

Brief Description of the Drawings

Figure 1a: Schematics of proposed coatings with multi-functional structure:

101 – organic lubricant/solvent; 102- solid particles as micro-nanotextured materials; 103 – emulsifier agent; 104 – polar solvent (water); 105 -antimicrobial agent, crosslinking agent, electrolyte agent.

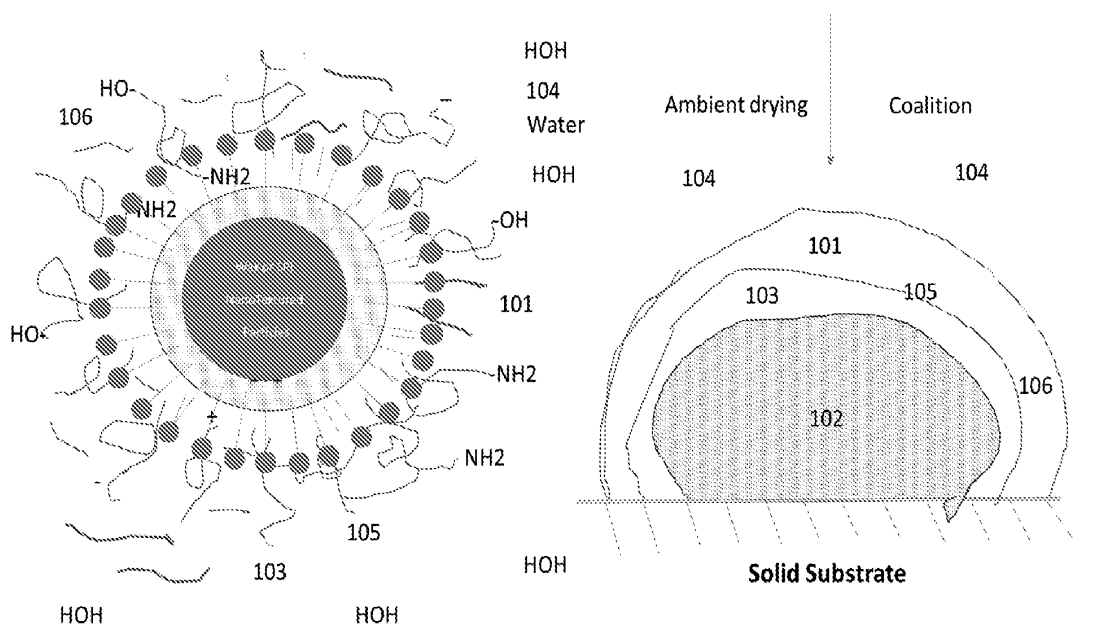


Figure 1a

Figure 1b

Figure 1b: Solid substrate – proppants or frac sand materials; 106 – hydrogel polymer. It shows that a multi-layered structure with organic lubricants (101) is spread on the outmicelle layer; connected with 101 is the hydrogel polymer and emulsifiers (103); crosslinked with cross-linking polymers (105). The hydrogel polymer (105) is functionally interacted with lubricant (101), emulsifier (103), micro/nanotextured particles (102), and solid substrates (proppants or sand). The emulsion can be swelled with expansion or entangled them self into coiled micro-bead components in the water (104) or restricted from swelling by lubricant and hydrophobic particles.

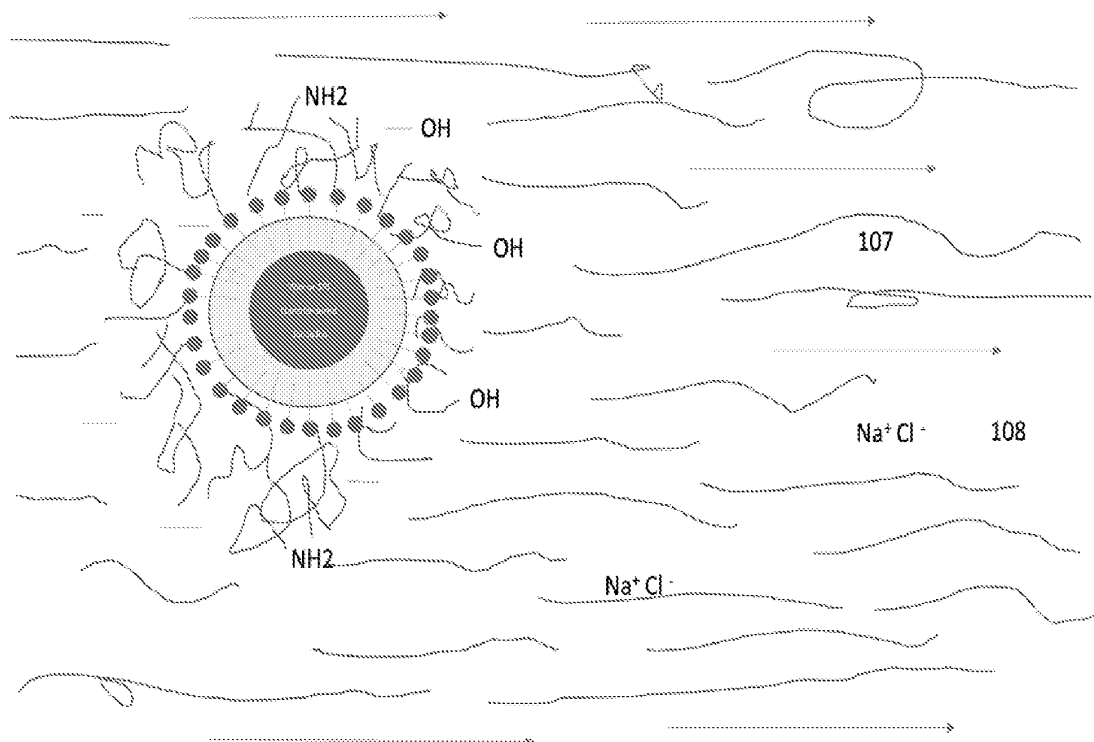
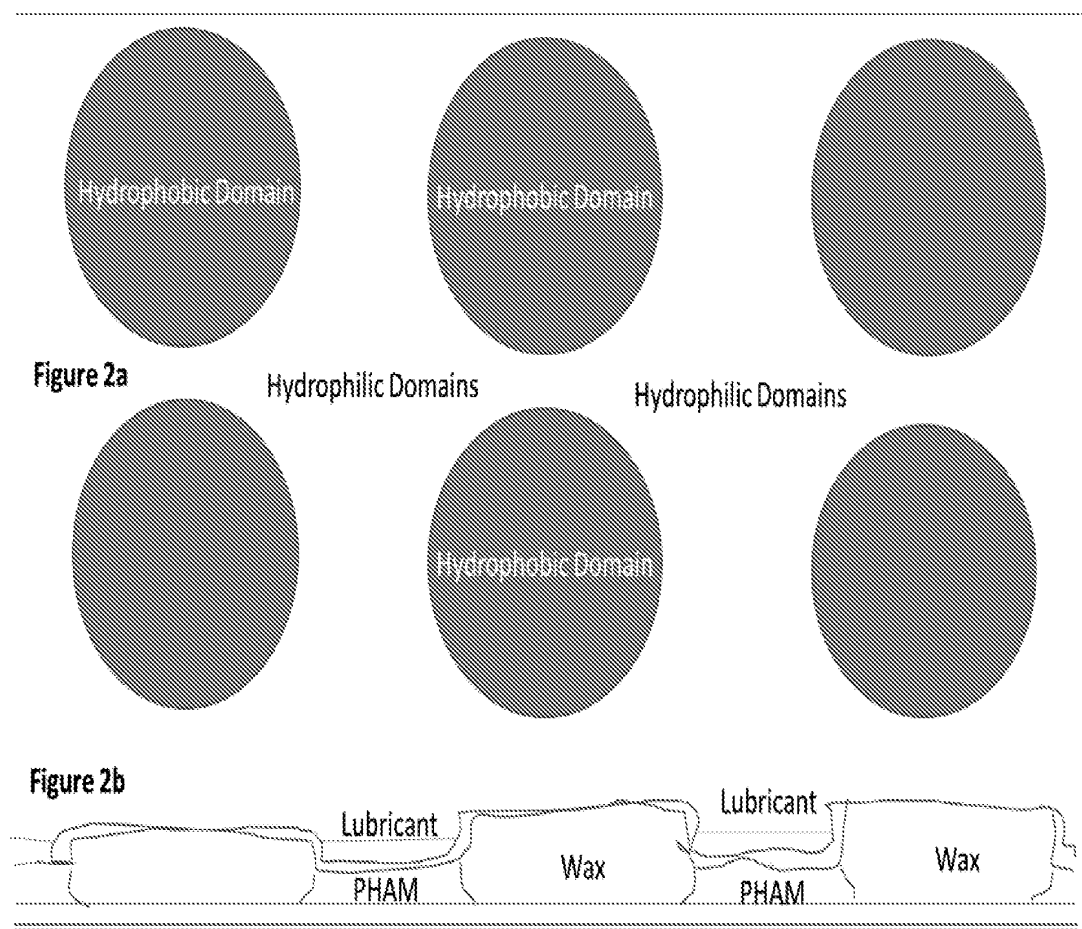
**Figure 1c**

Figure 1c. Schematic of the interaction of emulsified micelles (1a and 1b) with a fracturing fluid containing a friction reducer of hydrolyzed polymers (107) and brine solution of sodium chloride salt (108).



Figures 2a and 2b. Schematic of the multi-functional coatings on the proppant surface: 2a) topographic view of hydrophobic domains comprising of the hydrophilic dot domains such as waxy bumps encapsulated in emulsifiers and hydrogel polymers; 2b) vertical cross-sectional view of multi-layered coatings (lubricant/mineral oil, poly-hydrolyzed acrylate sodium acrylamide (PHAM) hydrogel polymer, wax paraffins, or other textured particles).

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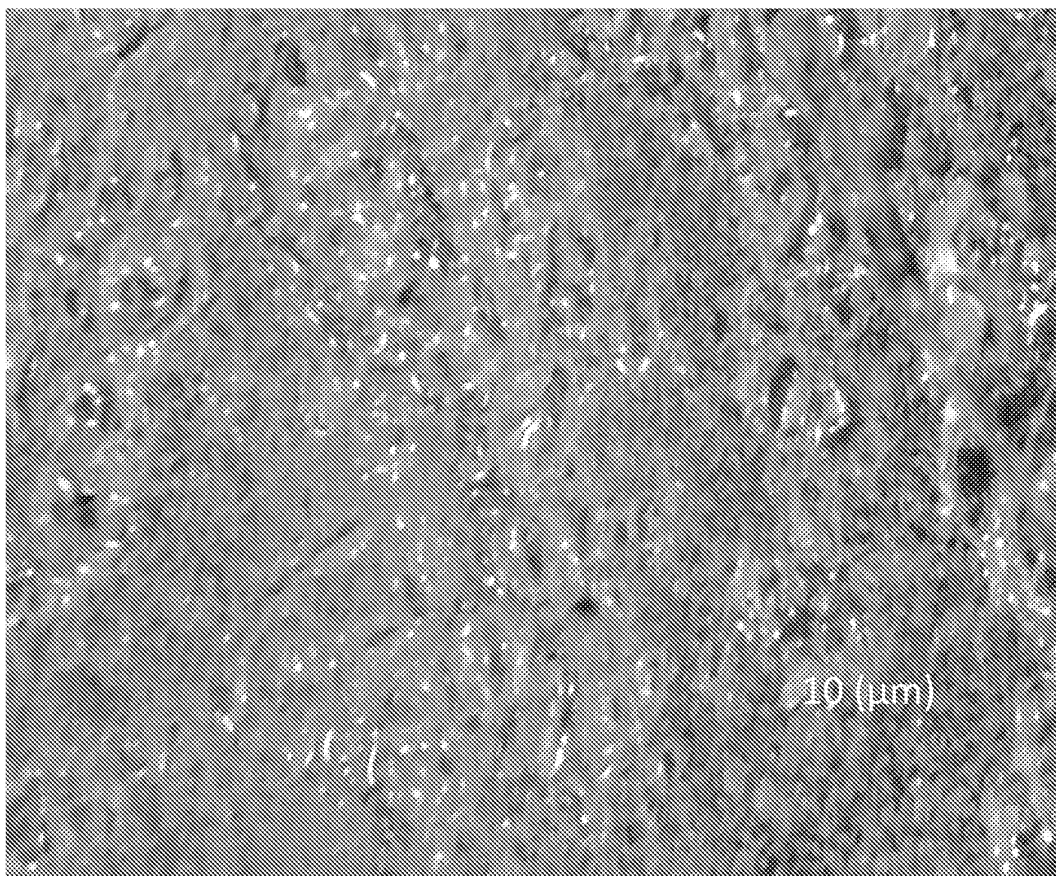


Figure 2c. A topographic view of the typical coating (notebook: PMSI_2_81_1) on the top of a glass substrate. Contour and rough surface morphology featured with mountain, valley, ridge, and hole are clearly shown.

Example 14: NaCl_2 @2.0% +FR @0.20% blended with PMSI_2_17_1

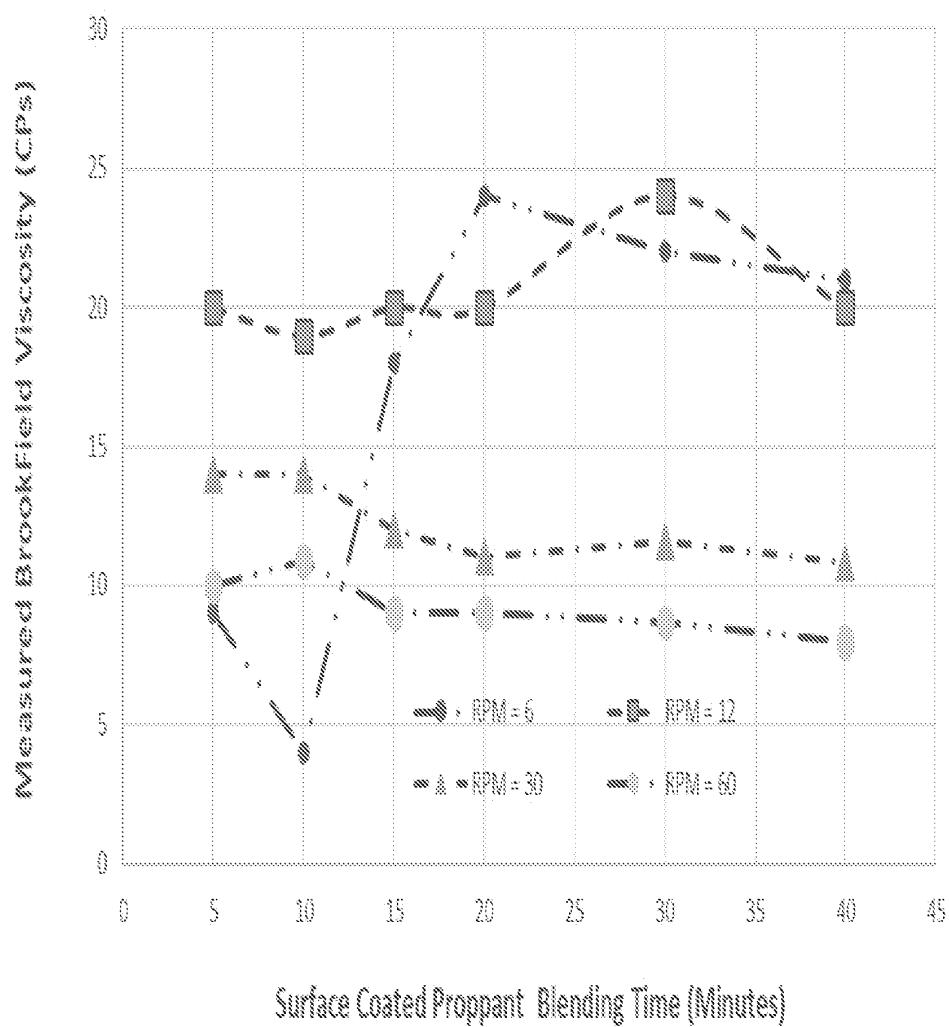


Figure 3. Plot of Brookfield viscosity of measured samples in example 14 as a function of mixing time of the surface treated proppant samples at different rotary speed.

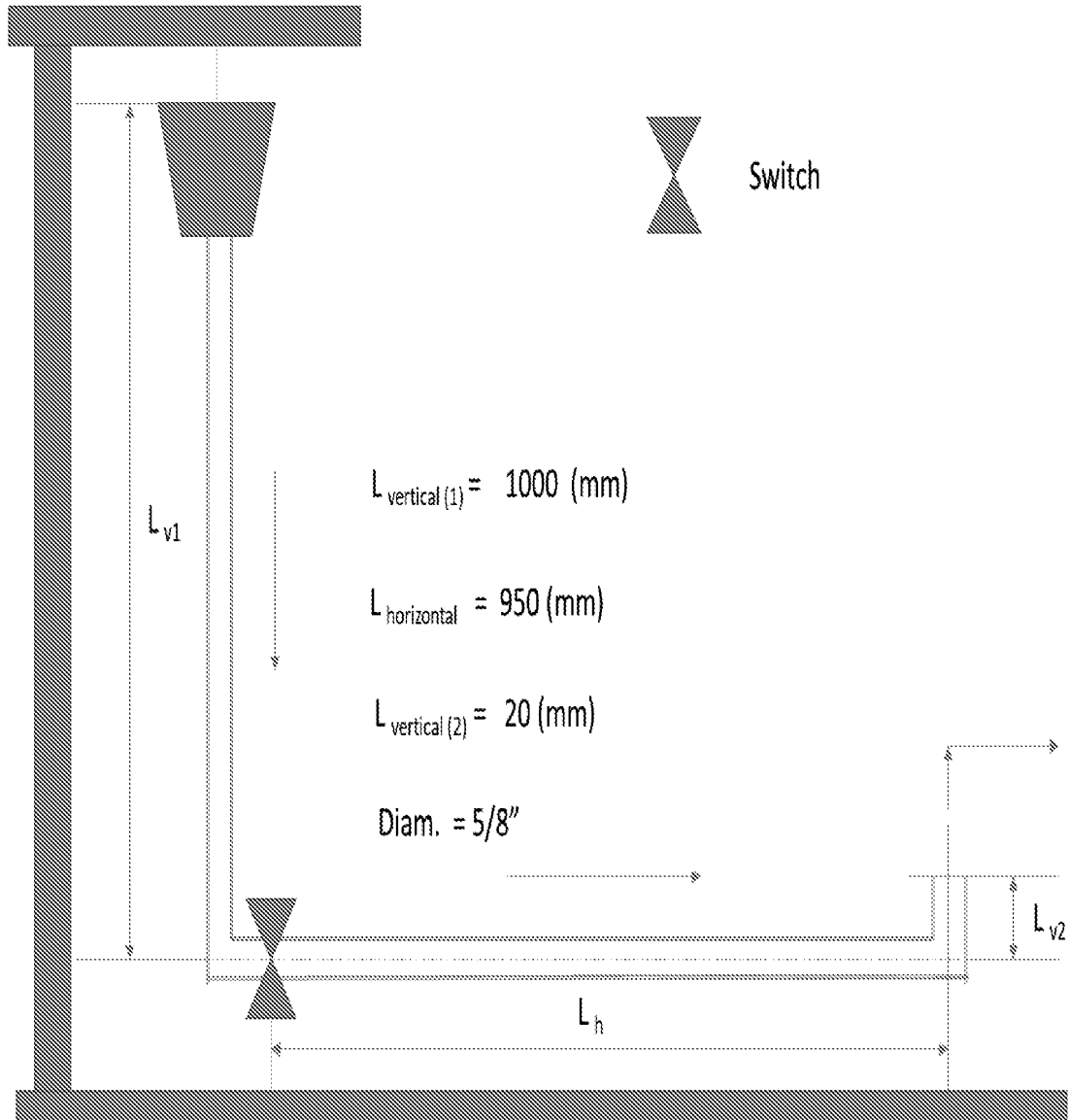


Figure 4. Schematic of open flow loop for determining the coefficient of friction (COF) on different solution and fracturing fluid. The inner diameter of the plastic tubing is $5/8''$ and vertical height distance is 980 (mm) and length of horizontal distance is 950 (mm).

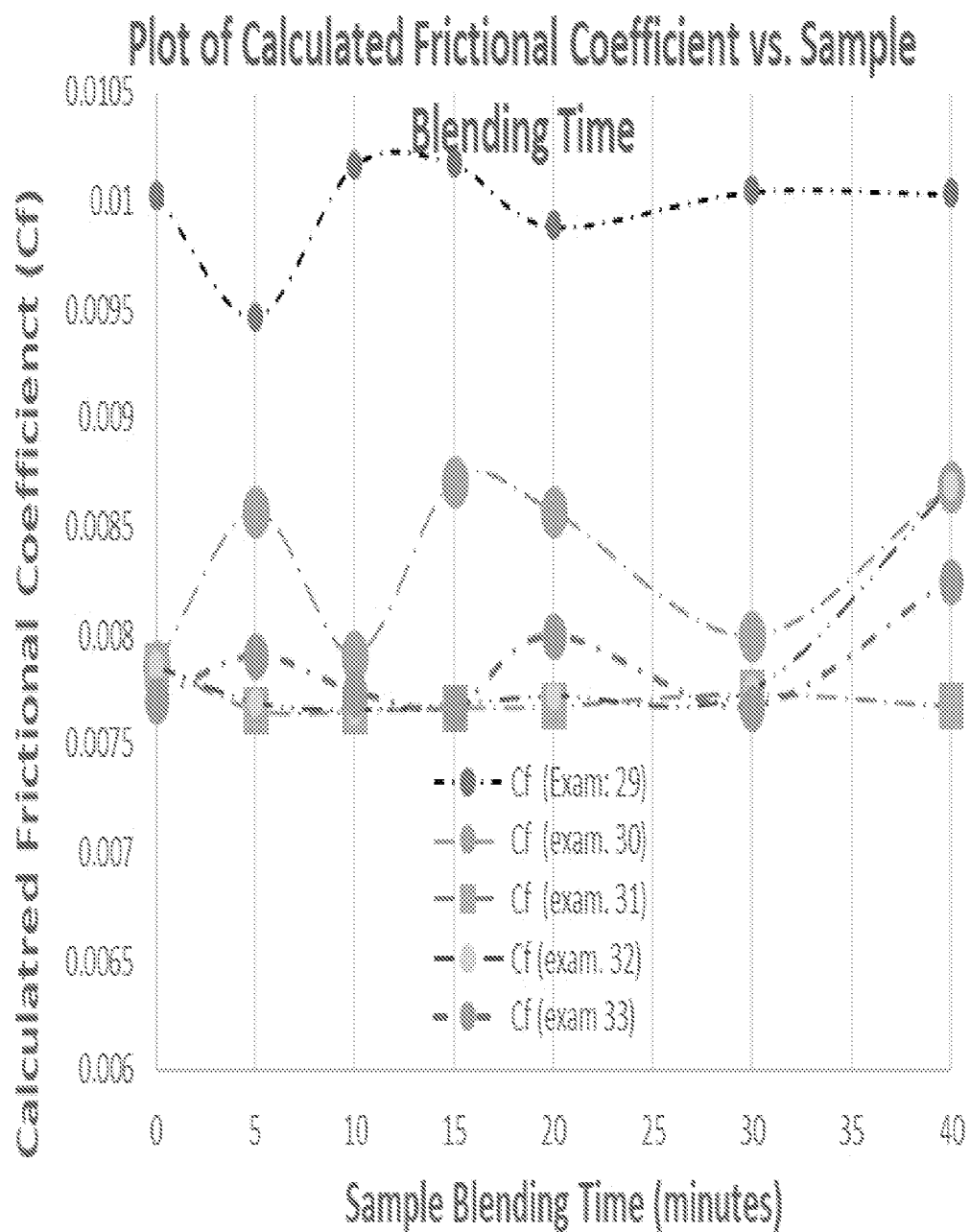


Figure 5. The predicted frictional coefficient as a function of sample blending time for selected examples 29 to 33.

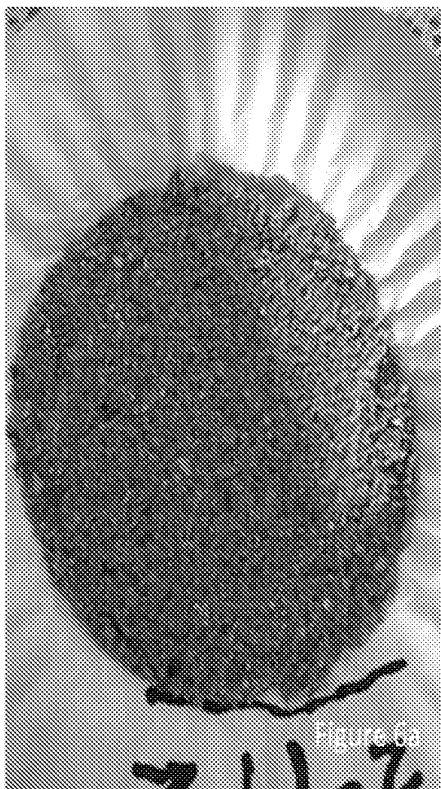


Figure 6a. Image of grain to grain caking in the inspected sample from exam. 24



Figure 6b. Caking test Setting up with 5 (lbs) of wt. of samples sandwiched.

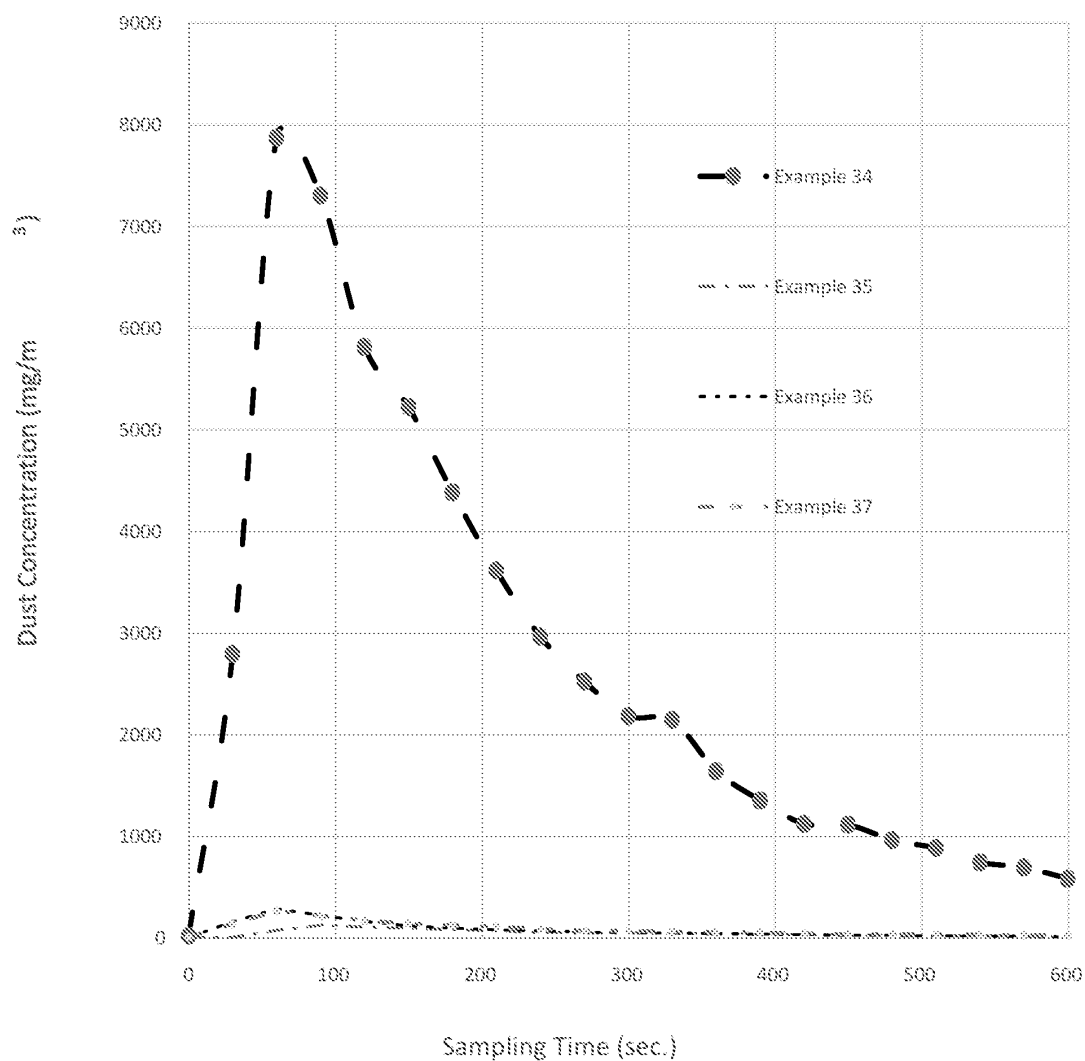


Figure 7. Plot of measured PM1.0 dust concentration of the selected proppant samples as a function of sampling time. example 34: playground sand (proppant); example 35: proppant coated at 3.0% with PMSI_2_80_2 recipe; example 36: proppant coated at 3.0% with the recipe of PMSI_2_59_1; example 37: proppant coated at 3.0% with the recipe of PMSI_2_87_1.

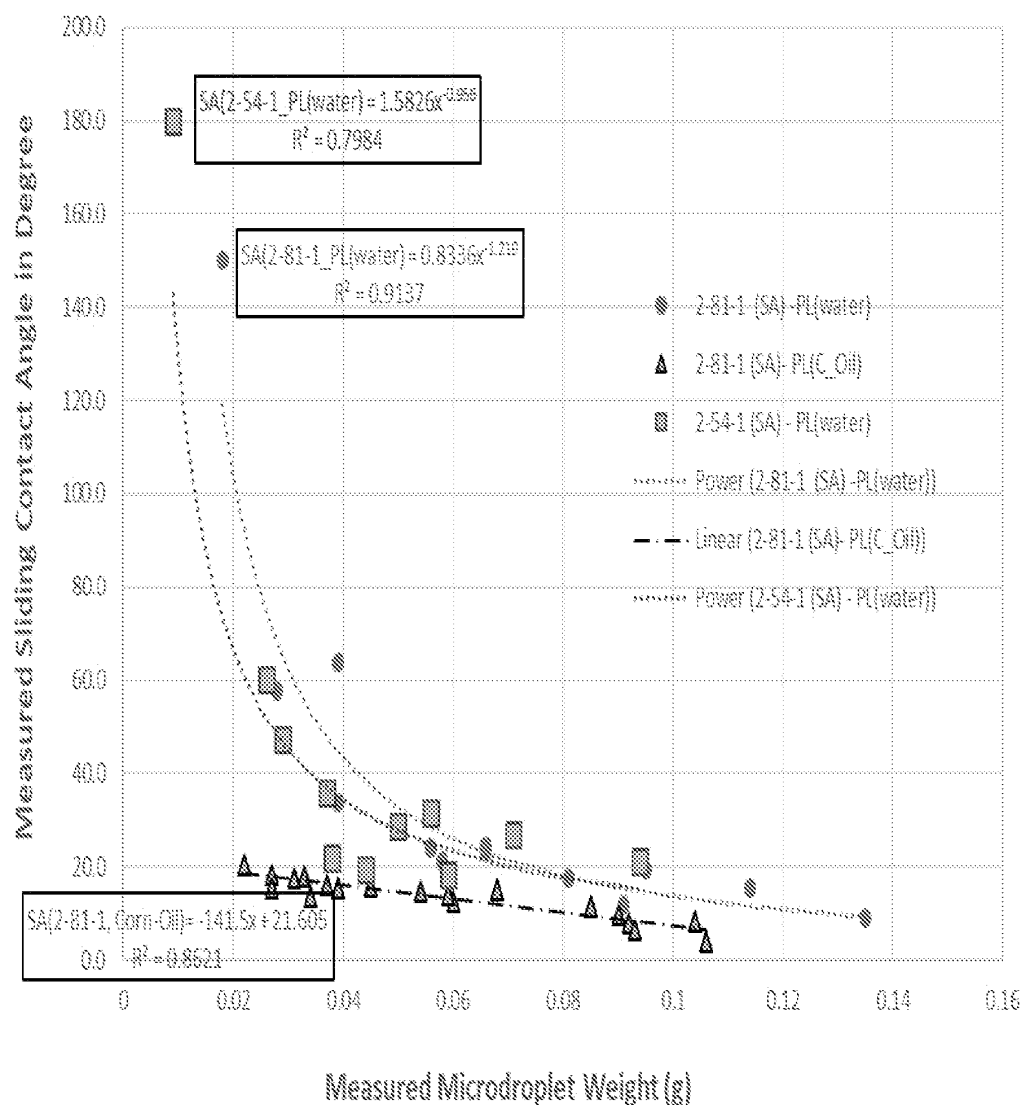


Figure 8a. Plot of measured static contact angle as a function of microdroplet weight with water and corn oil as probe liquid on the selected surfaces coated with: 1) disclosed emulsion coating (PMSI_2_81_1); 2) standard fracturing fluid solution containing 2.0% NaCl and 0.20% HPAM friction reducer additives (PMSI_2_54_1).

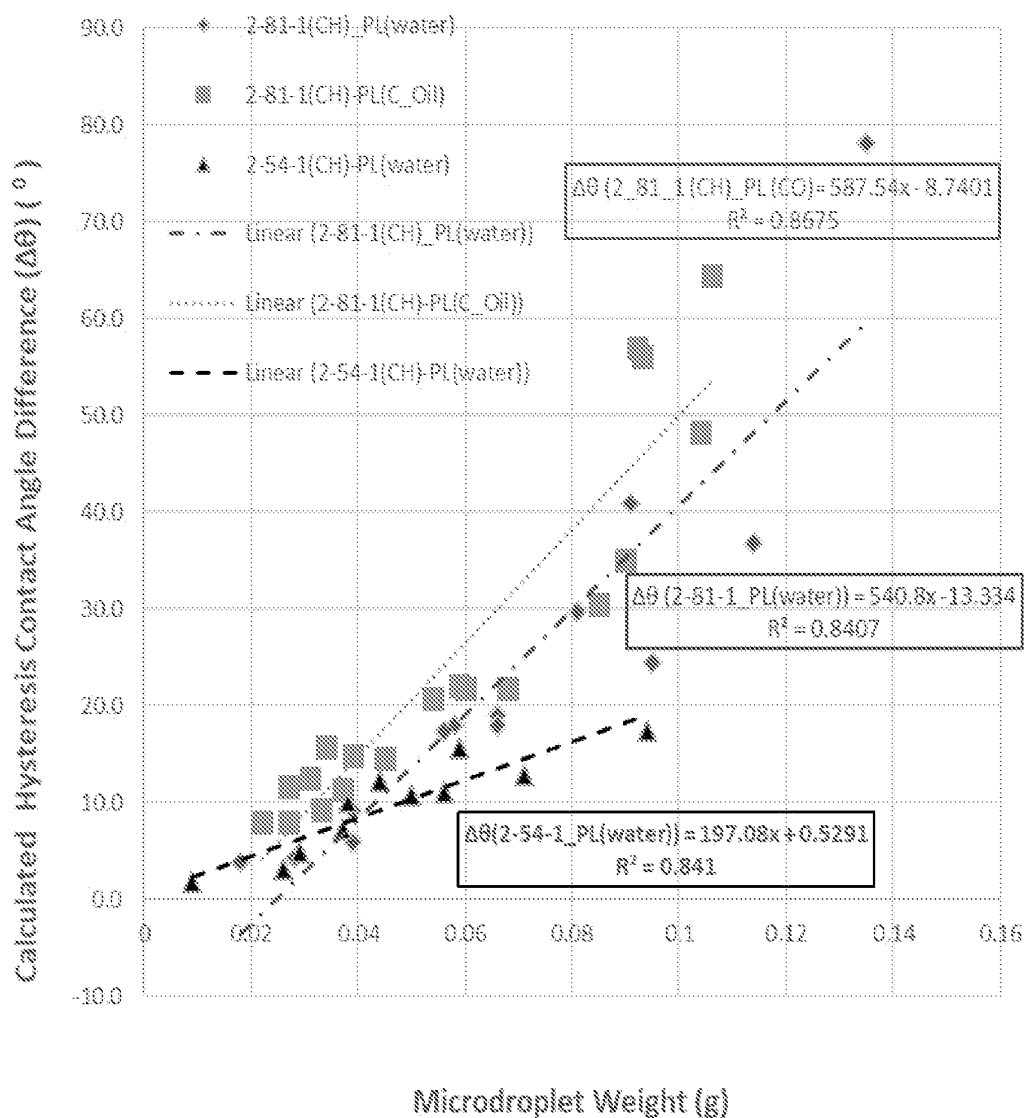


Figure 8b. Plot of the calculated Hysteresis contact angle difference as a function of microdroplet weight with selected coating surfaces: Disclosed emulsion coating (PMSI_2_81_1) and 2) standard fracturing fluid solution containing 2.0% NaCl and 0.20% HPAM friction reducer additives (PMSI_2_54_1).