THE PERFORMANCE OF WASTE FRYING PALM OIL BIODIESEL AS ESTER-BASED DRILLING FLUID

MOHD NAZRI BIN MOHD SOKRI

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to lecturers and friends,
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ABSTRACT

Ester based mud (EBM) derived from vegetable oil has been known as one of the alternative for conventional oil-based mud due to its environmental friendly properties. However, the cost for ester, or biodiesel, derived from virgin oil are relatively high compared to conventional oil-based mud. The used of waste frying palm oil (WFPO) could be the best option to tackle the cost related problem. The waste frying palm oil derived ester should be tested to meet the required properties as the drilling fluids such as rheological properties, environmentally friendly, and its compatibility to the rubber and seal elements. Hence, this study was done in order to investigate the use of biodiesel generated from waste frying palm oil to fullfill the above requirements. WFPOB shows good mud properties except for HTHP filtrate loss where it exceeds beyond control value. But, for the blending of 70:30 Sarapar to WFPOB mud shows some reduction in HTHP filtrate loss. For rubber compatibility test, NBR components had been exposed to three different temperature, 27^{o}C , 80^{o}C and 125^{o}C for one and two weeks. WFPOB mud give greater changes in rubber compound. The presence of WFPOB in blending mud shows some reduction in rubber changes rate. However, the NBR components lost more than 80% of its initial strength after exposure at 125^{o}C due to incompatibility of NBR components at such high temperature. As for toxicity study, the Cyprinus Caprio (carp fish) has been used as test organism. The LC_{50} of WFPOB and the blending mud obtained in this study is 56,000 ppm and 32,000 ppm which lies under Practically Non-Toxic category in toxicity classification. The result shows that the WFPOB mud can be used as base oil in drilling mud formulation with certain limitation. At the same time, the possibility of WFPOB blending with other mineral oil such as Sarapar can be made to improve the technical requirements and meet the environmental requirements.

ABSTRAK

Lumpur berasaskan ester (EBM) daripada minyak sayuran dikenali sebagai satu alternatif bagi lumpur berasaskan minyak konvensional disebabkan ciri-ciri mesra alam. Walaubagaimanapun, kos untuk ester, atau biodiesel, yang ditukar daripada minyak sayuran suci adalah tinggi jika dibandingkan dengan minyak konvensional. Penggunaan sisa minyak masak sawit (WFPO) menjadi pilihan terbaik untuk mengatasi masalah kos. Ester daripada sisa minyak sawit ini perlu diuji bagi memenuhi ciri-ciri keperluan sebagai bendalir penggerudian seperti ciri reologi, mesra alam dan kesesuaian dengan getah. Oleh itu, kajian ini dilakukan untuk mengkaji kegunaan biodiesel yang dijana daripada sisa minyak masak sawit (WFPOB) bagi memenuhi keperluan di atas. Lumpur berasaskan WFPOB menunjukkan ciri-ciri lumpur yang baik kecuali kehilangan turasan HTHP yang melebihi nilai kawalan. Tetapi lumpur campuran 70:30 Sarapar kepada WFPOB menunjukkan penurunan di dalam kehilangan turasan HTHP. Bagi ujian kesesuaian getah, komponen NBR didedahkan kepada tiga suhu berasingan 27^{o}C , 80^{o}C and 125^{o}C selama satu dan dua minggu. Lumpur berasaskan WFPOB memberi perubahan besar terhadap getah. Kehadiran WFPOB didalam lumpur campuran memberi sedikit penurunan kepada kadar perubahan getah. Namun begitu, NBR kehilangan lebih 80% daripada kekuatan asalnya selepas didedahkan pada suhu 125 ^{o}C. Bagi ujian ketoksikan, ikan Cyprinus Caprio (ikan kap) digunakan sebagai organisma ujian. Nilai LC_{50} bagi lumpur WFPOB dan campuran ialah 56,000 ppm dan 32,000 ppm yang terletak dalam kategori *"Practically Non-Toxic"* di dalam pengkelasan ketoksikan. Keputusan menunjukkan lumpur daripada sisa minyak masak sawit boleh digunakan dalam penghasilan lumpur penggerudian dengan had tertentu. Lumpur daripada sisa minyak sawit juga boleh dicampur dengan minyak mineral seperti Sarapar untuk memperbaiki keperluan teknikal dan pada masa yang sama, dapat memenuhi keperluan alam sekitar.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

WBM	-	Water Based Mud
OBM	-	Oil Based Mud
SBM	-	Synthetic Based Mud
EBM	-	Ester Based Mud
WFPO	-	Waste Frying Palm Oil
WFPOB	-	Waste Frying Palm Oil Biodiesel
NBR	-	Nitrile Butadiene Rubber
API	-	American Petroleum Institute
EPA	-	Environmental Protection Agency
OECD	-	Organization for Economic Co-Operation and Development
EU	-	European Union
NaOH	-	Sodium Hydroxide
KOH	-	Potassium Hydroxide
BOP	-	Blowout Preventer
ACN	-	Acrylonitrile
BD	-	Butadiene
XNBR	-	Carboxylated Nitrile
ASTM	-	American Society of Testing Material
PAH	-	Poly Aromatic Hydrocarbon
ppm	-	Part per Million
LC50	-	Fifty Percent Lethal Concentration

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The rising of global energy demand has led to exploration for oil and gas in increasingly difficult environments. Exploration is now extending into sensitive areas, in particular, offshore field. The development of deep and ultra-deep offshore operations brings new and more complex technical challenges due to the harsh conditions encountered at these water depths. To encounter this challenges, oil based drilling fluid are much prefered to be used for drilling in this condition because it performs better than water based mud (Dosonmu *et al*., 2010; Apeleke *et al.*, 2012)

Oil-based mud (OBM) are among the best performant and cost effective fluids in hostile conditions. They are used in particular when drilling water-sensitive shale, or when high temperatures are encountered, risk of important differential pressure sticking, exposure to acid gas, or long directional intervals requiring minimum torque and drag on the drill string. Even though they may be two or three times more expensive than water based muds, their use is justified by better performances and savings on mud maintenance.

Diesel has been for years the only base chosen for the formulation of drilling fluids for oil-based mud (Sachez *et al.,* 1999). However their intensive use make conventional, diesel oil-based mud an important source of pollution.

During the last decade, environmental regulations have severely restricted the use of conventional oil-based muds, mainly because of their impact in marine environment during offshore operations. All these general environment concerns have led to an extensive industrial research aiming at designing non-toxic substitution fluids that could replace conventional oil based muds but have the same performances in a wide range of drilling conditions. Low toxicity mineral oils containing substantially lower concentrations of aromatic or naphtenics were used to replace diesel as the base fluid in these muds (Dosonmu *et al.*, 2010).

However, the legislation has become more and more restrictive and even these classical low toxic fluids like kerosene have been contested and will progressively leave the market under the pressure of environmental requirements. If we aim further in the future, a zero discharge limit may be imposed in many areas which would preclude the use of oil-based mud or necessitate that drilled cuttings be transported to shore and treated to remove adhering oil.

These regulations have not only made the use of oil based mud more costly but some local regulatory guidelines make oil-based mud difficult or impossible to use (Hussein *et al.*, 2010). Faced with this scenario, alternatives to the present low aromatic oil-based mud systems are required by the petroleum exploration industries. This has lead to the research on the application of ester as ester based mud (EBM).

Compared to diesel and mineral oil, ester is non-toxic, highly biodegradable and does not contain aromatic compounds when derived from biomass. This ester, called as biodiesel, contains mono-alkyl esters of long-chain fatty acids derived from vegetable or animal oils and fats.

Esters were first field trialled offshore Norway (Peresich *et al.*, 1991) and been used to drill several hundred wells since that time (Eckhout *et al.*, 2000; *Burrows et al.*, 2001). Ester-based drilling fluids have had limited success in field applications. Esters generally have higher kinematic viscosity, which translates into higher drilling fluid rheological properties. High rheological properties limit the

ability of ester-based fluids to tolerate high solids loading at higher fluid density. To take into account, esters are also much more aggressive to elastomer components used in downhole drilling and completion equipment. Additionally, esters are susceptible to hydrolysis. Hydrolysis, the reaction of ester with water to produce carboxylic acid and alcohol, increases in rate at higher temperatures and increased by the presence of alkalinity agents such as lime.

However, esters have some advantages over these base oil alternatives in terms of biodegradation and toxicity. This made esters as one of the best alternatives to produce the suitable drilling fluid that satisfies both technical and environmental criteria. To meet this both criteria, the industry has recognized the potential of vegetable oil-based mud. To overcome several drawbacks of vegetable oil, good drilling fluid formulation could be suggested for efficient oil-based drilling fluid (Amin *et al.,* 2010). However, the use of vegetable oils is relatively high cost compared to the conventional oil based mud. The high cost of this drilling fluid mainly due to the cost of virgin vegetable oil (Amin *et al.,* 2010). Therefore, it is not surprising that the vegetable oil based mud produced from vegetable oil costs much more than petroleum based diesel. It is estimated that for vegetable oil, it will cost around USD 225 – USD 425 per barrels whereas cost for mineral oil only around USD 80 – USD 100 per barrels.

Besides, it is necessary to make an effort and explore the way to reduce production costs of vegetable oil-based mud. Based on that, methods that permit minimizing the costs of the raw material are of special interest. The use of waste frying oil instead of virgin oil to produce oil-based mud is an effective way to reduce the raw material cost because waste frying oil are estimated to be about half the price of virgin oil.

The amount of used frying palm oils are estimated about 7000 tonnes, both vegetable oils and animal fats are disposed off as waste yearly in Malaysia without treatment (Berger, 2005). This action will give a negative impact on environment. This waste frying palm oil might be use if it purified (Veil *et al.,* 1999). Hence, the

idea of using waste frying palm oil in the petroleum industry as a drilling mud perhaps can reduce the cost of operation using oil-based mud .

1.2 Objectives of Study

The main objectives of this study is to investigate the performance of waste frying palm oil biodiesel (WFPOB) as ester-based drilling fluid. This study investigated the rheological properties, the effect of biodiesel on rubber component and the toxicity level of the ester-based drilling fluid from WFPOB and the possibility of WFPOB blending with Sarapar.

1.3 Scope of the Study

The scopes of this study are:

i. To prepare biodiesel from waste frying palm oil through transesterification process and investigate the suitability of WFPOB as base oil for drilling fluid.

ii. To compare the physical properties of WFPOB with standard base mineral oil, Sarapar.

iii. To conduct the rheological properties using WFPOB as base oil in drilling mud and compare it with standard base mineral oil, Sarapar.

iv. To conduct the test of WFPOB effect on the rubber component using Nitrile Butadiene Rubber (NBR).

v. To perform the toxicity test using Cyprinus Caprio (Carp Fish) as test organism to determine the WFPOB toxicity level.

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