Research Journal of Applied Sciences, Engineering and Technology 4(17): 3065-3068, 2012
ISSN: 2040-7467

Submitted: February 07, 2012 Accepted: March 15, 2012 Published: December 01, 2012

A light review on Polymer and CO_2 Flooding (With Suggestion Combination of CO_2 into Polymer Solution to Superior Flooding)

[1]O. Arjmand and [2]A. Roostaei
[1]Department of Chemical Engineering,
[2]Department of Petroleum Engineering, Marvdasht Beranch, Islamic Azad University, Marvdasht, Iran

Abstract: Today carbon dioxide (CO_2) is one of displacing fluids that is used in Enhanced Oil Recovery (EOR) process. However the low viscosity of CO_2 causes it to finger towards the production well and bypassed large amounts of oil. Because of during flooding of CO_2 its mobility is very less than crude oil into reservoir that causes to leave a great amount of oil, so a reduction in CO_2 mobility would be inclined to mitigate. We in this review study state that could increase CO_2 viscosity with dissolving it into polymer solution, that it can delay breakthrough time of CO_2 during EOR process. In addition with making of such solution can decrease oil viscosity during flooding process into reservoir simultaneously. In actual with mixing of CO_2 gas at high pressure into Partial Hydrolyzed Polyacrylamide solution (HPAM) as an anionic polymer can increase the viscosity of CO_2 with a concentration optimum of polymer and improve the sweep efficiency of oil during EOR process using this method.

Keywords: CO_2/polymer solution, EOR, viscosity

INTRODUCTION

After application of primary and secondary recovery production of oil, much of the oil still remains in place due to inefficiency of these recovery processes. The aim in EOR is to increase the production of crude oil beyond the limit recoverable by primary and secondary production methods, CO_2 being as the second least expensive flooding fluid after water, has been using in EOR for many years. CO_2-rich mixtures have been used for fracture cleanup and sand fracturing of wells since the early 1960's, with the sand being carried by a second phase, such as gelled water, methanol, or oil (Moritis, 1998; Stevens and Gale, 2000). The use of liquid CO_2 as the only constituent of a fracturing fluid has been employed since the early 1980's. Recently, CO_2-N_2 mixtures have also been employing. The fracture is generated by the pressurized fluid and is thin propped open by the sand particles. The CO_2 is then removed through the well bore when it is opened to flow for production (Gozalpour *et al*., 2005). The carbonic acid that forms in reservoir water in the presence of dense carbon dioxide has not known to damage sandstone formations. Carbon Dioxide (CO_2) injection has been used as a commercial process for Enhanced Oil Recovery (EOR) since the 1970s. Currently, 20,000 tons per day of CO_2 are delivered to oil fields for EOR projects (Alston *et al*., 1985).Terry *et al*. (1987) attempted to increase the viscosity of CO_2 via the in-situ polymerization of CO_2-soluble monomers. They found that polymerizations could be achieved in the high pressure CO_2-environment using commonly available initiators (Terry *et al*., 1987). Polymers can typically be added to the injection water flooded through a reservoir to achieve IOR. The purpose of this additive is to block 'highways' for the injection water in the reservoir in order to change and optimize flow patterns. With the other technique, surfactants (detergents) are added to injection water to 'wash out' more oil in the reservoir. More specifically, polymers increase sweep efficiency by improving the mobility ratio. Surfactants, for their part, enhance microscopic recovery by reducing capillary forces in addition to boosting sweep efficiency. Conventional polymers help to raise the viscosity of the injection water, whilst surfactants reduce interfacial tension between oil and water. In actual polymer solutions can sweep the more area of oil-bearing reservoir and it can delay the breakthrough time as well (Taber *et al*., 1997). During a standard water flood, breakthrough time relatively come up fast and water fingering take place into the oil front because of high mobility of water relative to oil, therefore its sweep efficiency will be low (Sung-Hua, 2007). Polymer is added to injecting water so that it can increase the viscosity of solution because of its high molecular weight

Corresponding Author: O. Arjmand, Department of Chemical Engineering, Mahshahr Branch, Islamic Azad University, Mahshahr, Iran

and as a result of that, the fingering effect will be reduced and the sweep efficiency can be improved (Zeynali *et al*., 2004) Hydrolyzed Poly Acryl Amide (HPAM) and Xantan gum as synthetic and natural polymer, respectively are usually used in polymer flooding both in field and in pilot projects. In 1964, Pye and Sandi established that polymer flooding can increase oil recovery compared to water flooding, they expressed that partially Hydrolyzed Poly Acryl Amide (HPAM) can reduce the mobility of displacing water with increasing its viscosity and improve the sweep efficiency of flooding process (Du, 2004). Foulin and Wang (2006) utilized high concentration of HPAM polymer solution through flooding studies for Canadian oil field and illustrated the promising effect of HPAM to increasing recovery factor is around 21% (OOIP) (Fulin *et al*., 2006). Alkaline-Surfactant-Polymer (ASP) flooding during the EOR process of a Chinese oil field studied by Zhang and stated that oil recovery more improved with combination Alkaline-Surfactant-Polymer (ASP) compared to polymer flooding lonely (Zhang *et al*., 2006). Kotler *et al*. (2007) studied the influence of combination of polymer (mobility control agent), surfactant (reducing IFT agent) and a small bi-functional molecule (increasing solubility agent and reducing salinity effect) during flooding to enhanced oil recovery factor and deduced that oil recovery can be increased by 20% OOIP (Kotler *et al*., 2007; Tabary and Bazin, 2007) investigated the improved oil recovery techniques and remarked that chemical process plays an important role in recovering upswept oil by improving the mobility ratio and reducing residual oil saturation during processes such as polymer flooding, Surfactants Polymer flooding (SP) and Alkaline/Surfactant/Polymer (ASP). Basically surfactants reduce the interfacial tension between oil & water and mobilize the residual oil saturation (Tabary and Bazin, 2007). Poly acryl amide is a condensation polymer which has very useful properties. The structure of poly acryl amide is similar to polyethylene, but having hydrogen on every other carbon replace by an amide group,-ONH2. The molecule is composed of repeating-CH2-H (CONH2)-units. The amide groups allow for linking between polymer strands. The-ONH2 group from one molecule can react with the same group of another molecule, forming a link between them with the structure-ONHCO. Partially hydrolyzed poly acryl amide is widely used in water treatment as well as in EOR processes to displace more oil and increase the recovery efficiency of water flooding process by modifying the water/oil mobility ratio, as an anionic coagulant (Zeynali *et al*., 2004). The objective of this study is to review on CO_2 and polymer flooding process. This study states limitations of using CO_2 and polymer flooding during EOR. We proposed that can mobilize CO_2 with solving CO_2 gas into polymer solution in high pressure which lead to increase oil recovery factor in the one stage because interfacial tension between oil and water decreases due to CO_2 and viscosity increases because of polymer into such solution simultaneously. As result of further percent of oil recovers compare to use of polymer and CO_2 only. We believed this technique at high concentration of CO_2 and polymer should be utilized for recovery of oil with high API degree.

CARBON DIOXIDE (CO_2) FLOODING

Carbon dioxide is injected into oil reservoirs in order to increase oil recovery factor. When pressure of reservoir is depleted through primary and secondary production, carbon dioxide flooding can be useful method for EOR. It is particularly effective in reservoirs deeper than 2,000 ft., where CO_2 will be in a supercritical state, with API greater than 22-25º and remaining oil saturations greater than 20%. In fact Carbon dioxide flooding is not affected by the lithology of the reservoir area but simply by the reservoir characteristics. Carbon dioxide flooding works on the premise that by injecting CO_2 into the reservoir, the viscosity of any hydrocarbon will be reduced and causes better to sweep to the production well. If a well has been produced before and has been designated suitable for CO_2 flooding, the first thing to do is to restore the pressure within the reservoir to one suitable for production. This is done by injecting water (with the production well shut off) which will restore pressure within the reservoir to a suitable pressure for CO_2 flooding. Once the reservoir is at this pressure, the next step is to inject the CO_2 into the same injection wells used to restore pressure. The CO_2 gas is forced into the reservoir and is required to come into contact with the oil. This creates this miscible zone that can be moved easier to the production well. Normally the CO_2 injection is alternated with more water injection and the water acts to sweep the oil towards the production zone. CO_2 flooding is the second most common tertiary recovery technique and is used in facilities around the world.

POLYMER FLOODING

Nowadays, polymer flooding as an EOR process is received more attention due to high price of oil in the world. Since the polymeric compounds have high molecular weight, they can increase the viscosity of the water solution after adding so that the water to oil mobility ratio reduces. Therefore, more oil recovery and sweep efficiency will be obtained. Generally, polymer flooding can improved water injection processes around 5-10%. In enhanced oil recovery a dilute aqueous solution of partially hydrolyzed poly acryl amide is used as a pushing fluid in the injection wells to sweep oil in the reservoir into the production well. Mobility reduction or ability viscosity behaviour of partially hydrolyzed poly acryl amide solutions plays an important role in improving of oil recovery. The properties of poly electro lytes in aqueous solutions have been widely investigated in the past decade (Perry *et al*., 1982; Du, 2004). For polyelectrolyte solutions it Polymer flooding as an EOR method is used to improving the efficiency of water flooding. When soluble polymers are added to water, solution viscosity will be increase owning to high molecular weight of polymer. Hence, during the flooding tests, the mobility ratio of water to oil reduces and as a result more sweep efficiency will be obtained. Actually during a standard water flood the sweep efficiency is not as good as desired, because the mobility of water stream is higher than oil which water can bypass the oil zone in a finger shape and break into the well bore soon (Du, 2004; Alban and Gubitta, 1999). Therefore, it leaves behind very quantity of oil and water cut increase progressively. Polymer solutions which have less mobility compared to fresh water can increase the sweep efficiency around 10% OOIP.

DISCUSSION

The efficiency of both carbon dioxide miscible displacement and carbon dioxide fracturing can be improved if the mobility of dense CO_2 can be decreased. There have been three methods of approaching this problem:

- Reduction of CO_2 relative permeability in the reservoir via-co injection with water
- Generation of CO_2 foam
- Increasing the viscosity of CO_2 via the addition of a 'thickening agent'

The initial attempts to diminish CO_2 mobility for miscible displacement were focused on the reduction of the relative permeability CO_2, rather than increasing its viscosity. Several teams of researchers have investigated the use of CO_2-foams (also referred to as emulsions) for mobility control or for blocking high-permeability zones (Kotler *et al*., 2007). Foams can be formed by injected an aqueous surfactant solution into the reservoir. Subsequently, a CO_2 slug is injected. As the CO_2 is injected, foam will be generated in-situ. The CO_2 resides inside 'bubbles' that are separated by thin aqueous films. Because most of the aqueous solution will enter the most permeable zone, these foams will form in the high permeability zone upon the CO_2 injection. Tremendous reductions in CO_2 mobility can occur when these foam forms and thus this foam can be used for profile modification to block preferential flow channels by reservoir heterogeneities. These may occur as the surfactant adsorbs and the foam breaks down when it contacts oil as propagates through the reservoir. A recent field test of CO_2 foams has demonstrated both profile modification and mobility controls. Tows important in the oil and gas industry that use dense carbon dioxide are fracture stimulation and enhanced oil recovery. Because of the low viscosity of dense carbon dioxide, its effectiveness as a fracturing fluid has questioned. In this study we attempts to expresses that CO_2 viscosity using polymer solutions to better fluid leak off control and placement of higher sand concentrations could be increased. With the huge difference in viscosity between dense carbon dioxide and gelled fluids, such as partial poly acryl amide an increase in the viscosity of carbon dioxide could improve the placement of more and larger sand particles and improve fluid leak off. It is clear that CO_2 flooding is one of most important EOR processes, because CO_2 sine inject into reservoir can sweep oil towards well bore and in reservoir condition as miscible gas can sole into light hydro carbons of crude oil as this results decrease oil viscosity too and can extract a mount great of oil left into reservoir and according to CO_2 for injection is economically sound and availability, therefore CO_2 play an important role during EOR process, but due to mobility of CO_2 which is very less than crude oil, that cause CO_2 breakthrough into oil bank and leave a great mount of crude oil. We proposed for overcoming on this problem; can mobilize CO_2 with mixing of it into water/soluble/polymer solution such as HPAM. With making this solution (polymer/CO_2 solution) we have a solution that can increases CO_2 viscosity and decreases oil viscosity simultaneously.

CONCLUSION

This study reviews CO_2 and polymer flooding process and presents that CO_2 flooding plays an important role during EOR process. Because of the mobility of CO_2 is very less than crude oil, during flooding into reservoir, CO_2 break through into oil bunk and leave a further percent of original oil in place. We strongly believe that For overcoming in this problem can mobilize CO_2 with combining of CO_2 gas into water/soluble/polymer such as Partially Hydrolyzed Poly Acryl Amide (HPAM) that Causes the breakthrough time will delay and the viscous fingering effect will be mitigated and movement of CO_2 through the porous media is more longitudinal. Therefore, the recovery factor and sweep efficiency will rise. In addition CO_2/Polymer/Solution can be solved into crude oil at high pressure of reservoir and decrease oil viscosity, so with this method can increase CO_2 viscosity and decrease oil viscosity simultaneously and extract further percent of crude oil.

NOMENCLATURE

EOR	:	Enhanced Oil Recovery
OOIP	:	Original Oil in Place
IOR	:	Improved Oil Recovery
IFT	:	Interfacial Tension
CO_2	:	Carbone dioxide
HPAM	:	Hydrolyzed Poly Acryl Amide

REFERENCES

Alban, N. and J. Gubitta, 1999. Surfactant-Polymer Interaction in Enhanced Oil Recovery. Chemical Engineering Department Prairie View A&H University, Prairie View, TX.

Alston, R.B., G.P. Kokolis and C.F. James, 1985. Co2 Minimum Miscibility Pressure: A correlation for impure Co2 steam and live oil systems. SPEJ., 25(2): 268-274.

Du, Y., 2004. Field-scale; polymer flooding: lessons and experiences gained during past 40 years. SPE International Petroleum Conference in Mexico, 7-9 November 2004, Puebla Pue., Mexico, ISBN: 978-1-55563-982-2, pp: 6.

Fulin, Y., W. Demin and K. Chunling, 2006. Daqing oil field Ltd. Co., Study on high concentration polymer flooding to future enhanced oil Recovery Paper SPE101202. Presented at the SPE Annual Technical conference and exhibition, San Antonio, ISBN: 978-1-55563-149-9, pp: 5.

Gozalpour, F., S.R. Ren and B. Tohidi, 2005. Co_2 EOR and storage in oil reservoir. Oil Gas Sci. Technol., 60(3): 537-546.

Kotler, H.S.K. and D. Selle and O. Torsaeter, 2007. Enhanced Oil recovery by COMB-Flow: Polymer floods Revitalized. Paper SPE106421, Presented at the SPE International Symposium on oil field chemistry held in Houston, Texas, ISBN: 978-1-55563-190-1, pp: 6.

Moritis, G., 1998. Worldwide EOR survey. Oil Gas J., 20: 49-97.

Perry, A., R. Aryabright, J.S. Phudy, B. Phillips and Haruthon oil Co., 1982. Partially Hydrolyzed Polyacrylamides with superior is flooding. Paper SPE 11208, Presented at SPE Annual Fall Heeting, ISBN: 978-1-55563-666-1, pp: 15.

Stevens, S.H. and J. Gale, 2000. Geologic CO_2 sequestration may benefit upstream industry. Oil Gas J., 98(20): 40-44.

Sung-Hua, Y., 2008. Recent applications of polyacrylamide as biomaterials. Recent Patents Mater. Sci., 1(1): 29-40.

Tabary, R. and B. Bazin, 2007. Improved Oil Recovery (IOR) Techniques and Their Role in Boosting the Recovery Factor. IFP-OPEAC Joint Seminar, France, pp: 1-12.

Taber, J.J., F.D. Martin and R.S. Seright, 1997. EOR screening criteria revisited-part1: Introduction to screening criteria and enhanced recovery field projects. SPE Reser. Eng., 12(3): 189-198.

Terry, R.E., A. Zaid, C. Angelos and D.L. Whitman, 1987. Novel Co_2-thickeners for improved mobility control. SPEJ., 16270: 289.

Zeynali, M.E., A. Rabii and H. Bshaevand, 2004. Synthesis of partially hydrolyzed polyacrylamide and investigation of solution properties. Iranian Polymer J., 13(6): 479.

Zhang, D.L., S. Liu, W. Yan, M. Puerto and G.J. Hirasaki *et al*., 2006. Favorable attributes of alkali-surfactant-polymer flooding. Most, 2: 695-707.