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(54) **Title**: TREATMENT FLUID

(57) **Abstract**: Proppant transport assist in low viscosity treatment fluids. Treatment fluids and methods use fiber containing 0.1 to 20 wt% silicones to inhibit proppant settling without an unacceptable bridging tendency.

TREATMENT FLUID

RELATED APPLICATIONS

[0001] This application claims priority of International Patent Application No. PCT/RU2014/000271, filed April 15, 2014. The disclosure of priority application is hereby incorporated by reference herein in its entirety.

BACKGROUND

[0002] The statements in this section merely provide background information related to the present disclosure and may not constitute prior art.

[0003] Fibers have been used in some hydraulic fracturing treatments where a viscosified treatment fluid is used to carry proppant and/or where bridging contributed to by the fiber is desirable, e.g., in diversion applications. However, with low viscosity fluids such as, for example, treatments using slickwater (also sometimes referred to as waterfrac) to fracture shale or tight gas formations, bridging may be undesirable and narrow fracture widths would further exacerbate the bridging tendencies of fiber. Accordingly, there is a demand for further improvements in this area of technology.

SUMMARY

[0004] In some embodiments according to the disclosure herein, compositions, methods and systems using fibers are employed in low viscosity treatment fluids to inhibit proppant settling while obtaining suitable resistance to bridging, e.g., without bridging in some embodiments.

[0005] In embodiments, compositions comprising a low viscosity carrier fluid, proppants and a polymeric fibers containing from 0.1 to 20 wt% of silicones are described.

[0006] In some embodiments, a well treatment fluid may comprise a low viscosity carrier fluid, e.g., having a viscosity less than 50 mPa-s at a shear rate of 170 s^{-1} and a temperature of 25°C, proppant dispersed in the carrier fluid, and fiber dispersed in the carrier fluid. Such fiber may be present in some embodiments in an amount effective to inhibit settling of the proppant, for example, in a static proppant settling test or in a large slot flow test without bridging at a flow rates equal to and greater than 10 cm/s.

[0007] In some embodiments, a method to treat a subterranean formation penetrated by a wellbore may comprise injecting a treatment fluid into the subterranean formation to form a hydraulic fracture system, the treatment fluid comprises: a low viscosity carrier fluid, proppant dispersed in the carrier fluid, and fiber dispersed in the carrier fluid. Such fiber may be present in an amount effective to inhibit settling of the proppant; and the method may include maintaining a rate of the injection to avoid bridging in the wellbore.

[0008] In some embodiments, a method to inhibit proppant settling in a low viscosity treatment fluid circulated in a wellbore may comprise dispersing fiber in the carrier fluid in an amount effective to inhibit settling of the proppant, and maintaining a rate of the circulation to avoid bridging in the wellbore.

[0009] In some embodiments, a system to treat a subterranean formation may comprise a subterranean formation penetrated by a wellbore; a treatment fluid injection unit to supply a treatment fluid stage, which comprises proppant in a low viscosity carrier fluid, to the formation above a fracturing pressure to form a fracture system; and a fiber supply unit to introduce fiber into the treatment fluid. In embodiments, the fiber is introduced into the treatment fluid in an amount suitable to inhibit proppant settling and/or the supply of the treatment fluid stage to the formation is at a flow rate sufficient to avoid inducing bridging.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] These and other features and advantages will be better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings.

[0011] Fig. 1A schematically illustrates a bridging test apparatus according to embodiments.

[0012] Fig. 1B schematically illustrates an enlarged detail of the slot design in the apparatus of Fig. 1A.

DETAILED DESCRIPTION

[0013] For the purposes of promoting an understanding of the principles of the disclosure, reference will now be made to some illustrative embodiments of the current application.

Like reference numerals used herein refer to like parts in the various drawings. Reference numerals without suffixed letters refer to the part(s) in general; reference numerals with suffixed letters refer to a specific one of the parts.

[0014] As used herein, "embodiments" refers to non-limiting examples of the application disclosed herein, whether claimed or not, which may be employed or present alone or in any combination or permutation with one or more other embodiments. Each embodiment disclosed herein should be regarded both as an added feature to be used with one or more other embodiments, as well as an alternative to be used separately or in lieu of one or more other embodiments. It should be understood that no limitation of the scope of the claimed subject matter is thereby intended, any alterations and further modifications in the illustrated embodiments, and any further applications of the principles of the application as illustrated therein as would normally occur to one skilled in the art to which the disclosure relates are contemplated herein.

[0015] Moreover, the schematic illustrations and descriptions provided herein are understood to be examples only, and components and operations may be combined or divided, and added or removed, as well as re-ordered in whole or part, unless stated explicitly to the contrary herein. Certain operations illustrated may be implemented by a computer executing a computer program product on a computer readable medium, where the computer program product comprises instructions causing the computer to execute one or more of the operations, or to issue commands to other devices to execute one or more of the operations.

It should be understood that, although a substantial portion of the following detailed description may be provided in the context of oilfield fracturing operations, other oilfield operations such as cementing, gravel packing, etc., or even non-oilfield well treatment operations, can utilize and benefit as well from the instant disclosure.

[0016] In some embodiments, a treatment fluid comprises a low viscosity carrier fluid having a low viscosity, proppant dispersed in the carrier fluid, and fiber dispersed in the carrier fluid. As used herein, a "low viscosity" fluid refers to one having a viscosity less than 50 mPa-s at a shear rate of 170 s^{-1} and a temperature of 25°C. In some embodiments, the treatment fluid comprises proppant particles and fibers dispersed in a carrier fluid.

[0017] In some embodiments, the treatment fluid comprises from 0.01 to 1 kg/L of the proppant based on the total volume of the carrier fluid (from 0.1 to 8.3 ppa, pounds proppant added per gallon of carrier fluid), e.g., from 0.048 to 0.6 kg/L of the proppant based on the total volume of the carrier fluid (0.4 to 5 ppa), or from 0.12 to 0.48 kg/L of the proppant based on the total volume of the carrier fluid (from 1 to 4 ppa). As used herein, proppant loading is specified in weight of proppant added per volume of carrier fluid, e.g., kg/L (ppa = pounds of proppant added per gallon of carrier fluid). Exemplary proppants include ceramic proppant, sand, bauxite, glass beads, crushed nuts shells, polymeric proppant, rod shapped, and mixtures thereof.

[0018] In some embodiments, the fiber is dispersed in the carrier fluid in an amount effective to inhibit settling of the proppant. This settling inhibition may be evidenced, in some embodiments, for example, in a static proppant settling test at 25°C for 90 minutes. The proppant settling test in some embodiments involves placing the fluid in a container such as a graduated cylinder and recording the upper level of dispersed proppant in the fluid. The upper level of dispersed proppant is recorded at periodic time intervals while maintaining settling conditions. The proppant settling fraction is calculated as:

$$\text{Proppant settling} = \frac{[\text{initial proppant level } (t=0)] - [\text{upper proppant level at time } n]}{[\text{initial proppant level } (t=0)] - [\text{final proppant level } (t=\infty)]}$$

[0019] The fiber inhibits proppant settling if the proppant settling fraction for the fluid containing the proppant and fiber has a lower proppant settling fraction than the same fluid without the fiber and with proppant only. In some embodiments, the proppant settling fraction of the treatment fluid in the static proppant settling test after 90 minutes is less than 50%, e.g., less than 40%.

[0020] In some embodiments, the fiber is dispersed in the carrier fluid in an amount insufficient to cause bridging, e.g., as determined in a small slot test comprising passing the treatment fluid comprising the carrier fluid and the fiber without proppant at 25°C through a bridging apparatus such as that shown in Figs. 1A and 1B comprising a 1.0 – 2.0 mm slot that is 15-16 mm wide and 65 mm long at a flow rate equal to 15 cm/s, or at a flow rate equal to 10 cm/s.

[0021] In some embodiments the fiber is dispersed in the carrier fluid in both an amount effective to inhibit settling of the proppant and in an amount insufficient to cause bridging, wherein settling and bridging are determined by comparing proppant accumulation in a narrow fracture flow test comprising pumping the treatment fluid at 25°C through a 1 - 2 mm slot measuring 3 m long by 0.5 m high for 60 seconds at a flow velocity of 30 cm/s, or at a flow velocity of 15 cm/s, relative to a reference fluid containing the carrier fluid and proppant only without the fiber. In the narrow fracture flow test, the slot may be formed of flow cells with transparent windows to observe proppant settling at the bottom of the cells. Proppant settling is inhibited if testing of the fluid with the proppant and fiber results in measurably less proppant settling than the same fluid and proppant mixture without the fiber at the same testing conditions. Bridging is likewise observed in the narrow fracture flow test as regions exhibiting a reduction of fluid flow also resulting in proppant accumulation in the flow cells.

[0022] In some embodiments, the treatment fluid comprises from 1.2 to 12 g/L of the fibers based on the total volume of the carrier fluid (from 10 to 100 ppt, pounds per thousand gallons of carrier fluid), e.g., less than 4.8 g/L of the fibers based on the total volume of the carrier fluid (less than 40 ppt) or from 1.2 or 2.4 to 4.8 g/L of the fibers based on the total volume of the carrier fluid (from 10 or 20 to 40 ppt).

[0023] In some embodiments, the fibers are crimped staple fibers. In some embodiments, the crimped fibers comprise from 1 to 10 crimps/cm of length, a crimp angle from 45 to 160 degrees, an average extended length of fiber of from 4 to 15 mm, and/or a mean diameter of from 8 to 40 microns, or 8 to 12, or 8 to 10, or a combination thereof. In some embodiments, the fibers comprise low crimping equal to or less than 5 crimps/cm of fiber length, e.g., 1-5 crimps/cm.

[0024] Depending on the temperature that the treatment fluid will encounter, especially at downhole conditions, the fibers may be chosen depending on their resistance or degradability at the envisaged temperature. In the present disclosure, the terms "low temperature fibers", "mid temperature fibers" and "high temperature fibers" may be used to indicate the temperatures at which the fibers may be used for delayed degradation, e.g., by hydrolysis, at downhole conditions. Low temperatures are typically within the range of from about 60°C (140°F) to about 93°C (200°F); mid temperatures typically from about

94°C (201°F) to about 149°C (300°F); and high temperatures typically about 149.5°C (301°F) and above, or from about 149.5°C (301°F) to about 204°C (400°F).

[0025] In some embodiments, the fibers comprise polyester. In some embodiments, the polyester undergoes hydrolysis at a low temperature of less than about 93°C as determined by slowly heating 10 g of the fibers in 1 L deionized water until the pH of the water is less than 3, and in some embodiments, the polyester undergoes hydrolysis at a moderate temperature of between about 93°C and 149°C as determined by slowly heating 10 g of the fibers in 1 L deionized water until the pH of the water is less than 3, and in some embodiments, the polyester undergoes hydrolysis at a high temperature greater than 149°C, e.g., between about 149.5°C and 204°C. In some embodiments, the polyester is selected from the group consisting of polylactic acid, polyglycolic acid, copolymers of lactic and glycolic acid, and combinations thereof.

[0026] In some embodiments, the fiber is selected from the group consisting of polylactic acid (PLA), polyglycolic acid (PGA), polyethylene terephthalate (PET), polyester, polyamide, polycaprolactam and polylactone, poly(butylene) succinate, polydioxanone, nylon, glass, ceramics, carbon (including carbon-based compounds), elements in metallic form, metal alloys, wool, basalt, acrylic, polyethylene, polypropylene, novoloid resin, polyphenylene sulfide, polyvinyl chloride, polyvinylidene chloride, polyurethane, polyvinyl alcohol, polybenzimidazole, polyhydroquinone-diimidazopyridine, poly(p-phenylene-2,6-benzobisoxazole), rayon, cotton, cellulose and other natural fibers, rubber, and combinations thereof.

[0027] Any type of PLA might be used. In embodiments, when PLA is used, said PLA may be poly-D, poly-L or poly-D, L lactic acid, or or stereocomplex polylactic (sc-PLA) and mixtures thereof. In embodiment the PLA may have a molecular weight (Mw) of from about 750 g/mol to about 5,000,000 g/mol, or from 5000 g/mol to 1 000 000 g/mol, or from 10,000 g/mol to 500,000 g/mol, or from 30,000 g/mol to 500 000 g/mol. The polydispersity of these polymers might be between 1.5 to 5.

[0028] The inherent viscosity of PLA that may be used, as measured in Hexafluoro-2-propanol at 30 degC, with 0.1% polymer concentration may be from about 1.0 dl /g to 2.6 about dl/g, or from 1.3 dl/g to 2.3 dl/g.

[0029] In embodiments, the PLA may have a glass transition temperature (Tg) above about 20°C, or above 25°C, or above 30°C, or from 35°C to 55°C. In embodiments, the PLA may have a melting temperature (Tm) below about 140°C, or about 160°C, or about 180°C or from about 220°C to about 230°C.

[0030] In some embodiments, the fibers contain silicones. Without wishing to be bound by any theory, it is believe that fibers containing 0.1 to 20 wt%, or 0.1 to 5% of silicones exhibit a higher dispersibility while also having a higher non-bridging capacity.

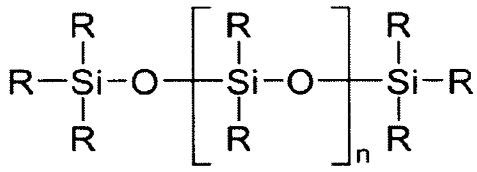
[0031] In embodiments, the fiber, comprising a polyester and silicones may be in the form of a dual component with a shell and a core. In this configuration at least the shell or the core contain a polyester and one of the component or both contain 0.1 to 20 wt% of silicones. The two components may have different degradation rate depending on the conditions.

[0032] The silicone may be present in the fiber in 0.1 to 20 wt%, or 0.1 to 5 wt%, or 0.1 to 3 wt%. or 0.5 to 3wt%. The fiber containing silicones in the present context shall be understood as polymeric fibers, such a polyester, containing a dispersed phase of silicones. This type of fibers may be obtained for example by mixing melting silicones and melted polymers and then extruding the mixture so that the repartition of silicones may be relatively homogeneous. In embodiments the fibers may be obtained by extrusion from pellets of thermoplastic material containing silicones and PLA.

[0033] Silicones in the present context may be understood broadly. The silicones as used in the disclosure are solid at room temperature (25°C). As mentioned previously, the polymer part and the silicones part may typically be mixed as solid at room temperature before melt so that a homogeneous distribution can be obtained throughout the polymer fiber. In embodiments, the silicone is obtained from silicate, for example silica, or fumed silica; when fumed silica is used, it may have a specific surface area (BET) above about $30m^2/g$, or above $50m^2/g$. In embodiments, the silicone used is prepared from polymer containing siloxane and organic radicals.

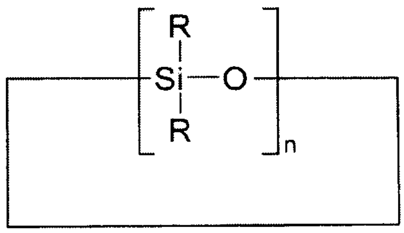
[0034] The silicone polymers may be cyclic polysiloxanes, linear polysiloxanes, branched polysiloxanes, crosslinked polysiloxanes and mixtures thereof.

[0035] Linear polysiloxanes that may be used are the ones of the formula:



Wherein R may be C1-C10 hydrocarbon radical, or alkyl, aryl, etc.

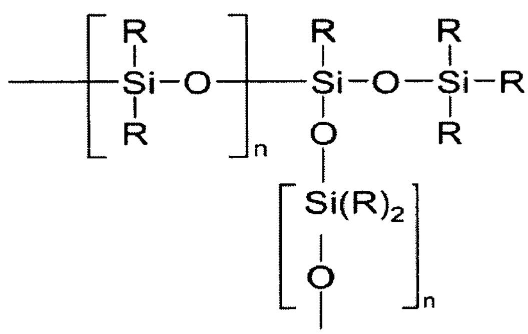
[0036] In embodiments cyclic polysiloxanes of the following formula may be used:



Wherein R may be C1-C10 hydrocarbon radical, or alkyl, aryl, etc.

n may be an integer of at least 4, 5 or 6.

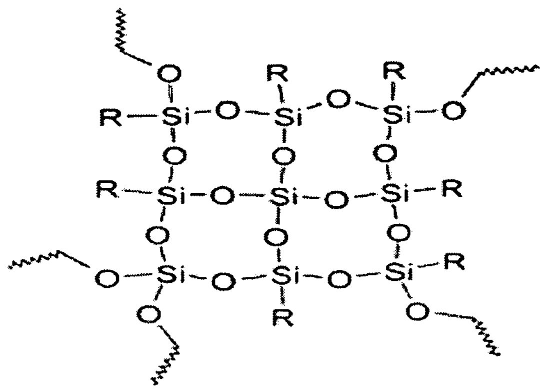
[0037] In embodiments, branched polysiloxane of the following formula may be used:



Wherein R may be C1-C10 hydrocarbon radical, or alkyl, aryl, etc.

n may be the same or different and for a number from 10 to 10,000.

[0038] In embodiments, cross-linked polysiloxanes of the following formula may be used:



Wherein R may be C1-C10 hydrocarbon radical, or alkyl, aryl, etc.

[0039] In embodiments, the silicone used is a linear silicone. In embodiment, such linear silicone has a molecular weight (Mw) of at least about 100,000 g/mol, or at least 150,000 g/mol, or at least 200,000 g/mol and up to about 900,000 g/mol, or up to 700,000 g/mol, or up to 650,000 g/mol, or up to 600,000 g/mol. In embodiments, the high molecular weight, non-crosslinked, linear silicone polymers used may have, at 25°C, a density between 0.76 and 1.07 g/cm^3, or from 0.9 to 1.07 g/cm^3, or from 0.95 to 1.07 g/cm^3.

[0040] The fibers containing silicone provide better proppant transport and reduced settling with reduced water requirements (higher proppant loading), reduced proppant requirements (better proppant placement) and reduced power requirements (lower fluid viscosity and less pressure drop). The fibers may increase proppant transport in a low viscosity fluid. The fibers may be degradable after placement in the formation.

[0041] The fibers can be used in hybrid treatments such as heterogeneous proppant placement and/or pulsed proppant and/or fiber pumping operation modes. If desired in some embodiments, the pumping schedule may be employed according to the alternating-proppant loading technology disclosed in U.S. Patent Application Publication No. US 2008/0135242, which is hereby incorporated herein by reference in its entirety. In this configuration the treatment fluid is pumped as proppant-laden stages between proppant-lean stages. For example the fluid may be slickwater first, followed adjacently by a proppant-laden pulse (or stage), immediately followed by another proppant-lean stage. In this configuration, the silicones modified fibers may be present only in the proppant-laden stage or maybe pumped continuously having thus only the proppant being spaced in a plurality of intervals.

[0042] In some embodiments, the carrier fluid may be slickwater, or may be brine. In some embodiments, the carrier fluid may comprise a linear gel, e.g., water soluble polymers, such as hydroxyethylcellulose (HEC), guar, copolymers of polyacrylamide and their derivatives, e.g., acrylamido-methyl-propane sulfonate polymer (AMPS), or a viscoelastic surfactant system, e.g., a betaine, or the like. When a polymer present, it may be at a concentration below 1.92 g/L (16 ppt), e.g. from 0.12 g/L (1 ppt) to 1.8 g/L (15 ppt). When a viscoelastic surfactant is used, it may be used at a concentration below 10 ml/L, e.g. 2.5ml/L to 5ml/L.

[0043] In some embodiments the treatment fluid may include a fluid loss control agent, e.g., fine solids less than 10 microns, or ultrafine solids less than 1 micron, or 30 nm to 1 micron. According to some embodiments, the fine solids are fluid loss control agents such as γ-alumina, colloidal silica, $CaCO_3$, SiO_2, bentonite etc.; and may comprise particulates with different shapes such as glass fibers, flocs, flakes, films; and any combination thereof or the like. Colloidal silica, for example, may function as an ultrafine solid loss control agent, depending on the size of the micropores in the formation, as well as a gellant and/or thickener in any associated liquid or foam phase.

[0044] . In some embodiments, the carrier fluid comprises brine, e.g., sodium chloride, potassium bromide, ammonium chloride, potassium choride, tetramethyl ammonium chloride and the like, including combinations thereof. In some embodiments the fluid may comprise oil, including synthetic oils, e.g., in an oil based or invert emulsion fluid.

[0045] In some embodiments, the treatment fluid comprises a friction reducer, e.g., a water soluble polymer. The treatment fluid may additionally or alternatively include, without limitation, clay stabilizers, biocides, crosslinkers, breakers, corrosion inhibitors, temperature stabilizers, surfactants, and/or proppant flowback control additives. The treatment fluid may further include a product formed from degradation, hydrolysis, hydration, chemical reaction, or other process that occur during preparation or operation.

[0046] In some embodiments, a method to treat a subterranean formation penetrated by a wellbore, comprises injecting the treatment fluid described herein into the subterranean formation to form a hydraulic fracture system, and maintaining a rate of the injection to avoid bridging in the wellbore, such as, for example, as determined in a bridging testing apparatus without proppant.

[0047] In some embodiments, the method may comprise injecting a pre-pad, pad, tail or flush stage or a combination thereof. In some embodiments, the pre-pad, pad, tail or flush may contain silicones modified fibers.

[0048] The treatment fluid may be prepared using blenders, mixers and the like using standard treatment fluid preparation equipment and well circulation and/or injection equipment. In some embodiments, a method is provided to inhibit proppant settling in a treatment fluid circulated in a wellbore, wherein the treatment fluid comprises the proppant dispersed in a low viscosity carrier fluid. The method comprises dispersing fiber in the carrier fluid in an amount effective to inhibit settling of the proppant, such as, for example, as determined in the small slot test, and maintaining a rate of the circulation to avoid bridging in the wellbore, such as, for example, as determined in a bridging testing apparatus without proppant and/or in the narrow fracture flow test. In some embodiments, the treatment fluid further comprises a friction reducer.

[0049] According to some embodiments, the proppant stage(s) may be injected into a fracture system using any one of the available proppant placement techniques, including heterogeneous proppant placement techniques, wherein the low viscosity treatment fluid herein is used in place of or in addition to any proppant-containing treatment fluid, such as, for example, those disclosed in US 3,850,247; US 5,330,005; US 7,044,220; US 7,275,596; US 7,281,581; US 7,325,608; US 7,380,601; US 7,581,590; US 7,833,950; US 8 061 424; US 8,066,068; US 8,167,043; US 8,230,925; US 8 372 787; US 2008/0236832; US 2010/0263870; US 2010/0288495; US 2011/0240293; US 2012/0067581; US 2013/0134088; EP 1556458; WO 2007/086771; SPE 68854: Field Test of a Novel Low Viscosity Fracturing Fluid in the Lost Hills Fields, California; and SPE 91434: A Mechanical Methodology of Improved Proppant Transport in Low-Viscosity Fluids: Application of a Fiber-Assisted Transport Technique in East Texas; each of which is hereby incorporated herein by reference in its entirety.

EXAMPLES

[0050] In the following examples, slickwater and low viscosity linear guar fluids were prepared from tap water. The slickwater, a fluid A, contained 1 mL/L (1 gpt) of a concentrated friction reducer solution and 2 mL/L (2 gpt) of clay stabilizer. A fluid B containing linear guar gel at a concentration of 2.4 g/L (20 ppt).

[0051] The fibers used in the following examples were polylactic acid fibers containing 0.9% silicones that were obtained from Trevira GmbH (Germany). Both mid and low temperature resistant fibers were used, the mid temperature fibers generally being useful in treatments with a formation temperature in the range of 94-149°C, and the low temperature resistant fibers at 60-93°C. The fibers were straight (uncrimped), low crimp (4-5 crimps/cm) or high crimp (>5 crimps/cm, e.g., 8-15 crimps/cm). In the fibers evaluated in these examples, the low crimp fibers performed well in terms of bridging resistance and inhibiting proppant settling at lower fiber loadings.

[0052] Example 1: Dispersion of fiber in slickwater. In this example two types of fibers were dispersed in fluid A at 4.8 g/L (40 ppt) fiber concentration. After moderate agitation with overhead mixer the slurry was placed into transparent Plexiglas slot of 10 mm width and images were taken for comparison of dispersion behavior of different fibers.

[0053] Batch A contained PLA fiber without silicone modification; image taken for batch A showed significant amount of undispersed fiber bundles that may cause a risk of bridging in a narrow slot.

[0054] Batch B contained similar PLA fiber with 0.9% of Organopolisilixanes; image taken for batch B showed uniform dispersion without visible bundles of undispersed fibers. Uniform dispersibility results in suppressed bridging of fiber material.

[0055] Example 2: Fiber Bridging in Low Viscosity Guar Fluid. In this example, a fluid containing a linear guar fluid, 2.4 g/L (20 ppt) guar, at 4.8 g/L (40 ppt) of fibers without proppant were used. Non modified PLA fiber and fibers containing silicones (OPS) were compared.

[0056] The bridging screen test apparatus used is seen in Figs. 1A and 1B. The fluid being tested was pumped through the apparatus at a flow rate of 10 – 800 mL/min for a period of at least 30 seconds (at the end of the time period the total volume of fluid pumped was 500 mL). Formation of a fiber plug in the slot (1-2 mm) was indicated by a pressure rise. Bridging tests using the test apparatus of Figs. 1A-1B were conducted without proppant. The fluid was recorded as negative for bridge formation if no plug was formed.

[0057] A narrow fracture flow test apparatus was also employed for more in depth analysis. The narrow fracture flow test apparatus employed parallel glass panes with a length of 3 m, height of 0.5 m and width of 1 - 2 mm for visualization of the fluid and proppant at a flow rate up to 50 L/min. The narrow fracture flow tests were run with L-, T- and X-shape slot orientation.

[0058] The bridge screening test results in 1 mm slot are presented in Table 2.

Table 2: Screening Bridge Testing.

Flow rate, mL/min	Linear velocity, cm/s	Fiber 12.4 microns No OPS	Fiber 12.4 microns 0.9 wt% OPS	Fiber 9.1 microns 0.9 wt% OPS
100	11.1	Bridged	Bridged	Bridged
200	22.2	Bridged	Bridged	No Bridge
300	33.3	Bridged	Bridged	No Bridge
400	44.4	Bridged	No Bridge	No Bridge
500	55.6	Bridged	No Bridge	No Bridge
600	66.7	Bridged	No Bridge	No Bridge
700	77.8	No Bridge	No Bridge	No Bridge
800	88.9	No Bridge	No Bridge	No Bridge

[0059] The foregoing data show that silicone modified fibers have improved non-bridging performance in low viscosity fluids. Then, it may be observed that the diameter may also be used in order to further optimize non-bridging efficiency.

[0060] While the embodiments have been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only some embodiments have been shown and described and that all changes and modifications that come within the spirit of the embodiments are desired to be protected. It should be understood that while the use of words such as ideally, desirably, preferable, preferably, preferred, more preferred or exemplary utilized in the description above indicate that the feature so described may be more desirable or characteristic, nonetheless may not be necessary and embodiments lacking the same may be contemplated as within the scope of the disclosure, the scope being defined by the claims that follow. In reading the claims, it is intended that when words such as "a," "an," "at least one," or "at least one portion" are used there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. When the language "at least a portion" and/or "a portion" is used the item can include a portion and/or the entire item unless specifically stated to the contrary.

CLAIMS

We claim:

1. A treatment fluid, comprising:
a low viscosity carrier fluid having a viscosity less than 50 mPa-s at a shear rate of $170\ s^{-1}$ and a temperature of 25°C;
proppant dispersed in the carrier fluid; and
fiber containing 0.1 to 20 wt% silicones dispersed in the carrier fluid.

2. The treatment fluid of claim 1, wherein the carrier fluid is slickwater or linear gel.

3. The treatment fluid of claim 1, wherein the carrier fluid comprises brine.

4. The treatment fluid of claim 1, comprising from 0.06 to 1 kg/L of the proppant based on the total volume of the carrier fluid (from 0.5 to 8.3 ppa, pounds proppant added per gallon of carrier fluid).

5. The treatment fluid of claim 1, wherein the fiber is dispersed in the carrier fluid in an amount effective to inhibit settling of the proppant inn the carrier fluid.

6. The treatment fluid of claim 1, wherein the fiber is dispersed in the carrier fluid in an amount effective to inhibit settling of the proppant, wherein the effective amount is determined by a static settling test at 25°C for 90 minutes.

7. The treatment fluid of claim 1, wherein the fiber is dispersed in the carrier fluid in an amount insufficient to cause bridging.

8. The treatment fluid of claim 1, wherein the fiber is dispersed in the carrier fluid in an amount effective to inhibit settling of the proppant and in an amount insufficient to cause bridging.

9. The treatment fluid of claim 1, wherein the fiber is dispersed in the carrier fluid in an amount effective to inhibit settling of the proppant and in an amount insufficient

to cause bridging as determined in a small slot test comprising passing the treatment fluid comprising the carrier fluid and the fiber without proppant at 25°C through a bridging apparatus comprising a 1 - 2 mm slot that is 15-16 mm wide and 65 mm long at a flow rate equal to 15 cm/s.

10. The treatment fluid of claim 1, wherein the effective amount of the fiber to inhibit settling of the proppant is determined by comparing proppant accumulation in a narrow fracture flow test comprising pumping the treatment fluid at 25°C through a 1 – 2 mm slot measuring 3 m long by 0.5 m high for 60 seconds at a flow velocity of 30 cm/s, relative to a reference fluid containing the carrier fluid and proppant only without the fiber.

11. The treatment fluid of claim 1, comprising from 1.2 to 12 g/L of the fibers based on the total volume of the carrier fluid (from 10 to 100 ppt, pounds per thousand gallons of carrier fluid).

12. The treatment fluid of claim 1, comprising less than 4.8 g/L of the fibers based on the total volume of the carrier fluid (less than 40 ppt).

13. The treatment fluid of claim 1, wherein the fibers are crimped staple fibers.

14. The treatment fluid of claim 1, wherein the fibers are crimped staple fibers comprising from 1 to 10 crimps/cm of length, a crimp angle from 45 to 160 degrees, an average extended length of fiber of from 3 to 15 mm, a mean diameter of from 8 to 40 microns, or a combination thereof.

15. The treatment fluid of claim 1, wherein the fibers are crimped staple fibers comprising crimping equal to or less than 5 crimps/cm of fiber length.

16. The treatment fluid of claim 1, wherein the fibers comprise polyester.

17. The treatment fluid of claim 1, wherein the fibers comprise polyester wherein the polyester undergoes hydrolysis at a low temperature of less than 93°C as determined by heating 10 g of the fibers in 1 L deionized water until the pH of the water is less than 3.

18. The treatment fluid of claim 1, wherein the fibers comprise polyester wherein the polyester undergoes hydrolysis at a moderate temperature of between 93°C and 149°C as determined by heating 10 g of the fibers in 1 L deionized water until the pH of the water is less than 3.

19. The treatment fluid of claim 1, wherein the fibers comprise polyester wherein the polyester is selected from the group consisting of polylactic acid, polyglycolic acid, copolymers of lactic and glycolic acid, and combinations thereof.

20. The treatment fluid of claim 1, wherein the fiber is selected from the group consisting of polylactic acid (PLA), polyglycolic acid (PGA), polyethylene terephthalate (PET), polyester, polyamide, polycaprolactam and polylactone, poly(butylene) succinate, polydioxanone, glass, ceramics, carbon (including carbon-based compounds), elements in metallic form, metal alloys, wool, basalt, acrylic, polyethylene, polypropylene, novoloid resin, polyphenylene sulfide, polyvinyl chloride, polyvinylidene chloride, polyurethane, polyvinyl alcohol, polybenzimidazole, polyhydroquinone-diimidazopyridine, poly(p-phenylene-2,6-benzobisoxazole), rayon, cotton, cellulose and other natural fibers, rubber, and combinations thereof.

21. The treatment fluid of claim 1, further comprising a friction reducer.

22. The treatment fluid of claim 1, wherein the fiber containing silicones is obtained by melt extrusion.

23. The treatment fluid of claim 1, wherein the silicone is a linear polysiloxane.

24. The treatment fluid of claim 1, wherein the silicone has an average molecular weight of from about 100 000 g/mol to about 900 000 g/mol.

25. A method to treat a subterranean formation penetrated by a wellbore, comprising:
injecting a treatment fluid into the subterranean formation to form a hydraulic fracture system, wherein the treatment fluid comprises:
a low viscosity carrier fluid having a viscosity less than 50 mPa-s at a shear rate of 170 s^{-1} and a temperature of 25°C;
proppant dispersed in the carrier fluid; and
fiber containing 0.1 to 20 wt% silicones dispersed in the carrier fluid; and
maintaining a rate of the injection of the treatment fluid to avoid bridging in the wellbore.

26. The method of claim 25, further comprising injecting a pre-pad, pad, tail or flush stage or a combination thereof, optionally comprising the fibers.

27. The method of claim 25, wherein the treatment fluid comprises from 0.06 to 1 kg/L of the proppant based on the total volume of the carrier fluid (from 0.5 to 8.3 ppa, pounds proppant added per gallon of carrier fluid).

28. The method of claim 25, wherein the treatment fluid comprises less than 4.8 g/L of the fibers based on the total volume of the carrier fluid (less than 40 ppt).

29. The method of claim 25, wherein the fibers comprise polyester and further comprising hydrolyzing the fibers downhole after the injection.

30. The method of claim 25, wherein the fiber is present in the treatment fluid in an amount effective to inhibit settling of the proppant as determined by comparing proppant accumulation in a narrow fracture flow test comprising pumping the treatment fluid at 25°C through a 1 – 2 mm slot measuring 3 m long by 0.5 m high for 60 seconds at a flow velocity of 30 cm/s, relative to a reference fluid containing the carrier fluid and proppant only without the fiber.

31. The method according to claim 25, wherein the injection of the treatment fluid is done heterogeneously by alternating proppant-laden pulses and proppant lean pulses.

32. A method to inhibit proppant settling in a treatment fluid circulated in a wellbore, the treatment fluid comprising the proppant dispersed in a low viscosity carrier fluid having a viscosity less than 50 mPa-s at a shear rate of 170 s^{-1} and a temperature of 25°C, comprising:
dispersing fiber containing 0.1 to 20 wt% silicones in the carrier fluid in an amount effective to inhibit settling of the proppant; and
maintaining a rate of the circulation to avoid bridging in the wellbore.

33. The method of claim 32, wherein the treatment fluid further comprises a friction reducer.

34. A system to treat a subterranean formation, comprising:
a subterranean formation penetrated by a wellbore;
a treatment fluid injection unit to supply a treatment fluid stage, comprising proppant in a low viscosity carrier fluid, to the formation above a fracturing pressure to form a fracture system; and
a fiber supply unit to introduce fiber containing 0.1 to 20 wt% silicones into the treatment fluid.

35. The system of claim 34, wherein the introduction of the fiber into the treatment fluid is in an amount suitable to inhibit proppant settling, and wherein the supply of the treatment fluid stage to the formation is at a flow rate sufficient to avoid inducing bridging.

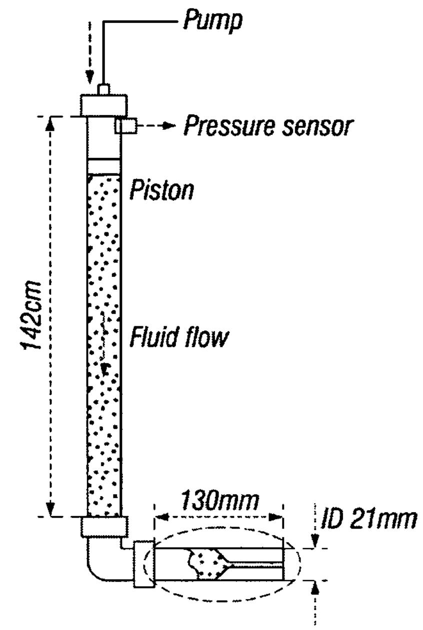

Pump
Pressure sensor
Piston
142cm
Fluid flow
130mm
ID 21mm

FIG. 1A

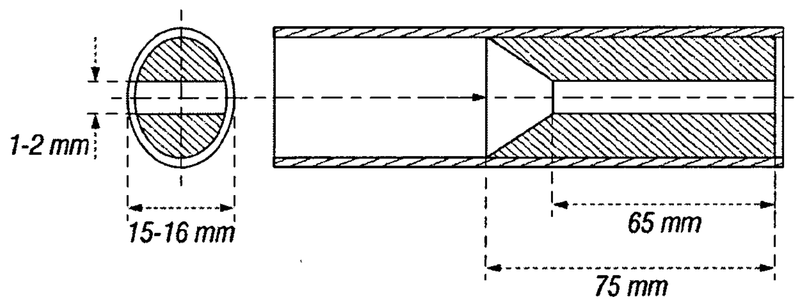

1-2 mm
15-16 mm
65 mm
75 mm

FIG. 1B

INTERNATIONAL SEARCH REPORT	International application No. PCT/RU 2014/000837

A. CLASSIFICATION OF SUBJECT MATTER

E21B 43/267 *(2006.01)*
C09K 8/80 *(2006.01)*
C09K 8/92 *(2006.01)*

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)

C09K 8/00-8/94, D04H 1/40-1/54, E21B 43/00-43/27

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 practicable, search terms used)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	WO 2014/039216 A1 (SCHLUMBERGER CANADA LIMITED et al.) 13.03.2014, claims 7, 11, par. [0007], [0008], [0022]-[0024], [0030], [0032], [0034], [0038], [0042], [0043], [0048], [0050]-[0053], [0055], [0058], [0068], [0075], [0088], [0093], [0099], [00100], [00103]-[00105], [00107], [00109], [00113], [00115], [00116], [00121], [00122], [00140]	1-8, 11-29, 31-35 9, 10, 30
Y	US 2010/0288500 A1 (3M INNOVATIVE PROPERTIES COMPANY) 18.11.2010, claims 1, 8, 17, par. [0015], [0018], [0020], [0037]	1-8, 11-29, 31-35
Y	US 2008/0070810 A1 (HALLIBURTON ENERGY SERVICES, INC.) 20.03.2008, par. [0006], [0020], [0025-[0027], [0037], [0058], [0080]	23, 24
Y	US 5082720 A (MINNESOTA MINING AND MANUFACTURING COMPANY) 21.01.1992, examples 1, A, fig. 1	14, 15

[X] Further documents are listed in the continuation of Box C.　　[ ] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 February 2015 (02.02.2015)	05 March 2015 (05.03.2015)

Name and mailing address of the ISA/RU:	Authorized officer
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 7275596 B2 (SCHLUMBERGER TECHNOLOGY CORPORATION) 02.10.2007	1-35
A	US 2008/0196896 A1 (OSCAR BUSTOS et al.) 21.08.2008	1-35
A	US 5501275 A (DOWELL, A DIVISION OF SCHLUMBERGER TECHNOLOGY CORPORATION) 26.03.1996	1-35
A	US 5618479 A (AKZO N. V.) 08.04.1997	1-35