Tensiometer Testing – Using the Tensiometer to Select Frac Surfactants

Liberty Tech Solution

LIBERTY

Properties of Frac Liquids

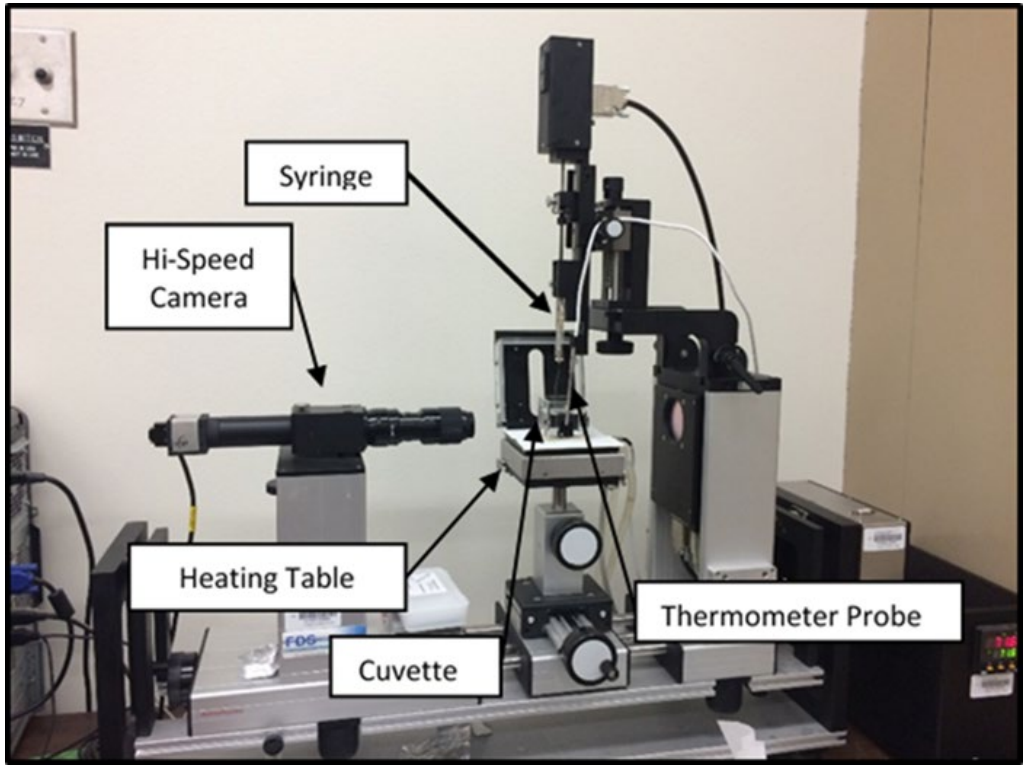
Why the Heck Did We Buy a Tensiometer?

Image of what was actually purchased.

A fine example of an optical tensiometer.

Properties of Frac Liquids

Tensiometer – Closer Look



- Optical Tensiomer Basics
  - Dosing needle or syringe
    - Consistent sized drop on a surface or inside of another liquid.
  - High speed camera
  - Add-ons
    - A table that tilts in different directions
    - Or a heater to heat your fluids
  - Software
    - To make your life easier.

Properties of Frac Liquids

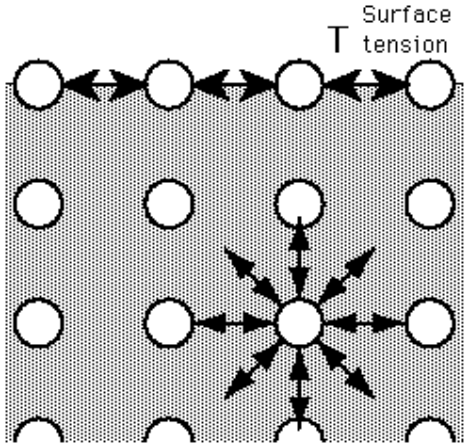
What Do We Measure with the Tensiometer?

- Basic properties of fluids and other liquids associated with frac.
  - Surface tension
  - Interfacial tension
    - > Can be measured on crude from an offset producer.
  - Wettability or contact angle
    - > Can be measured on core or outcrops when available.

Properties of Frac Liquids

Surface Tension (ST) – How much does your fluid like itself?

- Surface Tension
  - **"Cohesive** force of molecules at the surface of a solution attracting toward one another to take up the least possible surface area."
  - How much force it takes to keep a liquid together.



> Surface molecules missing half of attractive interactions.

This swimmer seems to defy the laws of physics.

ST is measured on our tensiometer by hanging a drop of a surfactant solution from the dosing syringe in air.

- CMC for a surfactant.
- The CMC is close to optimal loading of surfactant.

Properties of Frac Liquids

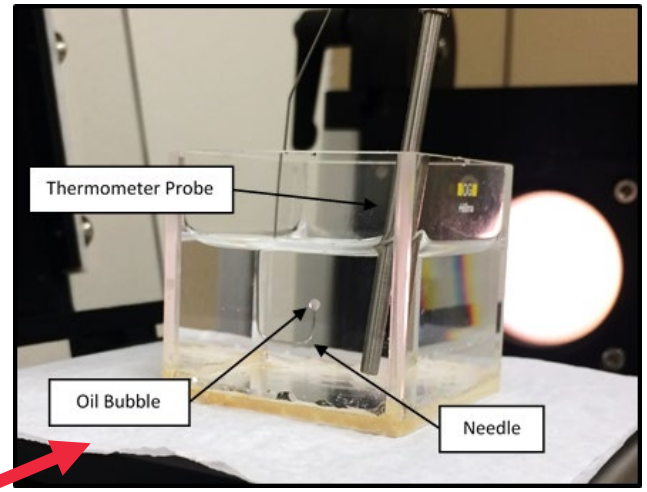
Interfacial Tension (IFT) – How much does your fluid like another fluid?

- Interfacial tension is sort of like surface tension for fluid / fluid interactions
  - Like surface tension, cohesive forces are involved.
  - However the main forces involved are adhesive forces
  - Interaction occurs at the surfaces or interfaces
    - > Best known distinction between the properties of two fluid interfaces.
  - Does not include the effects of the rock surface
  - Does influence major rock properties such as wettability and capillary pressure

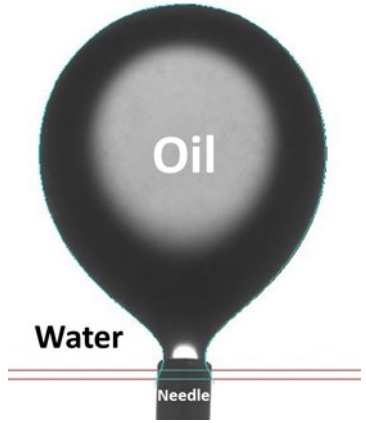
Properties of Frac Liquids

Interfacial Tension (FT) Technique

- Based on pendant drop method.
  - An upside down drop…
- Inversed method
  - Density of the oil sample (or the drop) is lower than the water or surfactant solution.
- Surfactant solution is poured into a cuvette
  - Heated to reservoir temperature 160°F
  - Needle is submerged into the solution
  - The oil bubble dispensed through the J-shaped needle
    - > Recorded by the hi-speed camera.
  - The size of the bubble is measured
    - > IFT is calculated by the software
- Why do we care:
  - Decreasing IFT lowers capillary pressure
    - > Allows the frac to flow.
  - Too low IFT can be detrimental
    - > Inhibit imbibition



Setup for IFT



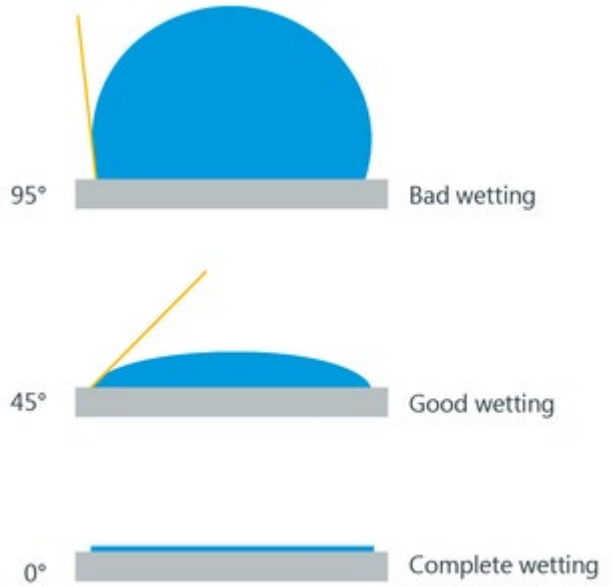
Captured bubble for IFT

LIBERTY

Properties of Frac Liquids

Contact Angle (CA) Basics

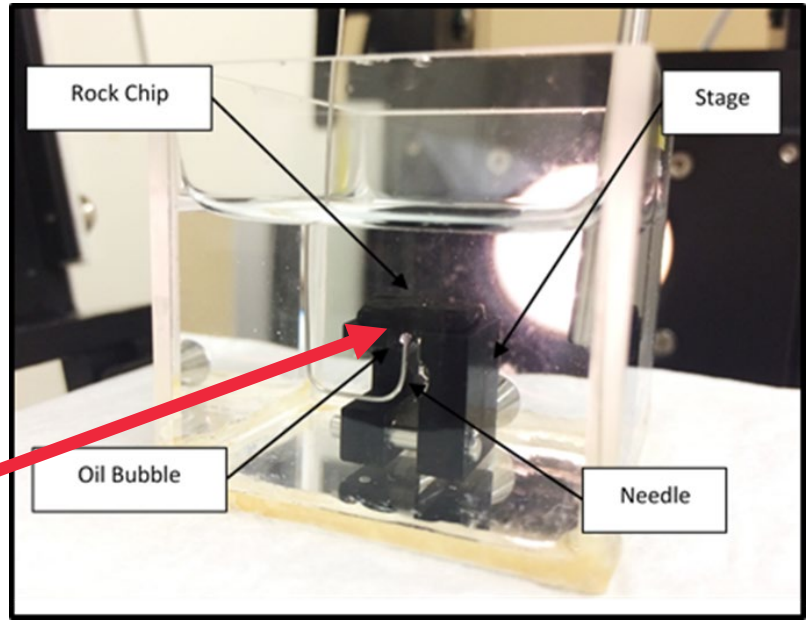
- Measured at interface between a liquid and a solid
  - The angle between the surface of the liquid and the outline of the contact surface
- Contact angle is a measure of the wettability of a solid by a liquid.
- Frac fluids
  - Attempting to water wet an oil wet or partially oil wet rock face with the addition of surfactants.

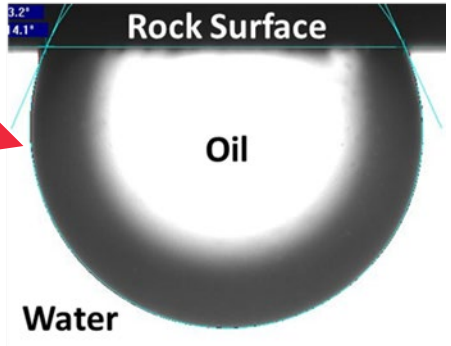


Properties of Frac Liquids

Wetting and the Contact Angle (CA) technique

- Based on captive bubble method
- Before the measurement prep work
  - Rock chips are aged for two weeks
  - In corresponding oil to restore the initial reservoir state of the rock.
- Surfactant solution
  - Poured into a cuvette
  - Heated to the reservoir temperature of 160°F.
- Rock chip is positioned inside the solution
- Oil bubble is dispensed at the tip of a J-shaped needle
  - Positioned at the bottom-facing part of the chip
  - Hi-speed camera records the image
  - Software calculates the angle of oil droplet formed on the rock chip.
- Measurements are important for frac
  - Single best indicator of oil expulsion from within the pores of shale rock





LIBERTY

Properties of Frac Liquids

What are the Other Liquids of Interest for Frac?

- Not just a surfactant in water
- Surfactant properties are affected by other factors
  - Additional chemistries in frac fluid
    - > Frac fluid base fluids
      - 2% KCl
      - produced water or blended produced?
    - > Frac fluid system chemicals
      - Friction reducers
      - Thickening agents (solvents, suspension agents, surfactants, etc),
      - Crosslinkers
      - Buffers
      - Breakers
    - > Frac fluid formation chemistries
      - Biocides
      - Scale inhibitors
      - Clay inhibitors
        - Some have surfactant properties
  - Formation water
    - > Brines with variety of ions
      - Charges affect the surfactant properties

Properties of Frac Liquids

Conclusion

- In summary, we can measure several basic properties of fluids using our new optical tensiometer: ST, IFT, CA
  - These measurements can be used to select a surfactant that works to meet you're specific performance targets.
  - Provide a recommendation for a specific surfactant and loading tailored to your reservoir.
  - Can be used to ensure that other chemicals included in your frac fluid don't interfere with the performance

LIBERTYFRAC.COM