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Silica Solution Option In Chemical EOR

By Michael Smallwood

HOUSTON–Imagine if every well in the United States could be economically treated for enhanced oil recovery. Primary and secondary recovery typically net only about 20 percent of the oil in the reservoir, leaving a great deal "stranded" in the rock.

According to U.S. Department of Energy studies, more than 200 billion barrels of oil in-place could be technically recoverable with enhanced oil recovery, not including the additional potential for EOR in oil shales, tar sands, and residual oil zones. Almost 500,000 wells today are categorized as marginal by the DOE. These wells produce less than 80 barrels a month and represent an immediate target for enhanced recovery. Tapping these resources could dramatically improve the country's energy independence.

But in order to achieve this ideal, the economics must make sense. Historically, the costs of EOR have limited its usefulness. These costs include transportation, labor, materials and cleanup, and often have exceeded the value of the incremental hydrocarbons it could free. When the price of oil is low, there is little tolerance for EOR costs.

A new solution has emerged that addresses enhanced-recovery economics by efficiently freeing hydrocarbons for recovery. This nanoscale, biodegradable solution requires only water in a high-ratio mix, thereby eliminating specialty transportation and preparation costs. It uses basic chemical and physical properties to separate hydrocarbons from the formation and leaves no toxic fingerprint that must be cleaned up.

In fact, the very mechanism used to recover hydrocarbons down hole enables it to separate hydrocarbons and other contaminants at the surface during remediation. This exciting combination of recovery and remediation in one solution simplifies processes at the site and further reduces cost.

Water And Steam Floods

Most oil wells no longer flow freely using the reservoir's natural pressures, even during initial production. Instead, the oil must be coaxed from the hole using a variety of techniques. In some formations, hydraulic fracturing is required to provide additional surface area and conduits within the rock formation for the hydrocarbons to travel.

After primary recovery, waterfloods provide a fluid flow to move hydrocarbons. This works for a time, but when water saturation increases, oil can become trapped as capillary forces cause water to collect at pore throats. If it is economical to do so at this point, operators can choose among thermal, gas and chemical EOR techniques, based on their needs and environment.

Steam injection–the standard for thermal EOR–typically is used for heavy oil recovery. The heat from the steam reduces viscosity and the hydrocarbons more easily separate from the rock. The oil then flows to the surface. The technique is quite effective when large volumes of steam are injected over time, but the treatment must be repeated to keep up production levels.

While no materials must be transported to the site, large volumes of water must be available, as must the means to heat that water. The energy-intensive process also produces heavy emissions. In some cases, co-locating a plant to generate the steam as a byproduct can reduce costs associated with steam flooding. In any case, the water produced from the well may be contaminated, and must be cleaned before it is returned to nature.

Gas, Chemical Injection

Gas injection is another favored technique, and has been in use for more than 40 years. Typically carbon dioxide is used, with most of the gas being mined from natural sources and about 25 percent coming from industrial output. The CO_2 must be captured, processed, stored and transported from its generation facility or naturally occurring deposits.

Gas is flooded into the field through several injection wells located around a producing well. The gas is injected at a pressure equal to or above the formation's minimum miscibility pressure (MMP), so that the oil and CO_2 can mix and form a liquid that flows more freely. Alternatively, if pumped at or below MMP, the CO_2 causes the oil to swell and viscosity is reduced.

Miscible CO_2 is usually more efficient in displacing oil than any other gas injection process. It has the properties of a gas, but the density of a liquid. The CO_2 and oil mix thoroughly, forming a single phase and eliminating interfacial tension. This yields higher oil recovery than immiscible gas injection.

Depending on permeability, each well may receive from tens to hundreds of thousands of metric tons of CO_2 a year. More than 48 million metric tons of CO_2 are used each year for enhanced oil recovery, and much of the CO_2 remains sequestered down hole.

Chemical EOR includes a variety of mixes of polymers and surfactants. Polymers increase the viscosity of injected water, enabling it to more efficiently displace medium weight oils. Surfactants can reduce interfacial tension between the oil and water. The surfactant is both hydrophobic and hydrophilic, allowing it to concentrate between the oil and water.

The alkaline surfactant polymer (ASP) technique adds alkaline to further aid recovery and help reduce surfactant retention. The alkaline converts acids in the oil to soaps, reducing interfacial tension and associated capillary forces.

ASP, which is very toxic to the underground environment and surface equipment, can cause significant corrosion. Surfactants have scaling and fouling issues, and improper treatment ratios can result in formation damage and blockage. ASP also is limited to applications involving waterfloods, where whole fields are being treated. Individual wells are not addressed with this method.

Enhancing EOR

A new chemical EOR option–a silica-based aqueous solution–specifically targets hydrogen, oxygen and carbon elements in relationship to hydrocarbon-bearing materials. In some ways this chemical acts much like an ASP solution, but with no alkaline or surfactant, and flow is effected without a polymer that can clog pores.

This multifaceted chemical compound works to break the bond between hydrocarbons and any other material to which they are attached or absorbed. The solution is extremely miscible–unlike a James Bond martini, it does not need to be shaken or stirred. As a result, it can penetrate even very heavy mud on its way to the formation.

When introduced into the formation, the compound initiates an ionic exchange mechanism that makes hydrocarbons more hydrophobic and colloidal. The oil is repulsed from the water and a water-wetting effect

FIGURE 1

Texas Well Study No. 1

View by: Production and Total Disposition | Disposition Details | County Production

Lease Name: [redacted] Lease No: [redacted]
District 01
Lease Production and Disposition
Jan 2007 - Dec 2008

Month Treated

Date	OIL (BBL)		Casinghead(MCF)		Operator Name	Operator No.	Field Name	Field No.
	Production	Disposition	Production	Disposition				
Jan 2007	0	42	0	0	[redacted]	[redacted]	PILGRIM (AUSTIN CHALK)	[redacted]
Feb 2007	0	0	0	0				
Mar 2007	0	0	0	0				
Apr 2007	0	0	0	0				
May 2007	0	0	0	0				
Jun 2007	0	0	0	0				
Jul 2007	0	0	0	0				
Aug 2007	0	0	0	0				
Sep 2007	0	0	0	0				
Oct 2007	447	345	0	0				
Nov 2007	767	762	0	0				
Dec 2007	216	162	0	0				
Jan 2008	82	170	0	0				
Feb 2008	287	174	0	0				
Mar 2008	271	339	0	0				
Apr 2008	284	0	0	0				
May 2008	491	673	0	0				
Jun 2008	282	341	0	0				
Jul 2008	316	332	0	0				
Aug 2008	142	176	463	463				
Sep 2008	NO RPT	NO RPT	NO RPT	NO RPT				
Oct 2008	NO RPT	NO RPT	NO RPT	NO RPT				

FIGURE 2

Texas Well Study No. 2

View by: Production and Total Disposition | Disposition Details | County Production

Lease Name: [redacted], Lease No: [redacted]
District 01
Lease Production and Disposition
Jan 2007 - Dec 2008

Month Treated

Date	OIL (BBL)		Casinghead(MCF)		Operator Name	Operator No.	Field Name	Field No.
	Production	Disposition	Production	Disposition				
Jan 2007	19	0	0	0	[redacted]	[redacted]	CHRISTIAN (6800)	[redacted]
Feb 2007	2	154	0	0				
Mar 2007	60	0	0	0				
Apr 2007	62	0	0	0				
May 2007	110	174	0	0				
Jun 2007	97	164	0	0				
Jul 2007	56	0	0	0				
Aug 2007	5	0	0	0				
Sep 2007	63	0	0	0				
Oct 2007	10	0	0	0				
Nov 2007	174	164	0	0				
Dec 2007	131	164	0	0				
Jan 2008	284	162	0	0				
Feb 2008	120	327	0	0				
Mar 2008	84	0	0	0				
Apr 2008	111	0	0	0				
May 2008	276	332	0	0				
Jun 2008	173	173	0	0				
Jul 2008	155	165	0	0				
Aug 2008	149	167	0	0				
Sep 2008	NO RPT	NO RPT	NO RPT	NO RPT				
Oct 2008	NO RPT	NO RPT	NO RPT	NO RPT				

allows oil to flow. The separated oil retains its original characteristics and is not adversely affected by treatment, water is significantly cleaner, and solids are separated for easy collection and disposal. The solution can be used in a single well or in a multiwell injection configuration.

In laboratory tests, 96 percent of oil absorbed in sand, shale, chalk and other foreign deposits were recovered. Reports from the Texas Railroad Commission confirm early observations that the solution effectively treated several wells in West Texas, where multiple wells were treated with the silica solution.

Well one was well bore with a single lateral and total depth of a little more than 11,000 feet. The solution was injected in two stages, one hour apart, followed by a water injection one hour later. The solution was then allowed to penetrate for 24 hours.

This treatment increased average monthly production by almost 400 percent (Figure 1). Production in the 24 months prior to treatment averaged 79 barrels a month. In the seven months following treatment, production rose to an average of 296 barrels.

Well two more than doubled production after treatment (Figure 2). This well was a straight hole producing an average of 80 barrels a month for the 24 months preceding treatment. The solution was injected twice over three hours, followed by water on vacuum. After 24 hours, the pumps were started again. Post-treatment production rose to 188 barrels a month on average over seven months.

Well three did not show improvement after treatment. If there is no oil lodged in the formation, none can be recovered. The owner/operator of all three wells subsequently scheduled 28 additional oil wells for treatment.

Costs related to the silica-based aqueous solution are substantially lower than other EOR techniques. The solution uses a natural, biodegradable technology with a high water ratio. The water stays clean in the process and can be returned to its source fully potable. Nothing toxic is left down hole or on the surface from this solution. No special equipment is required, no expensive transport is needed, and no other wells must be drilled or used for injection.

Remediation And Maintenance

Typical remediation products are made from organic petroleum distillates. The hydrocarbons are cleaned up, but the operator is left with a toxic mess. Using a natural, biodegradable solution creates less of a disposal problem and the opportunity to recover more waste oil.

Because of its oil separating properties, the silica-based solution can be used to efficiently remove contaminants from a site. This can include soil, water, drilling fluids, fracture fluid and tailing ponds. Best of all, this can be done on site. There is no need to haul away contaminated soil or water for processing elsewhere. Simply dig up the soil, put it in a frac tank and stir. Then auger the soil, test for effectiveness, and return it to the ground.

The solution also can treat brine, dropping the metals and chlorides, and precipitating the water. Substantially less refuse ends in a landfill, toxins are encapsulated as needed, and metals are separated for collection.

An interesting added benefit of the silica-based solution is its positive effect on equipment. Because the solution is oxygen scrubbing, it fights corrosion. Its small molecular structure readily penetrates the sludge that fouls perforations and corrodes the production string, bonding with the metal surface to resist corrosion.

The decrease in corrosion enabled one well to be on line substantially longer: 30 days in a month rather than seven or eight. In another, after six months of operation, the operator pulled the tubing string for inspection. In the past, the pipe would have been seriously compromised by corrosion. In this case, the string was still in operating condition and was returned to the hole.

Because of the effective barrier it creates on metal, the silica solution potentially can be used for everything from protecting well site equipment to cleaning pipes and pipelines, tanker trucks, and barges.

Armed with an affordable green solution for both recovery and remediation, operators should be better positioned when interacting with regulators and local authorities.

Disturbances to the natural habitat also should be minimized. Ultimately, adopting a low-cost solution for enhanced recovery should enable both field growth and increased production, to the benefit of all. ❐

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Michael Smallwood serves as chief science officer, directing all research and development activities for Planet Resource Recovery in Houston. He spent more than 15 years developing PetroLuxus™, a biodegradable, nanoscale solution for recovery and remediation in the oil and gas industry. With more than 20 years' experience in the petrochemical industry, management, and research and development, Smallwood has been employed by or consulted for corporations such as Equistar, El Paso Energy, and Valero. He holds a B.S. in industrial engineering from Texas A&M University and a B.A. in environmental sciences from the University of Houston. Smallwood is a board certified safety professional, a Texas state certified environmental site assessment consultant and professional safety engineer, master trainer/administrator (NCCER), and pro-technical (PADI).