCTION

A thick shale layer under the earth of Terengganu offshore, commonly known as Terengganu K-shale, consists mainly of siltstones and claystones [1], which are highly reactive to water and interbedded with hard shale streaks and coal stringers. Drilling through this water-sensitive shales can cause serious problems. As pointed out by many researchers [2,3,4], problem of borehole instability continue to be a major factor in the cost of petroleum drilling, logging, and completing the well.

In spite of years of study, water base drilling fluid has not been fully successful in providing borehole stability in shales. Therefore, much research effort has been expended in attempt to better understand shale and their interaction with drilling fluid. It is not uncommon that a particular fluid performs well in one area or one well, but is not successful on the next well or in different area [5].

In general, the wellbore stability can be achieved by use of an oil continuous phase, but the move away from oil-based drilling fluids for environmental reasons has created a need for a better understanding of drilling fluid and shale interaction when using aqueous system.

Due to lack understanding of interaction between the drilling fluid and the shale, this study will focus on effects of different polymers and concentration on shale hydration by using hot-rolling dispersion test. Besides, this research will also identify affects of polymers on system rheology. KCl-polymer system will be used for this study.

Swelling Shale

There are two main clay minerals in the swelling clay: (1) montmorillonite is by far the best known member of the smectite group, and has been extensively studied because of its common occurrence and economic importance. (2) vermiculite is classified as an expandable mineral along with smectites, having higher cation exchange capacity [5].

Shale Problem

Shale problems are normally caused by interaction between the drilling drilling fluid system and shale. The various forms of hole instability resulting from interaction between the drilling fluid and shale are all related to hydration phenomena. Basically, hydration take two forms in water-sensitive shale:

a. Surface hydration is adsorption of monomolecular layers of water on the planar surface of clay crystal lattices.
b. Osmotic swelling resulting from the high concentration of ions held by electrostatic forces in vicinity of clay surfaces.

Shale Stabilization by Polymer

Polymers were used as a viscosifier to study their effects on shale hydration. Xantham gum (natural polymer), polyplus (synthetic polymer), PAC-R and HEC (modified polymer) are carried out to study their effects on shale hydration by using hot-rolling dispersion test. In a sufficient concentration, polymers work to coat exposed shale and cutting, encapsulating them with a layer of polymer. This limits the ability of water to interact with shale and helps prevent cuttings from dispersing [6].

METHODOLOGY

In this study, the test procedures was conducted in four stages as shown below:

i. Preparation of shale sample - Before running hot-rolling dispersion test, the shale sample will be broken in small sizes and dried in the oven at 221 °F. After the shale dried, it is crushed in smaller sizes and the shale will sized between 6 and 10 mesh.
ii. Measuring the cation exchange capacity (CEC) by using methylene blue test (standard API-RP 13B).
iii. Rheological properties - The water-based drilling fluid (KCl-polymer system) was prepared by adding viscosifiers (with different concentrations of 1, 2, 3 and 4 ppb). Table 1 shows the composition of KCl-polymer system:

Table 1: Composition of KCl-polymer system.

Polymer (ppb)	Xantham Gum (1,2,3,4)	HEC (1,2,3,4)	PAC-R (1,2,3,4)	Polyplus (1,2,3,4)
Water (ml)	350	350	350	350
KCl (g)	40	40	40	40
NaOH (ppb)	0.25	0.25	0.25	0.25
Starlose (ppb)	4.0	4.0	4.0	4.0
Barite (g)	63.4	63.4	63.4	63.4

Before hot-rolling for dispersion test, the drilling fluid rheological properties such as plastic viscosity, yield point, gel strength and filtrate loss were measured.

iv. Analysis for the effect of viscosifiers on shale hydration - The hot-rolling dispersion test was carried out to analyzed the effects of viscosifier on Terengganu K-shale. After the preparation of drilling fluid systems and shale sample as described above, 5g of shale sample was added into the drilling fluid in the aging cell. The tests were conducted by placing the aging cell into hot-rolling oven and running it for 16 hours at 150 °F. After hot-rolled, the shale samples were dried in the oven at 221 °F for 24 hours. The recovery of shale sample was measured

RESULTS AND DISCUSSION

Rheological Properties

In this study, the effects of viscosifier on drilling fluid rheological properties was analyzed. The density of drilling fluid is maintained at 10 ppg and the pH value is at 10. Figure 1 shows the results of plastic viscosity for various viscosifier at different concentrations.

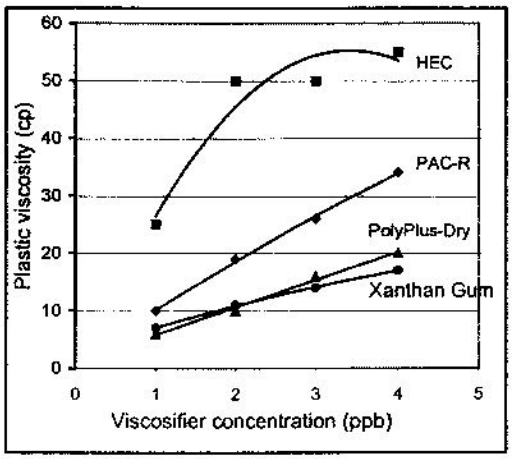

Figure 1: Plastic viscosity vs concentration for various viscosifiers

Figure 1 shows that plastic viscosity of the drilling fluid system increases with the increase of the viscosifiers concentration. However, HEC give the highest plastic viscosity value when compared to the other viscosifiers. According to MI-drilling engineering manual (1998), as a rule of thumb, plastic viscosity should be kept as low as possible in all cases because a lower plastic viscosity will result in better fluid flow in the annulus for hole cleaning. A practical upper limit for plastic viscosity is twice the fluid density. In this case, the optimum plastic viscosity should be kept around 20 cp. Therefore, xantham gum, poluplus-dry and RAC-R satisfy this criteria.

Figure 2 shows the result of yield point for various viscosifiers at different concentrations. The result showed that when 4 ppb of HEC were added to system, the yield point will increase dramatically. However, polyplus-dry and xantham gum give better value of yield point. Xantham gum give the most optimum and suitable drilling fluid rheological properties in KCl-polymer system. The result also showed that the variation of gel strength is not obvious before and after the hot-rolling dispersion test.

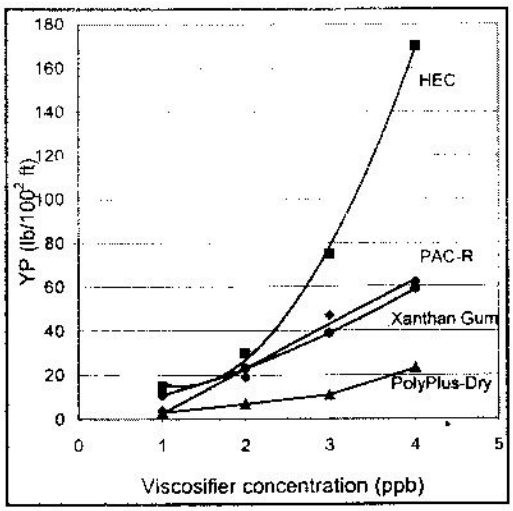

Figure 2: Yield point vs viscosifiers concentration.

Figure 3 shows the effect of viscosifier on filtrate loss. For comparison, xantham gum and polyplus-dry give a better fluid control compared to HEC and PAC-R.

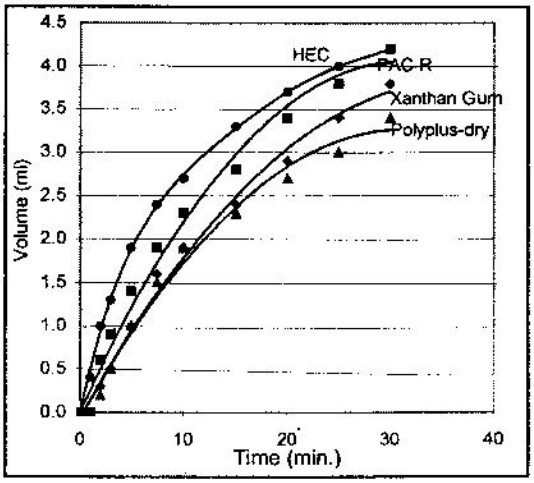

Figure 3: Filtrate loss vs time

Effects of Viscosifier on Shale Hydration

Four types of viscosifiers xantham gum, polyplus-dry, PAC-R and HEC with the different concentrations were used to identify the effects of viscosifiers concentration on shale hydration. Figure 4 shows the shale sample recovery for various concentration of viscosifiers. Generally, the result showed that the shale sample retained after hot-rolling dispersion test increased with an increased of viscosifiers concentration. The viscosifier will encapsulate the shale and will limit the ability of water to interact with the shale, thus helps to prevent cuttings from dispersing. An increase of polymer concentration will also increase viscosity of the fluid. It was observed that the recovery of shale will increase gradually with the xantham gum. However, HEC shows sudden increase of shale recovery when the concentration increase from 1 to 2 ppb.

Different viscosifiers showed different degree of shale retained. Figure 5 shows the result of shale retained after hot-rolling dispersion test for xantham gum, PAC-R, polyplus and HEC. This figure shows that xantham gum give the highest recovery of shale compared to HEC, polyplus-dry and PAC-R. Xantham gum will coat an exposed shales and cuttings, encapsulating them with a bound layer of polymer. However, polyplus only perform well in preventing shale hydration at 4 ppb. The inefficiency of polyplus is due to its high salinity. In order to overcome this problem, the viscosifier may require twice their normal concentration or even more, to perform in a saline environment. In terms of rheological properties, filtrate loss and the degree of shale recovery, xantham gum give optimum rheological properties in KCl-polymer system. It also give the highest degree of shale retained. Therefore, xantham gum is more effective in preventing shale hydration and dispersion.

CONCLUSION

The following conclusion can be derived from this study:

1. Shale recovery increased as viscosifier concentration increased.
2. Xantham gum is the most effective viscosifier compared to polyplus, PAC-R and HEC in preventing Terengganu K-shale hydration and dispersion.
3. Xantham gum will provide an optimum drilling fluid rheological properties in KCl-polymer system.

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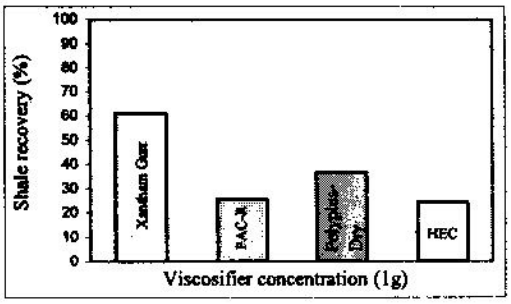

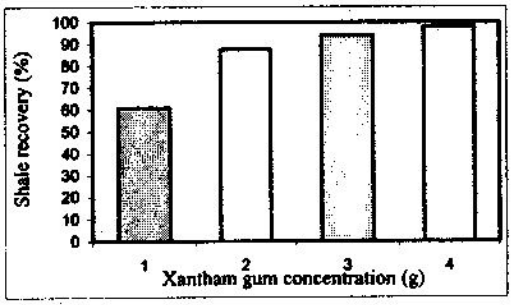

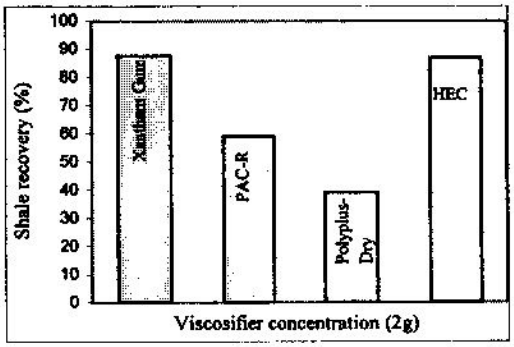

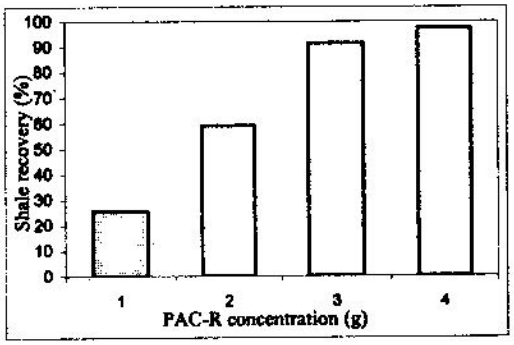

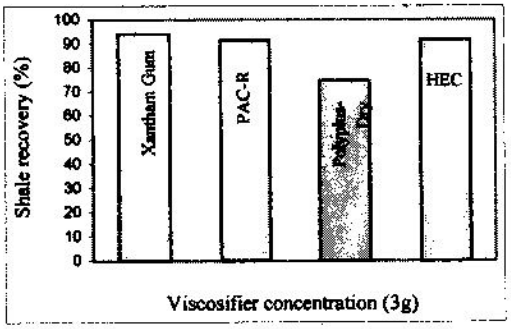

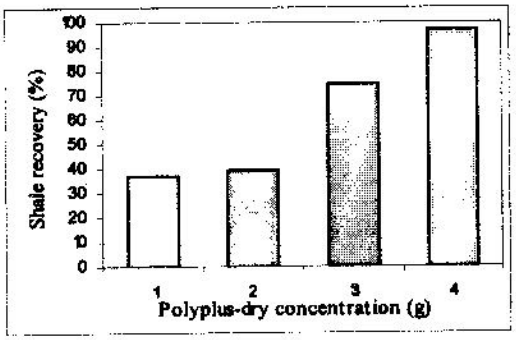

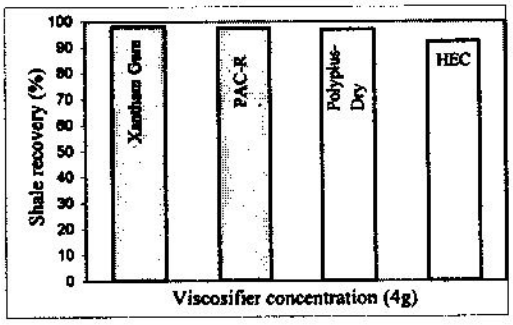

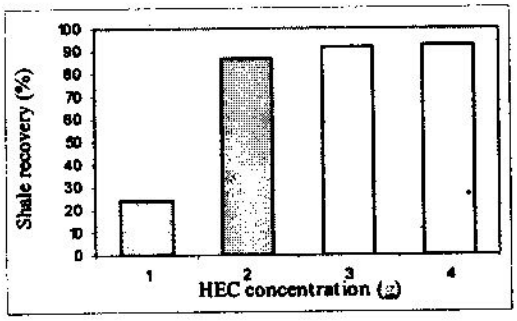

'igure 4: Comparison of Shale Recovery at Various Concentration

Figure 5: Comparison of Shale Recovery at Different Viscosifiers