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(54) Titre : COMPOSITION DE FLUIDE DE FORAGE
(54) Title: DRILLING FLUID COMPOSITION

(57) Abrégé/Abstract:
The present disclosure relates to drilling fluid containing ampholytic polymers with cationic hydrophobic monomer units.

## ABSTRACT

The present disclosure relates to drilling fluid containing ampholytic polymers with cationic hydrophobic monomer units.

# DRILLING FLUID COMPOSITION

## FIELD

[0001] The present disclosure relates to drilling fluid compositions. In particular, the present disclosure relates to drilling fluid compositions containing ampholytic polymers with cationic hydrophobic monomer units.

## INTRODUCTION

[0002] In Canada, South America and China, there are very large oil sands deposits known as oil-rich bitumen sands. These oil sands consist of a mixture of crude bitumen (a semi-solid form of crude oil), silica sand, clay minerals, and water. The Canadian oil sand deposits cover over about 141,000 square kilometers and have about 28 billion cubic meters (174 billion barrels) of economically recoverable crude bitumen. There are two ways to recover the crude bitumen from these oil sand deposits. One way is mining and the other, is *in-situ* operations. In Canada, approximately 15.6 billion cubic meters (98 billion barrels) of crude bitumen deposit can be recovered *via in-situ* operations. Steam Assisted Gravity Drainage (SAGD) is the main *in-situ* operation to recover crude bitumen from these oil sand deposits. SAGD uses dual horizontal wells, situated one on top of another, to recover the crude bitumen from these oil sand deposits. The main challenge of drilling the horizontal wells through these oil sand deposits is the bitumen sticking to the drilling components. The mixture of the crude bitumen or heavy oil and sand, often referred to as tar sands, makes the drilling cuttings from these formations malleable and sticky. Bitumen is a mixture of hydrocarbon compounds containing the other elements of nitrogen, sulfur, oxygen, metals and the like. Bitumen is known to have, overall, an anionic charge and hydrophobic surfaces. When the conventional water-base drilling fluids are used to drill through the oil sand deposits, the anionic polymer additives in the drilling fluids increase the anionic surface charge of bitumen particles, causing bitumen to disperse into the drilling fluids. The dispersed bitumen particles in the drilling fluids re-aggregate on the surfaces of metal or plastic or oil-like substances, which have very strong affinity for the bitumen or heavy oil.

The re-aggregated bitumen sticks to oil sand cuttings and causes the bitumen accretion or sticking problem known to occur while drilling oil sands deposits. Bitumen accretion causes many drilling problems, such as high torque and drag, slow travel, blinding of the shakers while drilling oil sand deposits and getting the liners stuck while running in the liners.

[0003] Water-soluble polymers are used in the oilfield in polymer flooding, in drilling and completion fluids, in fracturing / acid stimulation treatments and in profile modification. Water-soluble hydrophobically associating polymers are water-soluble polymers that contain a small number (less than 10% by weight) of hydrophobic moieties attached directly to the polymer backbone. In aqueous solutions, these hydrophobic groups of the water-soluble hydrophobic polymers can associate to minimize their exposure to the solvent (water), similar to the formation of micelles by a surfactant above its critical micelle concentration (CMC). Water-soluble hydrophobic polymer association can result in solution properties not available with conventional water-soluble polymers. The combination of nonionic hydrophobic polymers and cationic polymers is used for oily water cleaning-up, described by Jacques in US No. 4734205. As well, the hydrophobic polymers which contains 0.1~10% by weight of nonionic hydrophobic monomers are used in the drilling fluids to inhibit the bitumen or heavy oil from sticking on the drilling string, shakers and other drilling equipment while drilling through the subterranean oil sands or heavy oil formations, described by Wu in CA No. 2635300. The hydrophobic polymers that contain over 10% by weight of the nonionic hydrophobic moieties are insoluble in water.

## SUMMARY

[0004] The present disclosure relates a drilling fluid composition comprising:

(i) an ampholytic hydrophobic polymer comprising cationic hydrophobic monomer units,

(ii) an aqueous solvent, and

(iii) optionally, at least one conventional drilling fluid additive,

wherein the cationic hydrophobic units are present in the ampholytic hydrophobic polymer in an amount sufficient to provide the drilling fluid with a yield point of at least 5 Pa.

[0005] In one embodiment, the cationic hydrophobic monomer units are present in the ampholytic hydrophobic polymer in an amount of at least 10% (w/w).

[0006] In another embodiment of the disclosure, there is also included a method of recovering bitumen from oil sands comprising contacting a drilling fluid composition of the disclosure, with the oil sands to prevent the bitumen from sticking on the drilling string, shakers and other drilling equipment.

## DESCRIPTION OF VARIOUS EMBODIMENTS

(I) DEFINITIONS

[0007] The term "drilling fluid" as used herein refers generically to both drilling fluids (drilling muds) and drill-in fluids.

[0008] The term “ampholytic hydrophobic polymer” as used herein refers to a copolymer which both comprises cationic and anionic monomers, in which the cationic monomer possesses a hydrophobic moiety.

[0009] The term “cationic hydrophobic monomer” as used herein refers to a polymerizable monomer unit which possesses a formal cationic charge, such as a quaternary ammonium group, and which also possesses a hydrophobic moiety.

[0010] The term “hydrophobic moiety” as used herein refers to a group that is non-polar and provides a hydrophobic environment for the load molecule to interact in order to avoid the surrounding water environment. Hydrophobic moieties may be aliphatic hydrocarbon chains and/or ring compounds that do not have positive or negative charge and are capable of binding to molecules by hydrophobic interaction. The hydrophobic moieties are the portions of the molecule that are typically made up of hydrogen and carbon with minimal amounts of oxygen and nitrogen.

[0011] The term "yield point" as used herein refers to the ability of the drilling fluid to suspend and carry oil sand cuttings from downhole to the surface while drilling oil sands or heavy oil formations.

[0012] The term "vinyl non-ionic monomer" refers to a polymerizable monomeric unit which does not contain a cationic or anionic moiety, and in which the polymerizable group in the monomeric unit comprises a vinyl (-CH=CH) moiety.

[0013] The term "vinyl anionic monomer" as used herein refers to a polymerizable monomeric unit which contains an anionic moiety, and in which the polymerizable group in the monomeric unit comprises a vinyl (-CH=CH) moiety.

[0014] The term "aqueous solvent" as used herein refers to any solvent in which water comprises the majority of the solvent (typically at least: 80%, 85%, 90%, 95%, 98%, 99 or 99.9% water by weight), or pure water. The pure water is optionally a solvent consisting of pure water, such as deionized or distilled water (with no organic solvent present). The aqueous solvent forms a colloidal system with the components of the drilling fluid composition, in which the ampholytic hydrophobic polymer and optionally, at least one conventional drilling fluid additive, are dissolved or dispersed within the solvent. Examples of aqueous solvents include water (for example, fresh lake or river water, tap water, distilled water, or reverse osmosis water), acidic water, alkaline water, salt solutions (such as sodium chloride, potassium chloride, calcium chloride). It would be understood by a person skilled in the art that tap water, for example, would contain natural minerals, salts and/or other solutes, which would not affect the compositions of the disclosure.

[0015] The term "$C_{m-n}$alkyl" as used herein means straight and/or branched chain, saturated alkyl groups containing from "m" to "n" carbon atoms and includes (depending on the identity of m and n) methyl, ethyl, propyl, n-butyl, s-butyl, isobutyl, t-butyl, 2,2-dimethylbutyl, n-pentyl, 2-methylpentyl, 3-methylpentyl, 4-methylpentyl, n-hexyl, heptyl, octyl, nonyl, and the like, where the variable m is an integer representing the smallest number of carbon atoms in the

alkyl radical and n is an integer representing the largest number of carbon atoms in the alkyl radical.

[0016] The term "$C_{8-n}$alkenyl" as used herein means straight and/or branched chain, unsaturated alkyl groups containing from 8 to "n" carbon atoms and one or more, suitably one to five, more suitably one to three double bonds, and includes (depending on the identity of n), 1-octenyl, 2-octenyl, 1,3-oct-dienyl, 1-nonenyl, 2-nonenyl, 1,3-non-dienyl, and the like, where the variable n is an integer representing the largest number of carbon atoms in the alkenyl radical.

[0017] The term "$C_{8-n}$alkynyl" as used herein means straight and/or branched chain, unsaturated alkyl groups containing from 8 to "n" carbon atoms and one or more, suitably one to five, more suitably one to three triple bonds, and includes (depending on the identity of n), 1-octynyl, 2-octynyl, 1,3-oct-di-ynyl, 1-nonynyl, 2-nonynyl, 1,3-non-di-ynyl, and the like, where the variable n is an integer representing the largest number of carbon atoms in the alkynyl radical.

[0018] The term "ethylenically unsaturated" refers to a compound comprising a non-aromatic C=C double bond.

[0019] The term "carboxylic acid" or "carboxylate" as used herein means a group of the formula $-CO_2H$ or $-CO_2^-$, respectively.

[0020] The term "sulfonic acid" or "sulfonate" as used herein means a group of the formula $-SO_3H$ or $-SO_3^-$.

[0021] The term "amide" as used herein means a group of the formula -CONR′R″, wherein R′ and R″ are independently selected from H and $C_{1-20}$alkyl, suitably $C_{1-8}$alkyl.

[0022] In understanding the scope of the present disclosure, the term "comprising" and its derivatives, as used herein, are intended to be open ended terms that specify the presence of the stated features, elements, components, groups, integers, and/or steps, but do not exclude the presence of other unstated features, elements, components, groups, integers and/or steps. The foregoing also applies to words having similar meanings such as the terms, "including",

"having" and their derivatives. Finally, terms of degree such as "substantially", "about" and "approximately" as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed. These terms of degree should be construed as including a deviation of at least ±5% of the modified term if this deviation would not negate the meaning of the word it modifies.

**(II) COMPOSITIONS**

[0023] The present disclosure relates to drilling fluid compositions comprising an ampholytic hydrophobic polymer comprising cationic hydrophobic monomer units. It has been determined that a drilling fluid composition comprising an ampholytic hydrophobic polymer comprising a sufficient amount of cationic hydrophobic monomer units results in a drilling fluid with a yield point of at least 5 Pa. In one embodiment, the cationic hydrophobic monomer units are present in an amount of at least 10% (w/w) of the overall ampholytic hydrophobic polymer, which allows the polymer to sufficiently dissolve in the aqueous solvent and provide sufficient viscosity and yield point to the drilling fluid, and prevent the bitumen or heavy oil from sticking on the drilling string, shakers and other drilling equipment.

[0024] The yield point of the drilling fluid compositions refers to the ability of a drilling fluid to suspend and carry oil sand cuttings from downhole to the surface while drilling oil sands or heavy oil formations. Accordingly, drilling fluids with low yield points (for example, about 1 Pa), have a limited ability to suspend and carry oil sand cuttings to the surface. Drilling fluids with higher yield points have the ability to carry the cuttings to the surface. It will be understood by those skilled in the art that the yield point of a drilling fluid is measured using a viscometer (such as a Viscometer Model 35 from Fann® Instrument Company). The calculation of the yield point value is calculated using the following formula, and is known to those skilled in the art:

$$YP = (2 \times \text{viscometer reading at 300 rpm}) - (\text{reading at 600 rpm}) \ (\text{lb}/100\ \text{ft}^2)$$

or

$$YP = 0.478 \times (2 \times \text{reading at 300 rpm} - \text{reading at 600 rpm}) \ (\text{Pa})$$

[0025] It will be understood that the ampholytic hydrophobic polymers of the drilling fluid compositions absorb on the bitumen surface through their hydrophobic and cationic moieties, as a result of the interactions of the Van der Waals force and the static electric attraction force between the positive charge of the polymers and the negative charges on the bitumen particle surfaces. As a result, the bitumen particle surfaces stick less to the drilling apparatus after the ampholytic hydrophobic polymers have been adsorbed. Without being bound by theory, it is thought that the ampholytic hydrophobic polymers form a three dimensional network structure as a result of intra-molecular association of the hydrophobic moiety. The intra-molecular association of the polymers also results from the static electric attraction force between the positive and negative charges of the polymers. It is thought that the three dimensional polymer network structures provide the higher viscosity and yield point of the drilling fluid compositions.

[0026] The presence of the cationic hydrophobic monomers increases the yield point of the drilling fluid composition. It will be understood that the yield point of a drilling fluid refers to the capability of the drilling fluid to suspend and carry the oil sand cuttings from downhole to the surface while drilling oil sands or heavy oil formations. In one embodiment, the yield point of the drilling fluid compositions of the present disclosure is at least about 5.0 Pa, optionally between about 5.0 – 20.0 Pa, optionally between about 6.0 – 15.0 or between about 7.0 – 15.0 Pa. The yield point of a drilling fluid is an important parameter when evaluating the ability of the drilling fluid to suspend and carry the drilling cuttings from downhole to the surface, especially for horizontally drilled wells. The higher the yield point of the drilling fluid, the higher the ability of the drilling fluid to carry and suspend drilling cuttings. When the lateral length of a drilling hole is approximately 1000 meters long, a yield point of about 8 ~ 10 Pa of the drilling fluid is normally required.

[0027] The ampholytic hydrophobic polymer of the present disclosure contains both anionic groups (negative charges) and cationic groups (positive charges), which form intramolecular and intermolecular interactions resulting in

the three dimensional network structures of the polymers. In addition, the ampholytic hydrophobic polymer also contains hydrophobic groups which also form intramolecular and intermolecular interactions within and between the polymers also contributing to the network structures.

[0028] Accordingly, in one embodiment, the present disclosure includes a drilling fluid composition, comprising:

i. an ampholytic hydrophobic polymer comprising cationic hydrophobic monomer units;

ii. an aqueous solvent; and

iii. optionally, a conventional drilling fluid additive,

wherein the cationic hydrophobic units are present in the ampholytic hydrophobic polymer in an amount sufficient to provide the drilling fluid with a yield point of at least 5 Pa.

[0029] In one embodiment, the cationic hydrophobic units are present in an amount sufficient to provide the drilling fluid with a yield point of at least 5.5 Pa, 6.0 Pa, 6.5 Pa, 7.0 Pa, 7.5 Pa, 8.0 Pa, 9.0 Pa or 10.0 Pa.

[0030] In another embodiment, the cationic hydrophobic monomer units are present in the ampholytic hydrophobic polymer in an amount of at least about 10% (w/w).

[0031] In another embodiment, the ampholytic hydrophobic polymer is comprised of the following of monomer units:

(1) vinyl non-ionic monomers;

(2) vinyl anionic monomers comprising at least one carboxylic acid, carboxylate, or sulfonate moiety; and/or

(3) at least 10% (w/w) vinyl cationic hydrophobic monomers comprising at least one hydrophobic group.

[0032] In one embodiment, the vinyl non-ionic monomers comprise vinyl non-ionic monomers having at least one amide moiety. The vinyl non-ionic monomers having at least one amide moiety may comprise acrylamide or an ($C_1$-$C_8$)-alkyl-N-substituted acrylamide. In one embodiment, the vinyl non-ionic

monomer having at least one amide moiety comprises acrylamide. In other embodiments, the vinyl non-ionic monomers are selected from:

a) maleic anhydride;

b) vinyl acetate;

c) vinyl alcohol;

d) ethylene oxide;

e) styrene; and

f) acrylate esters.

[0033] In one embodiment of the disclosure, the vinyl non-ionic monomer is present in the ampholytic hydrophobic polymer at an amount between about 10 and 80% (w/w), optionally between about 50 and 70% (w/w).

[0034] In other embodiments of the disclosure, the vinyl anionic monomer comprises a monomer as follows:

i) ethylenically unsaturated carboxylic acids, and/or their corresponding salts, such as acrylic acid, methacrylic acid, itaconic acid, fumaric acid, and/or their corresponding salts;

ii) ethylenically unsaturated sulfonic acids, and/or their corresponding salts, such as ethylene sulfonic acid, vinyl benzyl sulfonic acid, and/or their corresponding salts;

iii) anionic N-substituted acrylamide, and/or their corresponding salts, such as 2-acrylamide-2-methylpropane sulfonic acid, and/or its corresponding salt; and/or

iv) alkyl sulfonate esters of unsaturated carboxylic acids, and/or their corresponding salts, such as 2-sulfoethyl methacrylate, and/or its corresponding salt.

[0035] In one embodiment, the vinyl anionic monomer is present in the ampholytic hydrophobic polymer at an amount between 10 and 50% (w/w), or optionally between about 10 and 30% (w/w).

[0036] In another embodiment of the disclosure, the hydrophobic group in the vinyl cationic hydrophobic monomer is a ($C_8$-$C_{30}$)-alkyl group, ($C_8$-$C_{30}$)-alkenyl group, or ($C_8$-$C_{30}$)-alkynyl group. In another embodiment, the hydrophobic group

in the vinyl cationic hydrophobic monomer is a ($C_8$-$C_{20}$)-alkyl group, ($C_8$-$C_{20}$)-alkenyl group, or ($C_8$-$C_{20}$)-alkynyl group. In a further embodiment, the vinyl cationic hydrophobic monomer is dimethyl ally $C_8$-$C_{30}$(alkyl) ammonium chloride, methyl dially ($C_8$-$C_{30}$)-alkyl ammonium chloride, acryloyoxyethyl dimethyl $C_8$-$C_{30}$(alkyl) ammonium chloride, or 2-methacryloyoxyethyl dimethyl $C_8$-$C_{30}$(alkyl) ammonium chloride.

[0037] In another embodiment, the vinyl cationic hydrophobic monomer is present in the ampholytic hydrophobic polymer at an amount between 10 and 100% (w/w). In a further embodiment, the vinyl cationic hydrophobic monomer is present in the ampholytic hydrophobic polymer at an amount between 10 and 60% (w/w). In a further embodiment, the vinyl cationic hydrophobic monomer is present in the ampholytic hydrophobic polymer at an amount between 10 and 35% (w/w).

[0038] In another embodiment of the disclosure, the drilling fluid compositions optionally include at least one conventional drilling fluid additive which is selected from viscosifiers, filtrate loss reducers, drilling fluid thinners / dispersants, shale inhibitors / clay inhibitors, lubricants, defoaming agents, bridging agents, weighting agents, pH adjusting agents, and the circulation loss materials. In a further embodiment, examples of viscosifiers include xanthan gum, guar gum or hydroxyl ethyl cellulose; examples of filtrate loss reducers include poly-anionic cellulose or drilling starch; examples of drilling fluid thinners or dispersants include lignite or lignosulfonate; examples of shale or clay inhibitors include an amine or potassium silicate; examples of lubricants include fatty acids or a derivatives thereof; examples of defoaming agents include an organic silicone defoamer, an alcohol based defoamer, or an ethylene oxide defoamer; examples of bridging agents include calcium carbonate; examples of weighting agents include barite; and examples of pH adjusting agent include sulfamic acid, citric acid, sodium bicarbonate or soda ash. In another embodiment, the at least one conventional drilling fluid additive is xanthan gum, poly-anionic cellulose or drilling starch.

[0039] The amounts of conventional drilling fluid additives to be added to the drilling fluid compositions will vary depending on the nature of the drilling fluid composition that is required for a particular environment. For example, a viscosifier (such as xanthan gum) typically has a concentration of about 1~3 kg per cubic meter drilling fluid. A filtrate loss reducer (such as poly-anionic cellulose) may be present in an amount of 1~5 kg per cubic meter drilling fluid, and/or 0~8 kg of starch per cubic meter drilling fluid. A shale clay inhibitor (such as an amine) may be present at about 0~5 kg per cubic meter drilling fluid. A lubricant (such as a fatty acid) may be present at about 0~5 kg per cubic meter drilling fluid. A defoamer may be present at about 0~2 kg per cubic meter drilling fluid. The concentrations of the main components in the drilling fluid are shown in Table 1. Normally the water content of the drilling fluid is over 95%.

**(III) USES AND METHODS OF USE OF THE COMPOSITIONS**

[0040] The drilling fluid compositions of the present disclosure are useful for recovering bitumen from oil sands in normal oil sand drilling operations. Accordingly, in one embodiment of the disclosure, there is include a method of recovering bitumen from oil sands comprising contacting a drilling fluid composition as defined in the present disclosure with the oil sands-to prevent the bitumen from sticking on the drilling string, shakers and other drilling equipment while drilling the oil sand or heavy oil formations.

[0041] In another embodiment of the disclosure, the contacting is done under conditions to reduce the friction coefficient of the mixture, comprising mixing the composition with the oil sands. In another embodiment, the composition is contacted with the oil sands during a drilling operation, such as a steam assisted gravity drainage operation, using drilling components, wherein the composition inhibits sticking of the bitumen to the drilling components. In a further embodiment, the drilling operation produces oil sand cuttings which are contacted with the composition, wherein the composition encapsulates the bitumen in the oil sand cuttings, and also reduces the friction coefficient of the mixture (cuttings and composition). It will be understood by a person skilled in

the art that the compositions of the present disclosure are able to reduce the friction coefficient and encapsulate bitumen in oil sands directly or from the cuttings of a drilling operation. When drilling components drill through the oil sands during a drilling operation, the drilling results in cuttings which contain bitumen, which are contacted with the composition.

**(IV) EXAMPLES**

[0042] The following non-limiting examples are illustrative of the present disclosure:

[0043] The xanthan gum (polyxan), bentonite (Gel), drilling starch (Aquastar™ EX) were supplied by Diversity Technologies Corp. Polyanionic Cellulose (PAC HV/LV) was provided by Luzhou North Qiaofeng Chemical Company. The hydrophobically associating ampholytic polymer (BT 1217) was provided by Chengdu Cationic Chemistry Company. The cationic polymer (Ultimer™ 7753) was supplied by Nalco Global Equipment Solutions Company. The polymer flocculant (Hyperfloc™ CE 2340) was supplied by Hychem Inc. The oil sand sample was supplied by Nexen Inc. A Hamilton Beach mixer was used to mix the drilling fluid compositions. A Viscometer Model 35 from Fann Instrument Company was used to test viscosity.

*Example 1 – General Preparation of Drilling Fluids*

*(i) Prior art drilling fluid composition using hydrophobic monomers*

[0044] To tap water was added 1 kg/m$^3$ polyxan, 2 kg/m$^3$ of polyanionic cellulose regular (PAC HV), and 4 kg/m$^3$ of drilling grade starch, as seen in Table 1. This mixture was then mixed for 20 minutes using a Hamilton Beach mixer.

[0045] To this mixture was then added 5 kg/m$^3$ of BT1217 having 3% (w/w) cationic hydrophobic monomers, and the mixture was stirred for 15 minutes using a Hamilton Beach mixer.

[0046] To this mixture was then added 1 kg/m$^3$ of sulfamic acid and the mixture was stirred for 5 minutes using the Hamilton Beach mixer, resulting in the

mixture having a pH of about 5. 100 kg/m$^3$ of oils sands were then added to the mixture and mixed using the mixer.

*(ii) Drilling fluid compositions of the present disclosure*

[0047] The compositions of the present disclosure were prepared in the same manner as in (i), but the cationic hydrophobic monomer BT1218 Plus replaced a portion of the hydrophobic monomer BT1217, as shown in Table 1.

*Example 2 – Rheology of Drilling Fluid Compositions*

[0048] The rheology of drilling fluid compositions were tested with Viscometer Model 35 from Fann Instrument Company Table 2 shows the testing results.

[0049] It is clear from Table 2 that the addition of the cationic hydrophobic monomers to the ampholytic hydrophobic polymer increase the yield point of the drilling fluid.

**Table 1: Drilling Fluid Formulations**

| Formulation | #1 (Prior art) | #2 | #3 | #4 |
|---|---|---|---|---|
| | | | | |
| **Product Names** | | | | |
| Polyxan (kg/m3) | 1 | 1 | 1 | 1 |
| PAC R (kg/m3) | 2 | 2 | 2 | 2 |
| Drilling Starch (kg/m3) | 4 | 4 | 4 | 4 |
| Mixing (min) | 20 | 20 | 20 | 20 |
| BT 1217 containing 3% (wt) hydrophobic monomer (kg/m3) | 5 | 4 | 3 | 2 |
| BT 1218 Plus containing 15% (wt) cationic hydrophobic monomer (kg/m3) | 0 | 1 | 2 | 3 |
| Total BT 1217, BT1218 Plus (kg/m3) | 5 | 5 | 5 | 5 |
| Mixing (min) | 15 | 15 | 15 | 15 |
| Sulfamic Acid (kg/m3) | 1 | 1 | 1 | 1 |
| Mixing (min) | 5 | 5 | 5 | 5 |
| pH Value | 5 | 5 | 5 | 5 |
| Oil Sand (kg/m3) | 100 | 100 | 100 | 100 |
| Mixing (min) | 10 | 10 | 10 | 10 |

**Table 2: Rheology of Drilling Fluid Formulations**

| Formulation | #1 (Prior art) | #2 | #3 | #4 |
|---|---|---|---|---|
| | | | | |
| **Mud Rheology** | | | | |
| Reading at 600 rpm | 26 | 46 | 54 | 60 |
| Reading at 300 rpm | 17 | 30 | 39 | 45 |
| Reading at 200 rpm | 13 | 22 | 28 | 40 |
| Reading at 100 rpm | 9 | 16 | 22 | 28 |
| Reading at 6 rpm | 3 | 4 | 5 | 8 |
| Reading at 3 rpm | 2 | 3 | 4 | 6 |
| PV (mPa.s) | 9 | 16 | 15 | 15 |
| YP (Pa) | 4 | 7 | 12 | 15 |
| pH Value | 5.5 | 5.5 | 5.5 | 5.5 |

**CLAIMS**:

1. A drilling fluid composition, comprising:

   i. an ampholytic hydrophobic polymer comprising cationic hydrophobic monomer units and anionic monomer units, wherein the cationic hydrophobic monomer units comprise a hydrophobic group which is a ($C_8$-$C_{30}$)-alkyl group, ($C_8$-$C_{30}$)-alkenyl group, or ($C_8$-$C_{30}$)-alkynyl group;

   ii. an aqueous solvent; and

   iii. optionally, a conventional drilling fluid additive,

   wherein the cationic hydrophobic units are present in the ampholytic hydrophobic polymer in an amount sufficient to provide the drilling fluid with a yield point of at least 5 Pa.

2. The drilling fluid composition of claim 1, wherein the cationic hydrophobic monomer units are present in the ampholytic hydrophobic polymer in an amount of at least 10% (w/w).

3. The drilling fluid composition of claim 1 or 2, wherein the ampholytic hydrophobic polymer is comprised of the following monomer units:

   i. vinyl non-ionic monomers;

   ii. vinyl anionic monomers comprising at least one carboxylic acid, carboxylate, or sulfonate moiety; and/or

   iii. at least about 10% (w/w) vinyl cationic hydrophobic monomers comprising at least one hydrophobic group.

4. The drilling fluid composition of claim 3, wherein the vinyl non-ionic monomers comprise vinyl non-ionic monomers having at least one amide moiety.

5. The drilling fluid composition of claim 4, wherein the vinyl non-ionic monomers having at least one amide moiety comprises acrylamide or an ($C_1$-$C_8$)-alkyl-N-substituted acrylamide.

6. The drilling fluid composition of claim 5, wherein the vinyl non-ionic monomer having at least one amide moiety comprises acrylamide.

7. The drilling fluid composition of claim 3, wherein the vinyl non-ionic monomers are selected from:

i) maleic anhydride;

ii) vinyl acetate;

iii) vinyl alcohol;

iv) ethylene oxide;

v) styrene; and

vi) acrylate esters.

8. The drilling fluid composition of any one of claims 3 to 7, wherein the vinyl non-ionic monomer is present in the ampholytic hydrophobic polymer at an amount between 10 and 80% (w/w).

9. The drilling fluid composition of claim 8, wherein the vinyl non-ionic monomer is present in the ampholytic hydrophobic polymer at an amount between 50 and 70% (w/w).

10. The drilling fluid composition of any one of claims 3 to 9, wherein the vinyl anionic monomer comprises:

i) ethylenically unsaturated carboxylic acids, and/or their corresponding salts;

ii) ethylenically unsaturated sulfonic acids, and/or their corresponding salts;

iii) anionic N-substituted acrylamide, and/or their corresponding salts; or

iv) alkyl sulfonate esters of unsaturated carboxylic acids, and/or their corresponding salts.

11. The drilling fluid composition of claim 10, wherein

i) the ethylenically unsaturated carboxylic acid is acrylic acid, methacrylic acid, itaconic acid, fumaric acid, or their corresponding salts;

ii) the ethylenically unsaturated sulfonic acid is ethylene sulfonic acid, vinyl benzyl sulfonic acid, or their corresponding salts;

iii) the anionic N-substituted acrylamide is 2-acrylamide-2-methylpropane sulfonic acid, or their corresponding salts; or

iv) the alkyl sulfonate ester of unsaturated carboxylic acids is 2-sulfoethyl methacrylate, or their corresponding salts.

12. The drilling fluid composition of any one of claims 3 to 11, wherein the vinyl anionic monomer is present in the ampholytic hydrophobic polymer at an amount between 10 and 50% (w/w).

13. The drilling fluid composition of claim 12, wherein the vinyl anionic monomer is present in the ampholytic hydrophobic polymer at an amount between 10 and 30% (w/w).

14. The drilling fluid composition of any one of claims 3 to 13, wherein the vinyl cationic hydrophobic monomer is dimethyl allyl $C_8$-$C_{30}$(alkyl) ammonium chloride, methyl diallyl ($C_8$-$C_{30}$)-alkyl ammonium chloride, acryloyoxyethyl dimethyl $C_8$-$C_{30}$(alkyl) ammonium chloride, or 2-methacryloyoxyethyl dimethyl $C_8$-$C_{30}$(alkyl) ammonium chloride.

15. The drilling fluid composition of any one of claims 3 to 14, wherein the vinyl cationic hydrophobic monomer is present in the ampholytic hydrophobic polymer at an amount between 10 and 60% (w/w).

16. The drilling fluid composition according to any one of claims 1 to 15, wherein the at least one conventional drilling fluid additive is selected from

viscosifiers, filtrate loss reducers, drilling fluid thinners / dispersants, shale inhibitors / clay inhibitors, lubricants, defoaming agents, bridging agents, weighting agents, pH adjusting agents, and the circulation loss materials.

17. The drilling fluid composition according to claim 16, wherein

i) the viscosifier is xanthan gum, guar gum or hydroxyl ethyl cellulose;

ii) the filtrate loss reducer is poly-anionic cellulose or drilling starch;

iii) the drilling fluid thinner or dispersant is lignite or lignosulfonate;

iv) the shale or clay inhibitor is an amine or potassium silicate;

v) the lubricant is a fatty acid or a derivative thereof;

vi) the defoaming agent is an organic silicone defoamer, an alcohol based defoamer, or an ethylene oxide defoamer;

vii) the bridging agent is calcium carbonate;

viii) the weighting agent is barite; and

ix) the pH adjusting agent is sulfamic acid, citric acid, sodium bicarbonate or soda ash.

18. The drilling fluid composition according to claim 17, wherein the conventional drilling fluid additive is xanthan gum, poly-anionic cellulose or drilling starch.

19. A method of recovering bitumen from oil sands comprising contacting a drilling fluid composition as defined in any one of claims 1 to 18 with the oil sands to prevent the bitumen from sticking on the drilling string, shakers and other drilling equipment while drilling oil sands or heavy oil formations.