Int. J. Chem. Sci.: 13(4), 2015, 1666-1672
ISSN 0972-768X
www.sadgurupublications.com

CHEMICAL REAGENTS FOR INCREASING THE WATER FLOODING EFFICIENCY IN OIL RESERVOIRS

A. A. DUNENOVA* and E. S. ORYNGOZHIN

Institute of Geology and Oil Gas Business After K. Turysova,
Kazakh National Technical University, After Name of K. I. Satpayev,
ALMATY, REPUBLIC OF KAZAKHSTAN

ABSTRACT

In order to improve the water flooding efficiency in oil reservoirs, water viscosity is increased by the addition of polymers in it. Polymers represent class of substances with specific properties due to the presence of giant chain structure molecules. During oil displacement, polymeric reagents increases the sweep efficiency by decreasing the mobility ratio of water to oil. The article examines the effectiveness of polymers and polymer flooding.

Key words: Polymer flooding, Oil recovery, Polyacrylamides, Polysaccharides.

INTRODUCTION

Flooding is one of the most frequently used methods of enhanced oil recovery. However, when using water flooding, there are problems often associated with the formation of fingering and early water breakthrough in production wells. Thus, it is necessary to control the mobility of the displacing agent. This control allows you to increase the enrollment ratio in terms of displacement and displacement factor at the microscopic level. In connection with the above, it is necessary to recall a concept such as fluid mobility ratio, which depends on the relative permeability and viscosity of the two fluids. The most preferred embodiment is the mobility ratio of less than one. Therefore, to improve the extrusion process, it is necessary either to increase the viscosity or decrease the effective permeability of the displacing agent. This can be done by adding the polymers to the displacement agent.

---

*Author for correspondence; E-mail: dunenova_a@mail.ru

Application of polymers

There are three ways to use the polymers during oil production:

(i) Injection of polymers into bottom-hole zones of injection and production wells in order to block the high permeability zones and, as a consequence, reduce watering.

(ii) As agents, which can cross-link to block the high permeability zone at depth.

(iii) As agents that reduce the water mobility by increasing its viscosity.

Sequence of fluid pumping during polymer flooding is following by next steps:

(i) Water with low salt content is injected.

(ii) Polymer solution is pumped, which regulates the mobility of water.

(iii) More fresh water is injected to protect the polymer solution.

(iv) At the end, displacing water is injected.

There are two types of polymers, which are most widely used during flooding - polyacrylamides and polysaccharides.

Polyacrylamides

Monomeric unit of these polymers is the acrylamide molecule. As used in polymer flooding, polyacrylamides have undergone partial hydrolysis, which causes anionic (negatively charged) carboxyl groups (–COO–) to be scattered along the backbone chain. The polymers are called partially hydrolyzed polyacrylamides (HPAM) for this reason. Typical degrees of hydrolysis are 30-35% of the acrylamide monomers; hence, the HPAM molecule is negatively charged, which accounts for many of its physical properties. This degree of hydrolysis has been selected to optimize certain properties such as water solubility, viscosity, and retention. If hydrolysis is too small, the polymer will not be water soluble. If it is too large, its properties will be too sensitive to salinity and hardness. The viscosity increasing feature of HPAM lies in its large molecular weight.

The polyacrylamide is water soluble and has a higher molecular weight comparing with other polymers. It is possible to get the necessary viscosity of displacement fluid and increase the recovery up to 7-10% by controlling the amount of the polymer. Solution concentration can vary between 0.025-0.5%; necessary solvent slug amount should be not less than 30% of pore volume.

Water-soluble polymers-polysaccharides

Polysaccharides include:

- Polymers obtained by chemical modification of the cellulose (Fig. 1)
- Starch reagents-natural and chemically modified (Fig. 2)
- Biopolymers, formed as a result of vital activity of certain types of microorganisms in a variety of nutrient environment (Fig. 3)

Fragments of the structures of polysaccharides

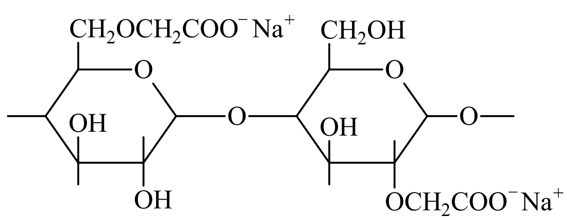

Fig. 1: Na – carboxymethylcellulose

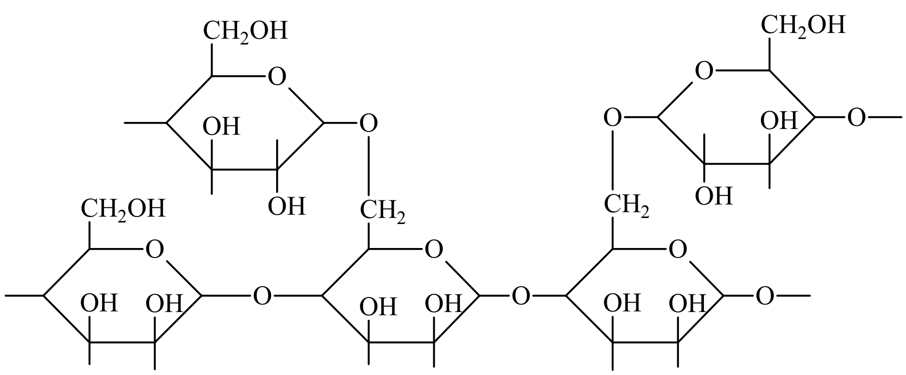

Fig. 2: Guar Gum (starch reagent)

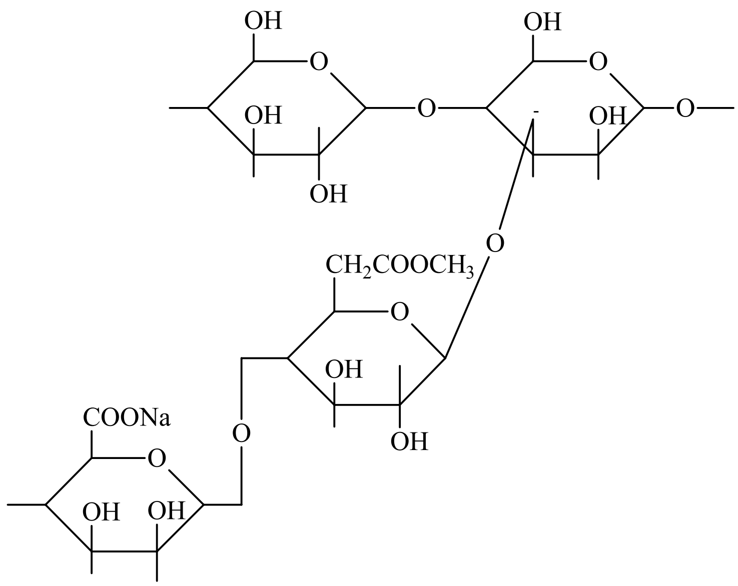

Fig. 3: Xanthan gum-biopolymer

These polymers are formed from the polymerization of saccharide molecules, which is bacterial fermentation process. This process leaves substantial debris in the polymer product that must be removed before the polymer is injected. The polymer is also susceptible to bacterial attack after it has been introduced into the reservoir. These disadvantages are offset by the insensitivity of polysaccharide properties to brine salinity and hardness.

Polymer structures and their characteristics

Structure	Characteristics	Sample polymers
–O– in the backbone	Low thermal stability, thermal degradation at high T, only suitable at < 80°C	Polyoxyethylene, sodium alginate, sodium carboxymethyl cellulose, HEC, xanthan gum
Carbon chain in the backbone	Good thermal stability, degradation not severe at < 110°C	Polyvinyl, sodium polyacrylate, polyacrylamide, HPAM
–COO− in hydrophilic group	Good viscosifier, less adsorption on sandstones due to the repulsion between chain links, but precipitation with Ca^{2+} and Mg^{2+}, less chemical stability	Sodium alginate, sodium Carboxymethyl cellulose, HPAM, xanthan gum

Cont…

Structure	Characteristics	Sample polymers
–OH or –$CONH_2$ in hydrophilic group	No precipitation with Ca^{2+} and Mg^{2+}, good chemical stability, but no repulsion between chain links, thus less viscosifying powder, high adsorption due to hydrogen bond formed on sandstone rocks	Polyvinyl, HEC, polyacrylamide, HPAM

- The main purpose of the polymers in enhanced oil recovery is alignment of heterogeneity of productive layers and increasing coverage of the flooding. Polymers are mostly used in the following technological operations.
- Polymer flooding (injection rim) in altering permeability reservoirs with high-viscosity oil; it's used in the early stages of development.
- Complex effect of polymeric gelling systems in combination with intensifying reagents (tensides, alkalis, acid) on the productive strata; it's used in the late stage of development.
- Impact on reservoir with viscoelastic mixtures for injectivity profile alignment and the intensification of oil production.
- Cyclic polymer flooding with a solution of cross-linked polyacrylamide, which contains a nonionic surfactant.
- Cyclical impact on the producing formation with polymer containing surfactant system.
- Alkaline polymer flooding.
- Polymer impact during injection of carbon dioxide.

Process of polymer flooding

Development of polymer flooding is quite a complex process that is achieved by constructing a three-dimensional model and performing various laboratory tests. However, there are six stages, which are common to all types of polymer flooding:

(i) Selection of reservoir. Technically, the selection of reservoir should be guided by two parameters: temperature and permeability of the formation. However, the main parameter is economic profitability of the project.

(ii) Selection of application method from listed above three methods.

(iii) Selection of the polymer type. The applied polymer should have some properties, such as:

- Good thickening efficiency, which means a large reduction of water mobility.
- High solubility in water. The polymers should dissolve well in water at different temperatures and in the presence of stabilizing agents.
- Low degree of adsorption on the rock.
- Shear resistance. When the polymers flow through a permeable area, polymer molecules undergo the stress, which can lead to the destruction of the polymer and, consequently, low viscosity will be achieved.
- Chemical resistance. Polymers can easily react, especially at high temperatures and in the presence of oxygen. In order to prevent this, process antioxidant are added.
- Biological resistance.

(iv) Calculation of necessary polymer volume. The amount of polymer to be pumped is equal to multiplication of the polymer slug, the pore volume and average concentration of the polymer.

(v) System design and modernization of equipment for polymer injection. Three important components are the mixing, filtering and pumping equipments.

(vi) Calculation of permitted injection rate, well mesh, taking into account the geological structure and reservoir conditions.

CONCLUSION

The main criteria of polymer flooding efficiency are amount of additional oil production per 1 ton of polymer. According to different pilot project operations, it is around 300-13000 m^3 of oil per 1 ton of polymer. It is established that using thickening agents such as polymers reduces water consumption, aligns the infectivity profile of injection wells and reduces the water cut.

REFERENCES

1. L. Lake, Enhanced Oil Recovery, Society of Petroleum Engineers (2010) p. 414.
2. J. J. Sheng, Modern Chemical Enhanced Oil Recovery, Elsevier Inc. (2011) p. 617.
3. L. S. Kaplan and A. L. Kaplan, Technology and Technology Impact on the Oil Reservoir, Oktiabrski (2000) p. 179.
4. T. A. Deeva, M. R. Kamartdinov, T. E. Kulagin and P. V. Shevelev, Modern Methods Development Fields, Tomsk (2006) p. 286.
5. M. L. Surguchev, Secondary and Tertiary Methods of Enhanced Oil Recovery, Nedra. (1985) p. 308.
6. www.ngpedia.ru/id22974p1.html
7. www.gubkin.ru/faculty/chemical_and.../chairs.../Nizova_VRP.

Accepted : 30.10.2015