"Enhanced Wellbore Stabilization and Reservoir Productivity with Aphron Drilling Fluid Technology"

Topical Report: Task 2.3 "*Aphron Shell Hydrophobicity*"

by

Miranda Fosdick

&

Fred Growcock

Issued October 28, 2004

DOE Award Number DE-FC26-03NT42000

MASI Technologies *LLC*

5950 N. Course Dr.

Houston, Texas 77072

DISCLAIMER

Objectives

Determine the oil-wetting/hydrophobic character of aphrons under downhole conditions to verify the lack of affinity of aphrons for each other and for the walls of pores and microfractures in reservoir rock.[1-3]

Project Description

Various methods were investigated to measure the oil-wetting character of transient bubbles under static and dynamic conditions, in order to determine the roles played by bubble and micellar agglomeration, coalescence and adhesion to mineral surfaces.

Conclusions

Qualitative tests indicate that aphrons have very little affinity for each other or for the mineral surfaces in rock formations encountered during drilling. Thus, aphrons resist agglomeration and coalescence, and it is expected that they can be pushed back out easily by reversing the pressure differential, thus minimizing formation damage.

Future Work

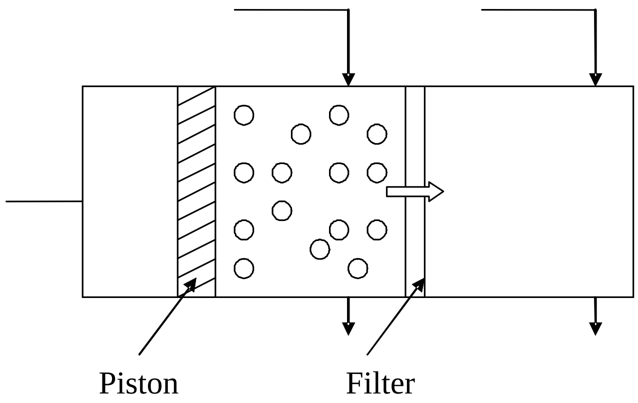
Future work will be directed at investigating the entire range of multiphase interactions during flow of aphron drilling fluids in the pore network of permeable rock. This will include examining aphron-aphron and aphron-pore wall interactions, but it will also include examining interactions of the base fluid with the walls and with produced fluid and interactions of produced fluid with the walls. A series of emulsion potential tests are being planned to determine compatibility of the APHRON ICS™ drilling fluid with different kinds of crude oil.

Experimental Approach

The fluids examined were all "transparent" versions of the APHRON ICS™ drilling fluid. They contained all of the components of the APHRON ICS™ system except the opaque products, and the pH was adjusted to 10 by use of caustic soda. The T APHRON ICS™ system was the transparent standard system, while the TE APHRON ICS™ system was identical save for added APHRONIZER A and APHRONIZER B.

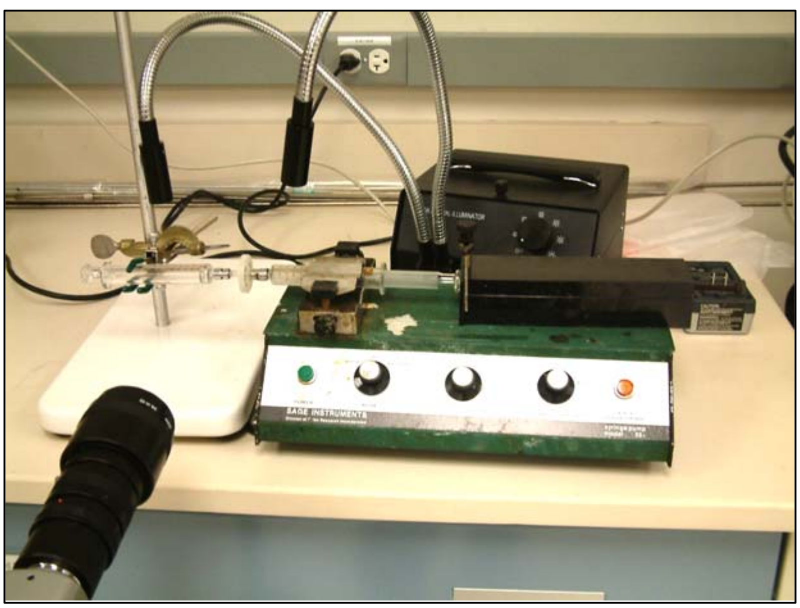
A test method was proposed to measure directly the tendency for aphrons to stick together or to the walls of sandstone pores. A schematic of the apparatus is shown in Figure 1. An APHRON ICS™ mud sample is placed in the chamber of a syringe. The aphrons are filtered and compressed while driving the bulk fluid through a fine glass filter that prevents passage of the aphrons. The syringe is then back-filled with the same aphron-free fluid to its initial volume and the bubbles that have agglomerated, coalesced and/or stuck to the walls of the chamber are counted.

Figure 1. Aphron Hydrophobicity Apparatus



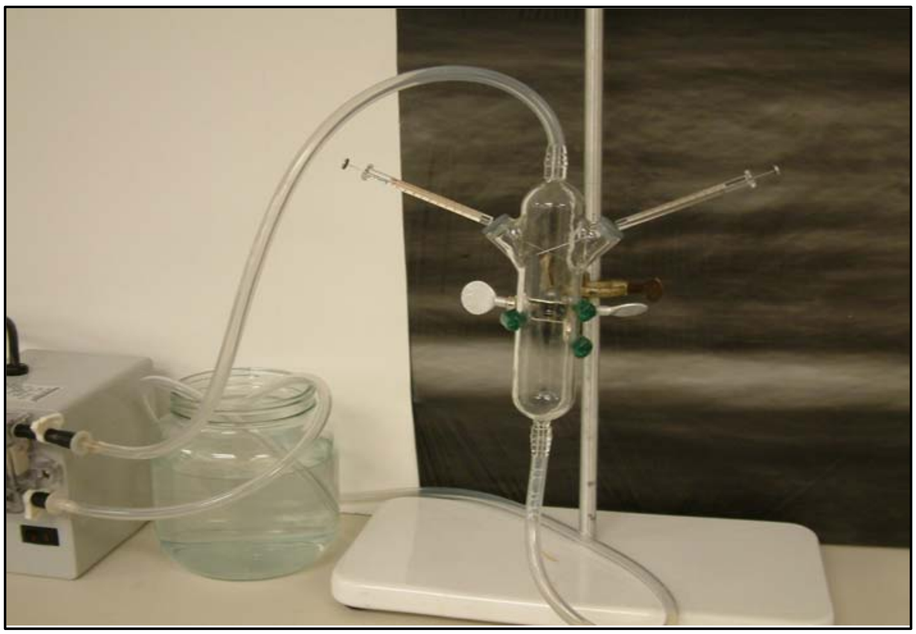
A modification of the apparatus shown in Figure 1 employs two glass syringes connected with a disposable filter of pore size much smaller than the average bubble size. A photograph of this apparatus fitted with a syringe pump is shown in Figure 2.

Figure 2. Dual Syringe Hydrophobicity Apparatus Fitted with Syringe Pump



To get a better idea of the surface character of the aphrons, an alternative technique was devised to better evaluate the tendency for aphrons to aggregate. The idea was to get two or more bubbles to collide and observe whether they stick together. If they move as an aggregate, it would mean that the bubbles have some affinity for each other. If they travel on different paths, the bubbles do not stick together and, therefore, they have little affinity for each other. Several techniques were tried, but the most promising (see Figure 3) involved a glass vessel through which the APHRON ICS™ mud moves vertically and the bubbles are injected through two open tubes capped with septa and positioned opposite each other at angles of 45 degrees to the vertical.

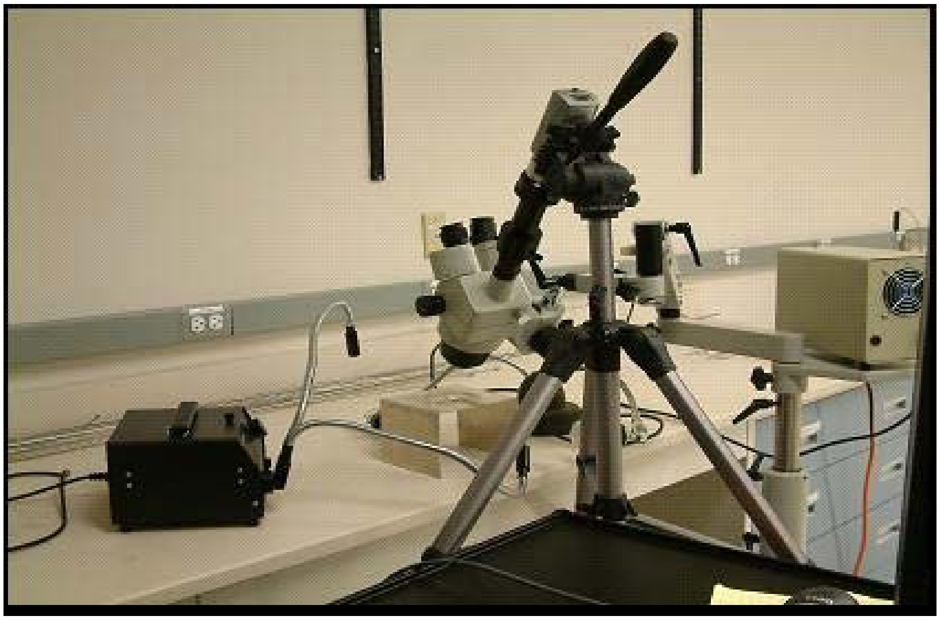
Figure 3. Air Injection Test Set-Up



Another method was developed to investigate how the bubbles act when some mechanical force is applied on them. For this, the mud is spread as a thin layer (a smear) on a standard microscopic slide. The set-up is shown in Figure 4.

A string of aphrons is created, as above, by injection of air through a syringe. Then the fluid around the aphrons was moved around by swirling it using the syringe needle.

Figure 4. Set-Up for Microscope Slide Smear Test



Results

Based on an initial survey of the literature, measurements of interfacial tension and contact angle would be sufficient to describe the oil-wetting nature of aphrons. With that in mind, Kreuss brought in a demo model of a BP2 Bubble Pressure Tensiometer to determine its suitability for measurements of surface tension and interfacial tension in the APHRON ICS^{TM} mud system. Unfortunately, it appears that the very high LSRV of the system precludes getting usable steady-state measurements of the surface tension.

The search for a suitable method to measure contact angle of bubbles narrowed to Contact Angle Goniometry. Rame-Hart offers such a device. For this method to provide usable information, it is necessary to construct a device to apply compressive and/or shear stresses on the bubbles while measuring contact angle.

While the contact angle method is promising and will be looked at in more detail, attention is now focused on measurements of the net oil-wetting character of aphrons by measurements of rate of agglomeration and coalescence of the aphrons and strength of adhesion of aphrons to mineral surfaces under compressive and/or shear stresses.

The first test method that was proposed to measure directly the tendency for aphrons to stick together or to the walls of sandstone pores was the dual syringe approach (Figure 2). However, very little force is required to squeeze over-size bubbles through the filter; indeed, repeated flow back and forth was found to simply "polish" the bubbles to produce a relatively narrow bubble size distribution of ever decreasing average bubble size. Not only did the bubbles go through the pores with no problem, they also did not appear to stick to anything, including each other. Indeed, the notable absence of aphrons on the glass walls of the syringes suggested that other mineral surfaces be tried. In a previous study, APHRON ICS™ muds were spread on Berea sandstone and Aloxite cores. When the cores were swirled slowly in deaerated mud, none of the aphrons was observed to remain attached to the mineral surfaces.

In the air injection test set-up (Figure 3), it was learned that injection of air through a single syringe resulted in a string of bubbles that would flow as an aggregate. However, the fluid traveled in plug flow and did not give the bubbles an opportunity to separate. (Aphrons will rarely coalesce if the fluid is kept in motion.[4])

At that pont, the Microscope Slide Smear Test was developed (Figure 4). It was clear from the smear procedure that the bubbles did not stay together. An example of this is shown in Figures 5 and 6.

Figure 5. An Aggregate of Aphrons Formed during Bubble Creation

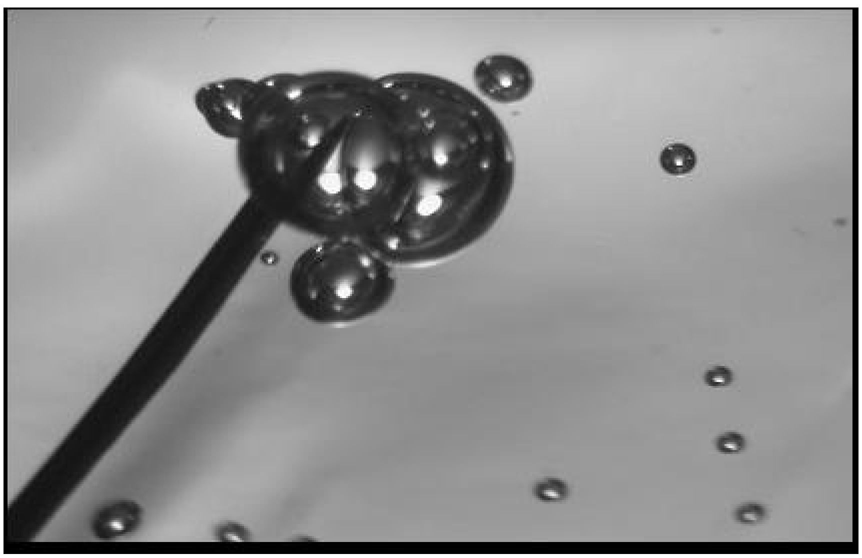


Figure 6. The Aphron Aggregate Breaks Up When Mild Swirling Force Is Applied

Repeated tests showed the same result. Thus, it appears that aphrons have little or no affinity for each other, nor do they have much affinity for silica or alumina surfaces.

References

1. Brookey, T.: "Micro-Bubbles: New Aphron Drill-In Fluid Technique Reduces Formation Damage in Horizontal Wells," SPE 39589, presented at the SPE International Symposium on Formation Damage Control, Lafayette, LA, Feb. 18-19, 1998.
2. Growcock, F.B., Khan, A.M., and Simon, G.A.: "Aplication of Water-Based and Oil-Based Aphrons in Drilling Fluid," SPE 80208, presented at the SPE International Symposium on Oilfield Chemistry, Houston, TX, Feb. 5-7, 2003.
3. Gardescu, I.I.: "Behavior of Gas Bubbles in Capillary Spaces," AIME Technology Publication, 306, 1930.
4. Sebba, F.: *Foams and Biliquid Foams - Aphrons,* John Wiley and Sons, Toronto, 1987.