Reducing fluid loss in a drilling fluid by adding 0.1 to 10% by weight of a radial styrene-butadiene-styrene (SBS) block copolymer having 25% or more styrene to the drilling fluid to provide an unexpected improvement in the fluid loss property of the drilling fluid by decreasing the HTHP H value by at least 55%.
REDDUCING FLUID LOSS IN A DRILLING FLUID

Field of the Invention

[0001] The invention relates generally to substantially reducing fluid loss in oil-base drilling fluid by adding an effective amount of a styrene-butadiene-styrene (SBS) block polymer having 25% or more styrene to the drilling fluid.

Background of the Invention

[0002] Drilling fluids are used in the process of drilling bore holes in subterranean deposits such as gas and oil. The boring is accomplished by well drilling tools and a drilling fluid. Drilling fluids serve to cool and lubricate the drill bits, to carry the cuttings to the surface as the drilling fluid is circulated in and out of the well; to support at least part of the weight of the drilling pipe and drill bit; to provide a hydrostatic pressure head to prevent caving in of the walls of the well bore, to deposit on the surface of the well bore a filter cake which acts as a thin, semi-pervious layer to prevent undue passage therethrough of drilling fluids; and to perform other functions as are well-known in the drilling art. It is important that the drilling fluid exhibit a relatively low rate of filtration or fluid loss in addition to having desirable, rheological properties, such as viscosity and gel strength.

[0003] Drilling fluids contain additives and conditioning agents that are important in determining the fluid loss properties of the drilling fluid, as well as inhibiting shale and clay disintegration. U.S. Patent No. 5,909,779 discloses that such additives or agents include modified lignite, polymers, oxidized asphalt, gilsonite, humates prepared by reacting humic acid with amide or polyalkyl polyamines. The amount of fluid loss agent added are usually less than 10% by weight, and preferably, less than 5% by weight or volume of the drilling fluid.

[0004] U.S. Patent No. 5,883,054 discloses adding a random styrene-butadiene (SBR) copolymers having an average molecular weight greater than about 500,000 g/mol to an oil-based drilling fluid to make a thermally stable drilling fluid system. The concentration of SBR is about 1 to about 6 pounds per barrel. According to the patent, the resultant drilling fluid system exhibits fluid loss-control at high temperatures and high pressure conditions. The reference compared the fluid loss (ml/30min) of a block styrene-butadiene copolymer
(30% styrene) to a random SBR copolymer. The fluid loss property of the random SBR is disclosed to be significantly better than a random SBR copolymer.

U.S. Patent Nos. 5,925,182 and 5,834,573 disclose adding an oil soluble block or random copolymers to water-based drilling fluids, milling fluids, and mining fluids. The copolymers comprise styrene-isoprene and styrene-butadiene and can be present in the fluid in an amount ranging from about 0.1 to about 10 wt. %. The copolymer provides a stable liquid composition for use in water-based drilling fluid. However, the reference does not disclose that radial block copolymers of styrene and butadiene significantly reduce fluid loss in drilling fluids. Also, U.S. Patent No. 6,034,037 discloses a synthetic fluid-based drilling fluid containing up to 30 pounds per barrel of a polymeric fluid loss control agent comprising a polymer consisting of at least two monomers selected from the group consisting of styrene, butadiene and isoprene.

U.S. Patent No. 6,017,854 discloses a non-aqueous drilling fluid containing a linear KRATON® (sold by Kraton Polymers, Inc.) SBS or styrene-isoprene-styrene (SIS) block copolymer as a viscosifying/fluid loss agent to help prevent fluid loss. The KRATON® polymers specifically disclosed are KRATON® G polymers and KRATON® D1101, 1102 and 1107 polymers. These are linear, and not radial block copolymers.

I have discovered that radial styrene-butadiene block copolymers containing 25% or more styrene, such as KRATON® D1184, improve the fluid loss property of a drilling fluid by at least 55%, and more preferably by at least 60%, when compared to a drilling fluid that does not contain the radial copolymer. I have discovered that radial block copolymers of styrene and butadiene such as KRATON® D1184, D1184G and D1122X unexpectedly provides excellent fluid loss properties in drilling fluids.

Summary of the Invention

The object of this invention is to provide an oil-base drilling fluid having improved fluid loss properties.

It is a further object of the invention to provide a drilling fluid that contains a radial SBS block copolymer containing 25% or more styrene.
[0010] It is a further object of the invention to provide a drilling fluid that contains about 0.02% to about 3.0% by weight of drilling fluid of a radial SBS block copolymer containing 25% or more styrene.

[0011] It is a further object of the invention to provide a method of drilling using the new drilling fluid that contains about 0.02% to about 3.0% by weight of drilling fluid of a radial SBS block copolymer containing 25% or more styrene.

[0012] It is still a further object of the invention to provide a drilling system using the new drilling fluid having improved fluid loss properties, in particular, a drilling fluid that contains about 0.02% to about 3.0% by weight of drilling fluid of a radial SBS block copolymer containing 25% or more styrene.

Detailed Description of the Invention

[0013] This invention relates to a method for improving the fluid loss in an oil-based drilling fluid. I have discovered that radial styrene-butadiene block copolymer added to drilling fluid unexpectedly results in a significant improvement in fluid loss control. A drilling fluid is used in combination with a rotating drill bit to drill a borehole in a subterranean formation. The drilling method comprises the steps of rotating a drill bit in the borehole and introducing the drilling fluid into the borehole to pick up the drill cuttings and carrying at least a portion of the drill cuttings out of the borehole. The drilling system employed in such method comprises the subterranean formation, the borehole penetrating the subterranean formation, the drill bit suspended in the borehole, and the drill fluid located in the borehole and proximate the drill bit.

[0014] The drilling fluid for purposes of this invention is a fluid having the following ingredients: an oil-base drilling mud, a weighting agent and optional ingredients such as asphalt, gilsonite and modified lignite. The drilling mud is a composition having the following components: oil, brine, lime, a viscosifier and gelling agent, and an emulsifier and wetting agent. The oil can be diesel oil; a low toxicity synthetic oil such as ESCALID® 110 (Exxon Mobile Corp.), NOVAPLUS® drilling fluid (from M-I Drilling Fluids L.L.C.) or SARALINE® (Unical Corp); an alpha-olefinic oil, or a non-synthetic oil such as mineral oil. A low toxicity oil is one that is not carcinogenic and environmentally friendly, and is safer than conventional diesel oil. The brine typically includes a salt such as calcium chloride.
The viscosifier and gelling agent can be an organophilic clay such as hectorite, bentonite and mixtures thereof. The emulsifiers and wetting agents include surfactants and ionic surfactants such as fatty acids, amines, amides and organic sulphonates and mixtures thereof. The weighting agents include materials such as barite, hematic, calcium carbonate, galena, siderite and mixtures thereof. Weighting agent is added to the drilling mud to adjust the density.

[0015] While it is known to add random and block styrene-butadiene copolymers to drilling fluids as viscosifying/fluid loss control agents, the viscosifying/fluid loss agent of the present invention is a block copolymer having a radial architecture.

[0016] Block copolymers are thermoplastic elastomeric or rubber compounds in which the polymer chains have either a linear or radial (i.e., multiarm or star-shaped) configuration. The polymer chains can be di-block, tri-block or multiblock.

[0017] Di-block copolymers comprise hydrogenated copolymers having an A-B architecture. Generally, the di-block copolymer comprises one polystyrene block or random polymer block derived from predominantly styrene and a minor amount of a conjugated diene, and one block of polyisoprene or poly-1,3-butadiene which has been hydrogenated after the polymerization to at least 80 mol % of the original unsaturation in the polybutadiene or polyisoprene block. Polymer blocks A are prepared from, for example, styrene, alphamethylstyrene, 2,4-dichlorostyrene, p-methoxystyrene, p-methylstyrene, 3,4-dimethylstyrene, m-tert-butylstyrene, p-phenylstyrene, p-acetoxy styrene, divinylbenzene, 1-vinyl naphthalene, 3,5-diethyl styrene, 4-n-propyl styrene, 2,4,6-trimethyl styrene, 4-p-tolyl styrene, 3,5-diphenylstyrene, 3-ethyl-vinyl naphthalene, 8-phenyl-1-vinyl naphthalene, or mixtures thereof. Polymer blocks B are prepared from, for example, 1,3-butadiene, 2-methyl-1,3-butadiene (isoprene), 1,3-pentadienes (piperylenes), 2,3-dimethyl-1,3-butadiene, 2-methyl-1,3 pentadiene, 2,3-dimethyl-1,3-pentadiene, 2-phenyl-1,3-butadiene, 1-phenyl-1,3-butadiene, or mixtures thereof. Examples of linear di-block copolymers include styrene-butadiene (SBR) and styrene-ethylene/propylene (SEP).

[0018] The tri-block rubbers have poly(vinylaromatic) such as polystyrene segments (S) on the ends of the molecule and a rubber segment in the center. In some instances, the elastomeric portion of these polymers is a saturated olefin rubber (e.g., ethylene/butylene
(EB), ethylene/propylene (EP)). In other instances, the rubber segment is unsaturated (e.g., butadiene (B), isoprene (I)). Due to their saturated nature, molecules containing a saturated olefin rubber are very stable at elevated temperatures. Examples of tri-block copolymers include styrene-butadiene-styrene (SBS) and styrene-ethylene-butylene-styrene (SEBS) and styrene-isoprene-styrene (SIS). These copolymers can be linear or radial (branched or "star shaped").

[0019] The block copolymer of the present invention is a radial styrene-butadiene-styrene (SBS) block copolymer containing 25% or more styrene, preferably 25% to 50% styrene, and more preferably 30% to 38% styrene. An example of such a block copolymer is KRATON® D1184 from Kraton Polymers.

[0020] The use of KRATON® polymers in drilling fluids is known. As discussed in the Background of the Invention, supra, U.S. Patent No. 6,017,854, discloses adding KRATON® G copolymers, in particular KRATON® G1702, as a viscosifying/fluid loss agent to a low toxic synthetic drilling fluid such as SARALINE®. The patent further discloses KRATON® D1101, 1102 and 1107. According to the patent, KRATON® G1702 is a di-block copolymer comprising a linear styrene-ethylene/propylene (SEP) block copolymer comprising 28% styrene and 72% of the ethylene/propylene. The total block copolymer concentration in the drilling fluid is from about 0.01 to 10 wt %. The fluid loss is disclosed to be 1.4 ml/30 min. However, the patent does not disclose a fluid loss reading for the drilling fluid without the KRATON® G1702. Therefore, it is unclear what the improvement would have been. A comparison made in Example 1 set forth below only shows a 9% improvement in fluid loss using KRATON® G1702 as compared to over 55% using KRATON® D1184 when about 0.2 wt. % of the block copolymer is added to the drilling fluid.

[0021] The concentration of the block copolymer in the low toxicity drilling fluid is in the range of about 0.02% to about 3% by weight of the oil-base drilling mud, preferably about 0.05% to about 2% by weight of the oil-base drilling mud, and more preferably about 0.1% to about 1% by weight of the oil-base drilling mud.

[0022] In the Tables 2, 4, 5 and 6 below, the viscosity dial readings, plastic viscosity reading, the yield point reading and gel strength readings were obtained using a Fann Model 35A Viscometer. The viscosity dial readings were obtained while holding the sample at a
temperature of 85° F. The gel strength is reported in lbs/100 ft², the first measurement at 10 seconds and the second measurement at 10 minutes. The term "HTHPFL" means high temperature high pressure fluid loss measured at 300° F and 500 psi. The term "FL" means fluid loss. The compositions shown in Tables 1 and 3 include "rev dust" which is a calcium monmorillonite clay that has been added to the compositions to simulate solids in the drilling fluids to be tested.

[0023] The Examples below shows that, oil-based drilling fluid compositions containing SBS radial block copolymers with more than 25% styrene provide lower/better HTHPFL than the compositions containing the SBS radial polymer with 23% styrene, SBS linear, SIS radial, and SEP linear polymers known in the art. Further, the compositions containing the SBS radial polymers with more than 25% styrene also have very good anti-settling properties.

EXAMPLE 1

[0024] An oil-base drilling mud, OBM #1, was prepared by mixing 44.3 grams of lime; 44.3 grams of VG 69® from (M-I Drilling Fluids L.L.C., Houston, Texas), an organophilic clay; 44.3 grams of VERSAMUL® (M-I Drilling Fluids), a multi-purpose emulsifier; 9.6 grams of VERSACOAT® (M-I Drilling Fluids), an organic surfactant; and 700 grams of calcium chloride (10 pounds per gallon) brine into 1325 grams of ESCAID® 110 (a low toxic synthetic drilling fluid from Exxon Mobil Corporation, Fairfax, VA).

[0025] OBM #1 was used for preparing eight drilling fluid compositions shown in Table 1. The compositions shown in Table 1 include the following ingredients: OBM #1 drilling mud, barite (a weighting agent) and rev dust to simulate solids in the drilling fluid. The ingredients were added while the fluids were being mixed with a Multimixer. After the addition of each ingredient, the mixing time is shown in parenthesis for each composition shown in Table 1. After the mixing completed, the fluids were rolled in closed containers in an oven for 16 hours. The oven was maintained at about 250° F during the rolling of the fluids. The fluids were then cooled to about 85° F, mixed 5 minutes on the Multimixer, and then tested according to the “Recommended Practice Standard Procedure for Field Testing Oil-Based Drilling Fluids, API Recommended Practice 13B-2 (RP 13B-2)”. The compositions in each of Runs 2-8 contain 0.34% of the block copolymer based on the weight of the drilling fluid. Runs 2 and 3 represent drilling fluid compositions of the present
invention using KRATON® D1184, an SBS block copolymer having a radial architecture and having 28% styrene content. Run 4 is also a composition of the present invention using KRATON® D1122X, an SBS block copolymer having a radial architecture and having 38% styrene content. Run 5 is not within the scope of the invention since the block copolymer contains less than 25% styrene while Runs 6 and 8 are not within the scope of the invention because the block copolymers are linear, and not radial. Run 7 is also not within the scope of the invention in that it contains an SIS block copolymer.

### TABLE 1

<table>
<thead>
<tr>
<th>Run</th>
<th>Composition of Drilling Fluid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>233 grams of OBM #1 + 130 grams of barite (5 minutes) + 12 grams of rev dust (15 minutes)</td>
</tr>
<tr>
<td>2</td>
<td>233 grams of OBM #1 + 130 grams of barite (5 minutes) + 12 grams of rev dust (5 minutes) + 0.8 gram KRATON® D1184 (SBS Radial, 30% Styrene) polymer (10 minutes)</td>
</tr>
<tr>
<td>3</td>
<td>233 grams of OBM #1 + 130 grams of barite (5 minutes) + 12 grams of rev dust (5 minutes) + 0.8 gram KRATON® D1184G (SBS Radial, 30% Styrene) polymer (10 minutes)</td>
</tr>
<tr>
<td>4</td>
<td>233 grams of OBM #1 + 130 grams of barite (5 minutes) + 12 grams of rev dust (5 minutes) + 0.8 gram KRATON® D1122X (SBS Radial, 30% Styrene) polymer (10 minutes)</td>
</tr>
<tr>
<td>5</td>
<td>233 grams of OBM #1 + 130 grams of barite (5 minutes) + 12 grams of rev dust (5 minutes) + 0.8 gram KRATON® D1116 (SBS Radial, 23% Styrene) polymer (10 minutes)</td>
</tr>
<tr>
<td>6</td>
<td>233 grams of OBM #1 + 130 grams of barite (5 minutes) + 12 grams of rev dust (5 minutes) + 0.8 gram KRATON® D1102 (SBS Linear, 30% Styrene) polymer (10 minutes)</td>
</tr>
<tr>
<td>7</td>
<td>233 grams of OBM #1 + 130 grams of barite (5 minutes) + 12 grams of rev dust (5 minutes) + 0.8 gram KRATON® D1124K (SIS Radial, 30% Styrene) polymer (10 minutes)</td>
</tr>
<tr>
<td>8</td>
<td>233 grams of OBM #1 + 130 grams of barite (5 minutes) + 12 grams of rev dust (5 minutes) + 0.8 gram KRATON® G1702 (SEP Linear, 28% Styrene) polymer (10 minutes)</td>
</tr>
</tbody>
</table>

[0026] The compositions were tested for plastic viscosity, yield point, gel strength and HTHPFL. The results are presented in Table 2 below. As shown in Table 2, the fluid containing the SBS radial block polymers with more than 25% styrene (Runs 2, 3, and 4) provided lower, i.e., better or improved HTHPFL than all other compositions (Runs 1, 5, 6, 7
and 8). In Run 2, the HTHPFL value when compared to the HTHPFL value of a drilling fluid without the SBS polymer (Run 1) was reduced by 61%. In Run 3, the HTHPFL value when compared to the HTHPFL value of Run 1 was reduced by 63%. In Run 4, the HTHPFL value when compared to the HTHPFL value of Run 1 was reduced by 72%. In addition, the compositions of runs 2, 3, and 4 also provided higher yield points, higher viscosity dial readings at 6 RPM and 3 RPM readings than the compositions of Runs 1, 5, 6 and 8. The high yield point in combination with high 6 and 3 RPM readings, and high gels indicate very good anti-settling properties of the fluids. Even though the fluid of Run 7 exhibited very good anti-settling properties, it gave the second highest HTHPFL. Run 1, which did not contain any polymer, gave the highest HTHPFL.

**TABLE 2**

<table>
<thead>
<tr>
<th>Run</th>
<th>Viscometer Dial Reading</th>
<th>Plastic Viscosity (cps)</th>
<th>Yield Point (lbs/100 ft²)</th>
<th>Gel Strength (lbs/100 ft²)</th>
<th>HTHPFL (ml/30 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>44</td>
<td>22</td>
<td>22</td>
<td>3/10</td>
<td>33.6</td>
</tr>
<tr>
<td>2</td>
<td>54</td>
<td>33</td>
<td>21</td>
<td>6/9</td>
<td>13.2</td>
</tr>
<tr>
<td>3</td>
<td>64</td>
<td>40</td>
<td>24</td>
<td>13/27</td>
<td>12.6</td>
</tr>
<tr>
<td>4</td>
<td>58</td>
<td>35</td>
<td>23</td>
<td>4/8</td>
<td>9.4</td>
</tr>
<tr>
<td>5</td>
<td>48</td>
<td>27</td>
<td>21</td>
<td>3/8</td>
<td>16.8</td>
</tr>
<tr>
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<td>1/1</td>
<td>17.8</td>
</tr>
<tr>
<td>7</td>
<td>53</td>
<td>35</td>
<td>18</td>
<td>7/8</td>
<td>32.8</td>
</tr>
<tr>
<td>8</td>
<td>59</td>
<td>32</td>
<td>27</td>
<td>4/8</td>
<td>30.6</td>
</tr>
</tbody>
</table>

**EXAMPLE 2**

This Example shows that, an oil-based drilling fluid composition containing KRATON® D1184G provides lower/better HTHPFL than the compositions containing SHELLVISO® 40 polymer (a hydrogenated styrene-isoprene copolymer from Infinium, the Shell:Exxon additive company). Further, the composition with D1184G polymer has the best anti-settling properties.

The compositions for this Example were prepared as follows: An oil-base mud (OBM #3) was prepared in a manner similar to the preparation of OBM #1 in Example 1. OBM #3 was mixed with barite and rev dust in the amounts set forth in Table 3 to form three drilling fluid compositions. The barite and rev dust were added while the fluids were being
mixed with the Multimixer. The mixing time after the addition of each ingredient is shown in parenthesis in minutes in Table 3 after each ingredient.

<table>
<thead>
<tr>
<th>Run</th>
<th>Composition of Drilling Fluid</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>233 grams of OBM # 3 + 125 grams of barite (5 minutes) + 12 grams of rev dust (5 minutes)</td>
</tr>
<tr>
<td>10</td>
<td>233 grams of OBM # 3 + 125 grams of barite (5 minutes) + 12 grams of rev dust (5 minutes) + 0.8 gram KRATON® D1184G (SBS Radial, 30% Styrene) polymer (5 minutes)</td>
</tr>
<tr>
<td>11</td>
<td>233 grams of OBM # 3 + 125 grams of barite (5 minutes) + 12 grams of rev dust (5 minutes) + 0.8 gram SHELLVIS® 40 polymer (5 minutes)</td>
</tr>
</tbody>
</table>

After the mixing completed, the fluids were rolled in closed containers in an oven for 4 hours. The oven was maintained at around 150°F during the rolling of the fluids. The fluids were then cooled to around 90°F and mixed 10 minutes on the Multimixer. After testing the fluids were further rolled 16 hours in the oven at 250°F and cooled to around 90°F. Then, they were mixed 10 minutes on the Multimixer and tested according to the “Recommended Practice Standard Procedure for Field Testing Oil-Based Drilling Fluids, API Recommended Practice 13B-2 (RP 13B-2)”. These results after rolling at 250°F are presented in Table 4. Next, the fluids were aged 16 hours in the oven at 300°F and, after cooling to around 100°F and mixing 10 minutes, they were tested again. These test results after aging at 300°F are presented in Table 5 below.

[0029] As shown below in Tables 4 and 5, the drilling fluid composition of within the present invention (Run 10) provided the lowest HTHPFL. This composition also had the highest 6 and 3 rpm reading, and the highest yield point and gel strength values indicating that the anti-settling properties are better for the fluid of Run 10 than the fluids of Runs 9 and 11.
### TABLE 4

<table>
<thead>
<tr>
<th>Run</th>
<th>Viscometer Dial Reading</th>
<th>Plastic Viscosity cps</th>
<th>Yield Point lbs/100 ft²</th>
<th>Gel Strength lbs/100 ft²</th>
<th>HTHPFL ml/30 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>46 25 2.5 2</td>
<td>21</td>
<td>4</td>
<td>3/9</td>
<td>13.2</td>
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<tr>
<td>10</td>
<td>79 52 8 8</td>
<td>27</td>
<td>25</td>
<td>4/14</td>
<td>5.2</td>
</tr>
<tr>
<td>11</td>
<td>81 46 3.5 2.5</td>
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<td>11</td>
<td>3/8</td>
<td>8.8</td>
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</table>

### TABLE 5

<table>
<thead>
<tr>
<th>Run</th>
<th>Viscosity Dial Reading</th>
<th>Plastic Viscosity cps</th>
<th>Yield Point lbs/100 ft²</th>
<th>Gel Strength lbs/100 ft²</th>
<th>HTHPFL ml/30 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>49 27 2 2</td>
<td>22</td>
<td>5</td>
<td>2/12</td>
<td>28.0</td>
</tr>
<tr>
<td>10</td>
<td>125 109 50 32</td>
<td>16</td>
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<td>11.2</td>
</tr>
<tr>
<td>11</td>
<td>73 42 3 2</td>
<td>31</td>
<td>11</td>
<td>2/7</td>
<td>21.6</td>
</tr>
</tbody>
</table>

### EXAMPLE 3

[0030] This Example shows that the SBS radial block copolymer (KRATON® D1184) provides lower/better HTHPFL than the SHELLVIS® 40 polymer in a sample of NOVAPLUS® drilling fluid (M-I Drilling Fluids L.L.C.). Further, KRATON® D1184G polymer also improves anti-settling properties of the mud.

[0031] The runs were carried out as follows. Two hundred eighty milliliters of NOVAPLUS® fluid were transferred in to pint jars. After mixing 0.4 g of polymer shown in Table 6, the resulting compositions were rolled in closed containers in an oven for 16 hours. The oven was maintained at around 250°F during the rolling of the fluids. The fluids were cooled to around 90°F, mixed 10 minutes on the Multimixer, and tested. After testing, the fluids were further rolled two hours in the oven at 250°F and the hot fluids were aged 16 hours in an oven at 300°F. They were then cooled to around 95°F and, after mixing 10 minutes, they were tested according to the “Recommended Practice Standard Procedure for Field Testing Oil-Based Drilling Fluids, API Recommended Practice 13B-2 (RP 13B-2)”. These results, after aging at 300°F, are reported in Table 6.

[0032] As shown in Table 6, the addition of 0.4 grams of D1184G polymer (Run 13) reduced the HTHPFL more than the addition of 0.4 grams of SHELLVIS® 40 polymer (Run...
14). The fluid containing D1184G polymer (Run 13) also had higher 3 and 6 RPM readings, higher yield point and higher gel strength than the fluid of Run 12. The higher properties indicate that the anti-settling properties are improved by the addition of D1184G polymer.

**TABLE 6**

<table>
<thead>
<tr>
<th>Run</th>
<th>Polymer</th>
<th>Viscometer Dial Reading</th>
<th>Plastic Viscosity cps</th>
<th>Yield Point lbs/100 ft²</th>
<th>Gel Strength lbs/100 ft²</th>
<th>HTHPFL ml/30 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>None</td>
<td>138 rpm 78 rpm 8.5 rpm 7.5 rpm</td>
<td>60</td>
<td>18</td>
<td>16/36</td>
<td>13.2</td>
</tr>
<tr>
<td>13</td>
<td>KRATON® D1184G</td>
<td>175 rpm 101 rpm 12 rpm 11 rpm</td>
<td>74</td>
<td>27</td>
<td>22/46</td>
<td>10.8</td>
</tr>
<tr>
<td>14</td>
<td>SHELLVIS® 40</td>
<td>177 rpm 101 rpm 11 rpm 9 rpm</td>
<td>76</td>
<td>25</td>
<td>20/39</td>
<td>11.4</td>
</tr>
</tbody>
</table>

[0033] While this invention has been described with reference to several preferred embodiments, it is contemplated that various alterations and modifications thereof will become apparent to those skilled in the art upon a reading of the preceding detailed description. It is therefore intended that the following appended claims be interpreted as including all such alterations and modifications as fall within the true spirit and scope of this invention.
What is claimed is:

1. A drilling fluid comprising an oil-base drilling mud and a radial styrene-butadiene-styrene block copolymer having 25% or more styrene, wherein the fluid loss property of the drilling fluid is reduced, the concentration of said radial block copolymer being about 0.02% to about 3% by weight of said oil-base drilling mud.

2. The oil-base drilling fluid composition according to claim 1, wherein said oil-base drilling mud includes an oil selected from the group consisting of synthetic low toxic oil, mineral oil, diesel oil, and an alpha-olefinic oil.

3. The oil-base drilling fluid composition according to claim 2, wherein the drilling fluid composition further includes a weighting agent.

4. The oil-base drilling fluid composition according to claim 3, wherein said oil-base drilling mud includes an organophilic clay.

5. The oil-base drilling fluid composition according to claim 4, wherein said oil-base drilling mud further includes brine, lime, a surfactant and an emulsifier.

6. The oil-base drilling fluid composition according to claim 5, wherein the drilling fluid composition further includes asphalt, gilsonite, and modified lignite.

7. A method of drilling in a subterranean formation, the method comprising the steps of rotating a drill bit in a borehole, and introducing drilling fluid according to claim 1 in said borehole.

8. A method of drilling in a subterranean formation, the method comprising the steps of rotating a drill bit in a borehole, and introducing a drilling fluid according to claim 2 in said borehole.
9. A method of drilling in a subterranean formation, the method comprising the steps of rotating a drill bit in a borehole, and introducing a drilling fluid according to claim 4 in said borehole.

10. A drilling system comprising a drill bit suspended in a borehole and a drilling fluid composition located in the borehole and proximate the drill bit, said drilling fluid comprising an oil-base drilling mud and a radial styrene-butadiene-styrene block copolymer having 25% or more styrene, wherein the fluid loss property of the drilling fluid composition is reduced, the concentration of said radial block copolymer being about 0.02% to about 3% by weight of said oil-base drilling mud.

11. The drilling system according to claim 10, wherein said oil-base drilling mud includes an oil selected from the group consisting of synthetic low toxic, non-aqueous fluid, mineral oil and diesel oil, and an alpha-olefinic oil.

12. The drilling system according to claim 10, wherein the drilling fluid further includes a weighting agent.

13. The drilling system according to claim 12, wherein said oil-base drilling mud includes an organophilic clay.

14. The drilling system according to claim 13, wherein said oil-base drilling mud further includes brine, lime, a surfactant and an emulsifier.

15. The drilling system according to claim 14, wherein the drilling fluid further includes asphalt, gilsonite and modified lignite.
# INTERNATIONAL SEARCH REPORT

## A. CLASSIFICATION OF SUBJECT MATTER

**IPC 7** C09K 7/06

According to International Patent Classification (IPC) or to both national classification and IPC.

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C09K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
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| X        | US 6 017 854 A (VAN SLYKE DONALD C)  
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column 3, line 23 - line 64; claims 1-27  
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20 May 1997 (1997-05-20)  
column 1, line 32 - column 2, line 48 | 1,2,5,6 |

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Date of the actual completion of the international search  
13 January 2004

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