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LABORATORY EVALUATION OF NOVEL NANO COMPOSITE GEL FOR WATER SHUT-OFF

E. F. Veliyev*[1, 2], A. A. Aliyev[1]

[1]*«OilGasScientificResearchProject» Institute, SOCAR, Baku, Azerbaijan;*

[2]*Composite Materials Scientific Research Center, Azerbaijan Sate University of Economics (UNEC), Baku, Azerbaijan*

A B S T R A C T

When extracting oil and gas from underground reservoirs, fluids such as water, CO2, polymer solutions, and surfactant solutions are often injected to displace the hydrocarbon resources. However, the presence of high-permeable layers, channels, and fractures in the reservoirs can hinder the efficiency of the displacement processes. The displacing fluids tend to channel through these high-permeability features, leaving behind significant amounts of hydrocarbon in low-permeability zones, which remain unswept. Recent developments in nanocomposite hydrogels, such as PPGs, have shown promising results for water shutoff due to their thermal stability and deformability. In this study, a preformed particle gel with nano additive (NC-PPG) was developed through free radical polymerization of AM, AMPS, and nanoclay. Nanoclay nanoparticles were found to act as physical cross-linkers in the polymer network, leading to smaller pore sizes and slightly enhanced thermal stability. The addition of an appropriate amount of nanoclay nanoparticles significantly improved the swelling rate and mechanical properties of NC-PPG. The presented composition also showed good salt tolerance, as evidenced by its compatibility with highly saline formation water and the plugging rate and RRF of 0.25% NC-PPG solution, which were 94.3% and 17.6, respectively, in the sand-pack flowing experiment. These results suggest that NC-PPG has the potential to effectively plug the high permeability zones in mature reservoirs, making it a suitable candidate for water shutoff treatment and enhanced oil recovery (EOR) strategies. The ability of NC-PPG to improve sweep efficiency and control water flow in reservoirs can contribute to more efficient oil production and reservoir management practices.

Keywords: enhanced oil recovery; water shut-off; plugging efficiency; preformed particle gel; nanoclay; sweep efficiency.

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1. Introduction

When extracting oil and gas from underground reservoirs, fluids such as water, CO_2, polymer solutions, and surfactant solutions are often injected to displace the hydrocarbon resources. The goal is to effectively sweep the reservoir spaces and achieve high hydrocarbon recovery [1-5]. However, the presence of high-permeable layers, channels, and fractures in the reservoirs can hinder the efficiency of the displacement processes. The displacing fluids tend to channel through these high-permeability features, leaving behind significant amounts of hydrocarbon in low-permeability zones, which remain unswept [6-10]. Additionally, the displacing fluids can rapidly break through adjacent producing wells, leading to issues such as emulsification, scaling, foaming, and difficult oil/water separation, which pose complex challenges. These problems not only increase costs but also have negative environmental impacts [11-13].

The complex transport and placement behavior of gel materials in porous media, particularly in super-K channels, is not yet fully understood [14-15]. Recent developments in nanocomposite hydrogels, such as PPGs, have shown promising results for water shutoff due to their thermal stability and deformability [16-18]. Nanocomposite hydrogels also exhibit improved mechanical properties compared to conventional hydrogels. Factors such as the size ratio of swollen PPG particles to pore throats, gel strength, and driving force have been identified as dominant factors in transport patterns [19-21]. Studies have shown that gel strength is more influential than particle size in determining transport behavior. Particle size distribution can also change after transportation through sandpacks, with a reduction in the fraction of large particles in the effluent, indicating possible entrapment or surface deposition in the sandpacks. A critical pressure gradient is required for gel particles to propagate in porous media, and this critical pressure gradient exponentially increases with the particle/pore matching size ratio. Gel dispersions tend to exhibit thinning behavior when flowing through porous media, which can benefit the in-depth placement of gel materials [22-30].

In this study, a preformed particle gel with nano additive (NC-PPG) was developed using acrylamide (AM) and 2-acrylamido-2-methylpropane sulfonic acid (AMPS) as monomers through in situ copolymerization. Nanoclay (NC) was added to the polymerization system as a physical cross-linker, and N,N-methylene-bisacrylamide (MBA) was used as a chemical cross-linker. The swelling rate of NC-PPG was investigated at different temperatures, taking into consideration various parameters such as the monomer ratio, NC concentration, chemical cross-linker, and initiator

***E-mail:** elchinf.veliyev@socar.az

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concentration. The pH sensitivity and salt tolerance of NC-PPG were also evaluated. Sand-pack flowing experiments were conducted to assess the plugging capacity of NC-PPG for water shutoff operations.

2. Materials and methods

2.1. Materials

Acrylamide (AM), 2-Acrylamido-2-methylpropane sulfonic acid (AMPS) was purchased from Merck. Ammonium persulfate (APS), N,N′-Methylenebisacrylamide (MBAA), sodium hydroxide and Hydrochlorid acid were purchased from local suppliers. Compositional analysis of formation water is shown in table 1.

Table 1
Composition of formation water

Ion	Concentration, ppm
Na^++K^+	22373
Ca^{2+}	120
Mg^{2+}	168
Cl^-	32900
SO_4^{2-}	0
HCO_3^-	4026
CO_3^{2-}	0
Total salinity	59587

2.2. Methods

2.2.1. Synthesis of NC-PPG

The synthesis of NC-PPG involved the following steps:

1. Dissolving nanoclay: Nanoclay was dissolved in 100 mL of fresh water using magnetic stirring to ensure uniform mixing.
2. Adding monomers: After the nanoclay was completely dissolved, AM (acrylamide) and AMPS (2-acrylamido-2-methylpropane sulfonic acid) were added to the solution and stirred for 90 minutes until a uniform solution was formed.
3. Incorporating chemical cross-linker and initiator: To facilitate the cross-linking reaction and initiate polymerization, the solution was supplemented with a chemical cross-linker and an initiator. The mixture was continuously stirred until complete dissolution was achieved.
4. Polymerization: The prepared solution was then placed in a 60 °C thermostat water bath and allowed to polymerize for 12 hours, forming a bulk gel.
5. Drying and cutting: The formed bulk gel was cut into small pieces and placed in a fume hood to dry spontaneously, allowing the gel to solidify and stabilize.

2.2.2. Swelling rate

The swelling rate of NC-PPG was determined using the formula:

$$S = \frac{(m_0 - m_t)}{m_0}$$

where, S – swelling rate of NC-PPG dimensionless; m_0 – initial weight of NC-PPG in g; m_t – weight of NC-PPG after soaking in water for t hours in g.

To calculate the swelling rate, the weight of NC-PPG samples (m_0) was measured initially. Then, the NC-PPG samples were soaked in water for a specific time period (t hours) and allowed to swell. After soaking, the weight of the swollen NC-PPG samples (m_t) was measured at regular intervals. The difference between the weight of swollen NC-PPG samples and the initial weight of NC-PPG samples was divided by the initial weight of NC-PPG samples, and the result was expressed as the swelling rate. This calculation allows for the determination of how much the NC-PPG samples swelled in relation to their initial weight, providing information about the swelling behavior and capacity of NC-PPG under the given experimental conditions.

2.2.3. Mechanical properties

The mechanical properties of NC-PPG, including the stretched length and breakdown pressure, were measured using a universal material tester and a gel strength tester.

For the uniaxial tensile test, a gel sample with a length of 1.5″ and a diameter of 0.5″ was prepared from the bulk gel. The gel sample was then subjected to uniaxial tensile testing using a universal material tester, with a testing rate of 10 mm/min. The test was carried out until the NC-PPG sample broke, and the maximum tensile length before the sample broke was recorded as the stretched length of the NC-PPG.

A bulk gel with a 2″ diameter and a 2″ height was created to test the breakdown pressure. In order to simulate the swelling behavior in a water environment, the bulk gel was submerged in water for 24 hours. After soaking, a gel strength tester was used to determine the breakdown pressure of the bulk gel. The breakdown pressure, which indicates the mechanical stability and strength of the NC-PPG under the specified experimental circumstances, is the pressure at which the bulk gel fractures or breaks under the applied external pressure.

2.2.4. Thermal stability

The thermal stability of NC-PPG was evaluated using Thermogravimetric Analysis (TG) and Differential Scanning Calorimetry (DSC). After absorbing formation water for 24 hours, the NC-PPG was set in a hermetic pan. TG-DSC measurements were conducted in a temperature range of 50-250 °C, with a scanning rate of 5 °C/min, under a nitrogen atmosphere.

By combining TG and DSC measurements, the thermal stability and behavior of NC-PPG can be characterized, providing insights into its performance under different temperature conditions, which is important for its potential applications in reservoir treatments.

2.2.5. Plugging efficiency

The sand-pack flowing experiments were conducted to evaluate the plugging capacity of NC-PPG (fig. 1). The experimental steps are as follows:

1. The sand-pack was filled with quartz sand size of 75-90 μm. Water flooding was carried out to determine the initial permeability of the sand-pack using Darcy's formula:

$$k = \frac{Q\mu}{A} \times \frac{L}{\Delta P}$$

where, k is the permeability in mD, Q is the flow rate in

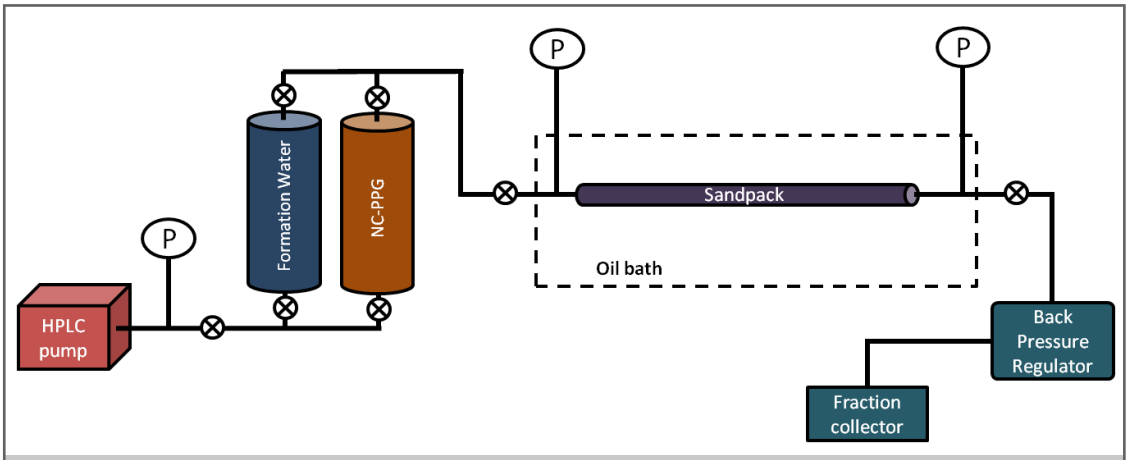

Fig. 1. Schematic illustration of experimental apparatus

ml/min, μ is the viscosity in cP, L is the length of porous medium (sandpack) in cm, A is the cross-sectional area of porous medium (sandpack) cm², ΔP is the difference in pressure at the inlet and outlet of sandpack in MPa.

2. A predetermined concentration of NC-PPG solution was prepared. The NC-PPG solution was injected into the sand-pack, displacing the water. A volume equal to 0.5 pore volumes (PV) of NC-PPG solution was injected. After that, 0.5 PV of water was injected to replace the NC-PPG solution. The sand-pack was then sealed and set at 60 °C for 36 hours, allowing the NC-PPG to form a gel and plug the porous medium.
3. The permeability of the sand-pack was tested again by water flooding after the NC-PPG had time to gel and plug the porous medium. The plugging rate and the residual resistance factor (RRF) of the NC-PPG were calculated using the following equations:

$$Plugging\ Rate = \left(1 - \frac{k_f}{k_i}\right) \times 100\%$$

where, k_f is the permeability of the sand-pack after NC-PPG injection, and k_i is the initial permeability of the sand-pack before NC-PPG injection. The plugging rate indicates the percentage reduction in permeability due to NC-PPG gelation and plugging.

$$RRF = \frac{k_i}{k_f}$$

where, RRF is a measure of the effectiveness of NC-PPG in reducing the permeability of the sand-pack. A higher RRF value indicates a higher plugging capacity of NC-PPG, as it indicates a greater reduction in permeability after NC-PPG injection compared to the initial permeability.

3. Results and discussion

3.1. Thermal stability

The TG-DSC analysis of NC-PPG after swelling in formation water at 80°C was conducted to investigate its thermal stability within temperature ranges of 50-250°C. From the TG-DSC curves, it can be observed that the TG and DSC curves of NC-PPG (with nanoclay) shift to the right compared to the curves of PPG without nanoclay (fig. 2). Only one endothermic peak is observed in the DSC curve of both samples. The weight loss of NC-PPG and PPG without nanoclay is 36% and 49%, respectively, as the temperature increases from 50 to 100 °C. This may be attributed to the evaporation of free water inside the hydrogel. The mass loss observed in the temperature range of 100 to 125 °C is attributed to the evaporation of bond water, which is bonded to the polar hydrophilic groups in the polymer chains within the hydrogel. Up to 125 °C, the TG curves of NC-PPG and PPG without nanoclay appear to be constant, with a total mass loss of 94% and 97%, respectively. This suggests that the presence of nanoclay nanomaterials slightly enhances the thermal stability of NC-PPG.

3.2. Effect of the monomer ratio on swelling rate

The water absorbency of NC-PPG, with varying ratios of AM and AMPS while keeping the total amount of monomers constant, was measured at ambient temperature (25 °C) and 60 °C, respectively. The experimental results, as shown in figure 3, indicate that the water absorbency of NC-PPG with the addition of AMPS is significantly higher than that without AMPS. Increasing the concentration of AMPS results in a higher swelling rate. This is attributed to the fact that the anionic groups (-SO_3-) on the NC-PPG molecular chains increase with the increase of AMPS concentration, leading to enhanced electrostatic repulsion and higher water absorbency [31] .

Furthermore, the swelling rate of NC-PPG increases with the increase of temperature. This may be due to the hydrolysis of more amide groups (-$CONH_2$) on the NC-PPG molecular chains into carboxyl groups (-COO-) and ionization of sulfonic acid groups (-SO_3H) with increasing temperature,

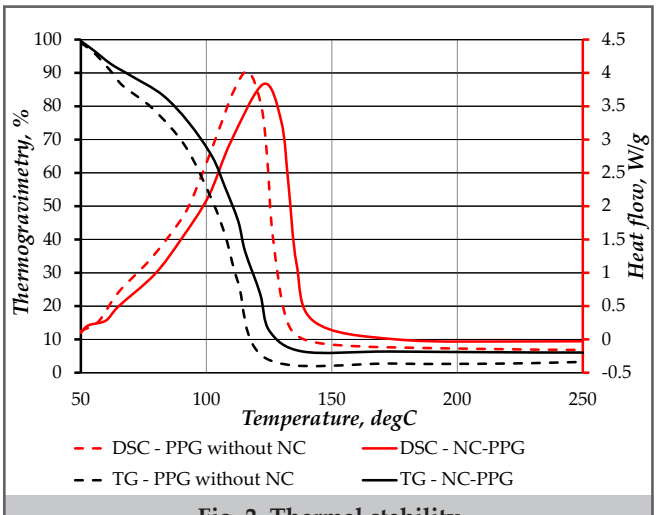

Fig. 2. Thermal stability

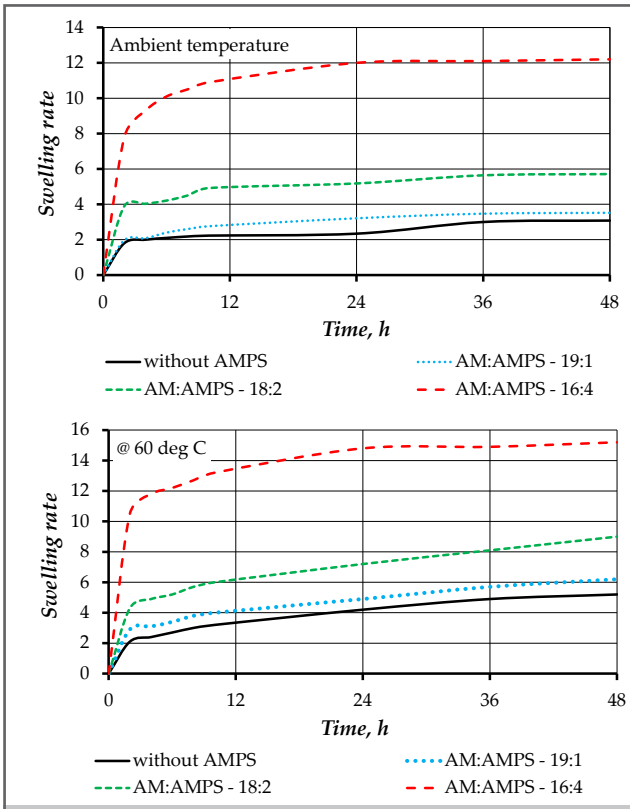

Fig. 3. Effect of monomer ratio on swelling rate

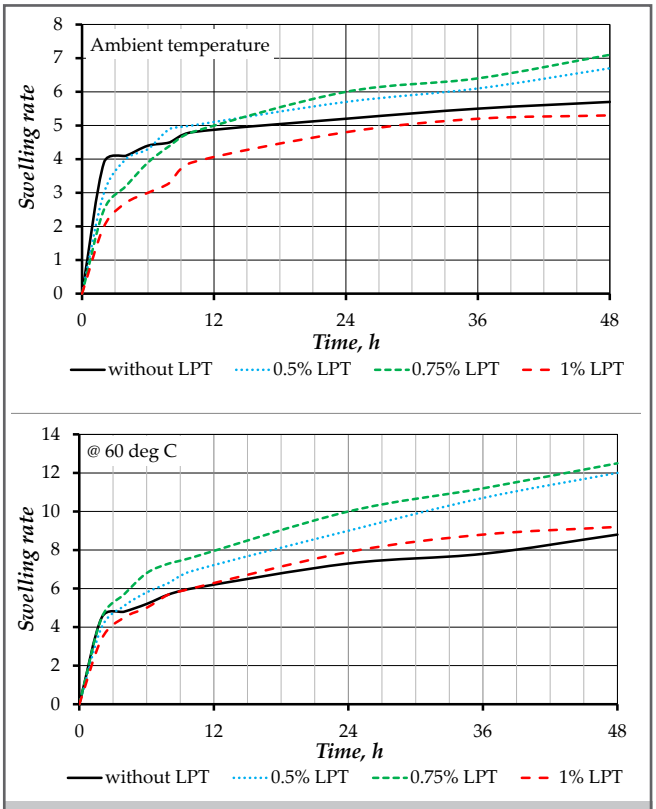

Fig. 4. Effect of nanoclay concentration on swelling rate

resulting in increased ionic charges inside the NC-PPG and hence higher water absorbency.

3.3. Effect of nanoclay concentration on the swelling rate

Nanoclay nanoparticles were incorporated into the polymerization system to prepare NC-PPG in order to improve the strength of PPGs (partially preformed particle gels). The water absorbency of NC-PPG was tested at ambient temperature (25 °C), and 60 °C and the results are shown in figure 4. It was observed that the swelling rate of NC-PPG initially increases with increasing nanoclay concentration and then decreases. The maximum swelling rate is achieved when the nanoclay concentration is 0.75%. Compared to NC-PPG without nanoclay, the water absorbency of NC-PPG after swelling for 48 hours is increased by 42% at 60 °C.

3.4. Effect of nanoclay concentration on mechanical properties

The effect of nanoclay on the mechanical properties of NC-PPG was evaluated by measuring the breakdown pressure and stretched length of NC-PPG after swelling for 48 hours, as shown in table 2. It was observed that both the breakdown pressure and stretched length increase with increasing nanoclay concentration. The NC-PPG sample with 0.75% nanoclay showed a significant increase in breakdown pressure (2.6 times higher) and stretched length (approximately 2 times higher) compared to the nanoclay-free sample. These results indicate that the addition of an appropriate amount of nanoclay not only enhances the water absorbency of NC-PPG but also improves its mechanical properties. This improvement is attributed to the physical cross-linking role of nanoclay nanoparticles in the polymerization system, which enhances the plugging strength of NC-PPG for water shutoff.

3.5. Effect of chemical Cross-Linker concentration on swelling rate

In the experiment, the AM (acrylamide)/AMPS (2-acrylamido-2-methylpropane sulfonic acid) ratio and nanoclay concentration were kept constant at 9:1 and 0.75%, respectively. The swelling rate of NC-PPG was then studied with varying concentrations of MBA (N,N′-methylenebisacrylamide). It was observed that the swelling rate of NC-PPG initially increases and then decreases with increasing MBA concentration (fig. 5). The highest swelling rate was obtained at a MBA concentration of 0.05%.

This observation can be explained by the effective cross-linking degree of the NC-PPG network. At low MBA concentrations, the cross-linking degree of the network is low, resulting in weak and loosely connected network structure. As a result, part of the network dissolves due to water absorption, leading to a low swelling rate. On the other hand, excessive MBA concentration results in a dense

Table 2

Effect of nanoclay concentration on mechanical parameters of gel

Nanoclay concentration, %	Breakdown pressure, kPa	Streched length, inches
0	1.2	29
0.5	2.4	51
0.75	3.2	62
1	4	69

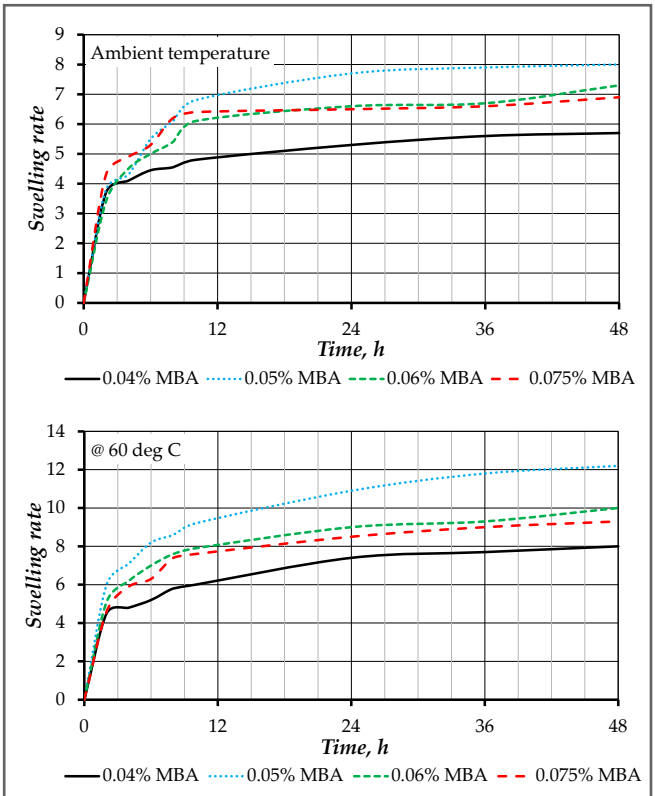

Fig. 5. Effect of chemical crosslinker on swelling rate

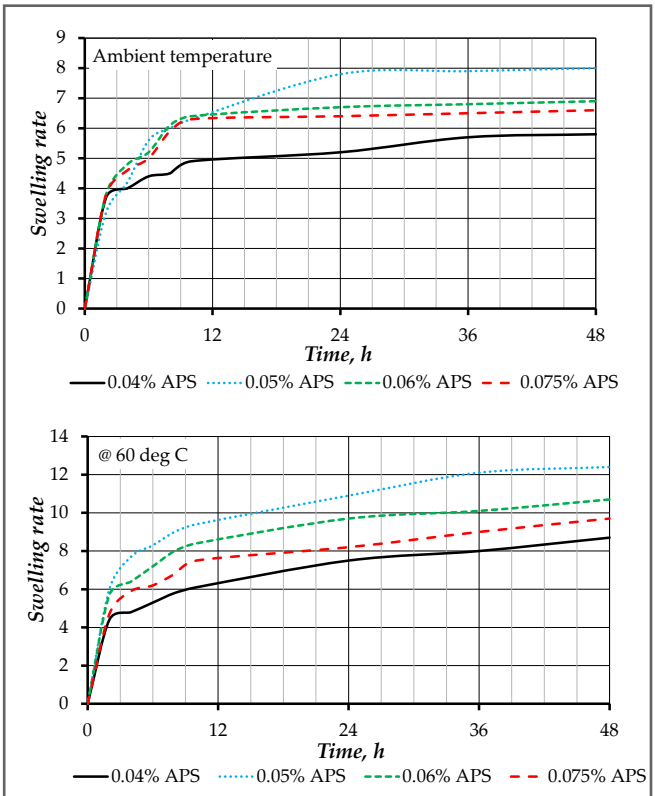

Fig. 6. Effect of initiator concentration on swelling rate

and tightly cross-linked network structure, which reduces the water absorption capacity of the network. This leads to a decrease in the water absorbency of NC-PPG.

Therefore, the optimal swelling rate of NC-PPG is achieved at an intermediate MBA concentration of 0.05%, where the cross-linking degree of the network is sufficient to provide structural integrity, while still allowing for efficient water absorption. This finding suggests that the concentration of cross-linker (MBA) should be carefully controlled to achieve the desired water absorbency and mechanical properties in the NC-PPG system.

3.6. Effect of initiator concentration on swelling rate

The experimental results (fig. 6) indicate that the effect of APS (ammonium persulfate) on the swelling rate of NC-PPG is similar to that of MBA (N,N'-methylenebisacrylamide). At low APS concentrations, fewer free radicals are produced during polymerization, resulting in reduced participation of monomers in the polymerization reaction. This leads to a lower number of hydrophilic groups on the molecular chain of the NC-PPG, resulting in a low swelling rate. On the other hand, as the APS concentration increases beyond 0.05%, more free radicals are generated, making the cross-linking reaction easier to occur. This leads to a higher cross-linking density in the NC-PPG network, resulting in a decrease in the swelling rate of NC-PPG.

Therefore, similar to the effect of MBA, the concentration of APS should also be carefully controlled in order to achieve the desired water absorbency of NC-PPG. Too low or too high APS concentrations can result in reduced swelling rates due to differences in cross-linking density, highlighting the importance of optimizing the APS concentration in the polymerization system to achieve the desired properties of NC-PPG.

3.7. Effect of pH on swelling rate

The experimental results indicate that the swelling rate of NC-PPG is significantly higher in alkaline medium compared to acidic and neutral media, especially at elevated temperatures (fig. 7). For instance, at a pH value of 9 and 60 °C, the swelling rate of NC-PPG reaches 27 times, which is 2.7 times higher than that at pH 5 and 2.45 times higher than that at pH 7, both at 60 °C. This suggests that NC-PPG is highly sensitive to alkalinity and exhibits enhanced water absorption capacity in alkaline environments.

The increase in water absorption capacity of NC-PPG in alkaline medium can be attributed to several factors. Firstly, the transformation of sulfonic acid groups (SO_3H) in the molecular chains of NC-PPG into sulfonate ions (SO_3^-) under alkaline conditions leads to charge repulsion, which expands the molecular chains of NC-PPG, resulting in increased water uptake capacity. This suggests that the presence of alkaline conditions promotes the swelling of NC-PPG by altering the charge state of the sulfonic acid groups in the polymer [32].

Furthermore, the negatively charged surface of the lamellar structure of nanoclay, which contains silanol groups (Si-O-), creates effective anionic repulsion, further enhancing the water uptake capacity of NC-PPG. This electrostatic repulsion between the negatively charged nanoclay surface and the surrounding water molecules contributes to the increased water absorption capacity of NC-PPG in alkaline medium [33].

Overall, the pH sensitivity of NC-PPG can be attributed to the combined effects of the transformation of sulfonic acid groups, charge repulsion, and electrostatic repulsion from the negatively charged nanoclay surface. This understanding of the pH sensitivity of NC-PPG can be useful in designing NC-PPG-based materials for specific applications that require water absorbency in different pH environments.

3.8. Compatibility with formation water

The experimental results demonstrate that the swelling

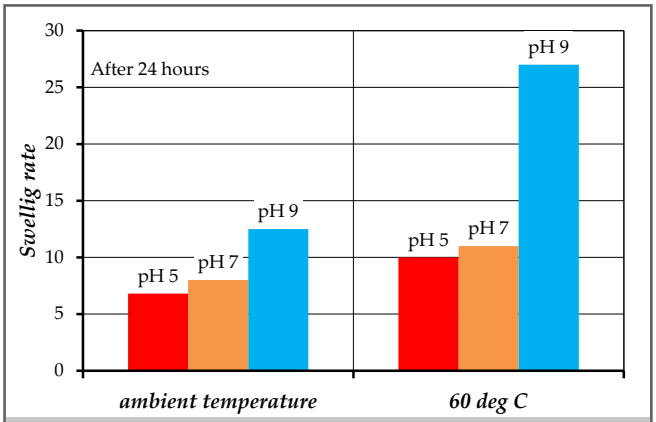

Fig. 7. Effect of pH on swelling rate

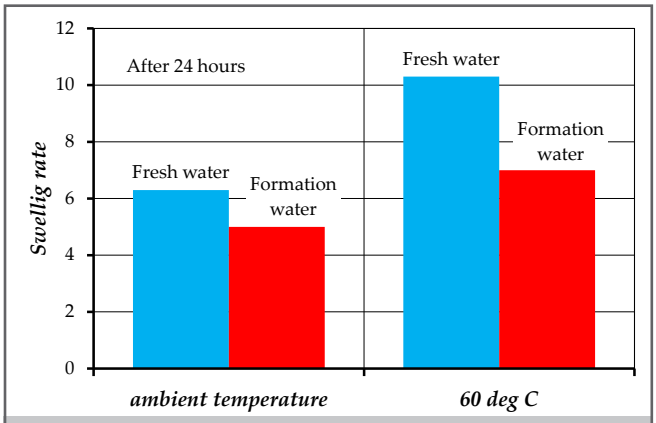

Fig. 8. Impact of formation water on Swelling rate of the NC-PPG

rate of NC-PPG in formation water, which contains various metal salt ions such as Na^+, K^+, Ca^{2+}, etc., is lower compared to that in fresh water (fig. 8). This is because the metal salt ions in the formation water penetrate into the network structure of NC-PPG and screen the carboxylate and sulfonate groups in the molecular chains of NC-PPG, resulting in impaired water absorption capacity. Nevertheless, even in the presence of high salinity in formation water (60000 ppm), NC-PPG still exhibits significant expansion, reaching 7 times at 60 °C after soaking for 24 hours.

Figure 9 shows that the equilibrium absorbency of NC-PPG in fresh water is reached after approximately 15 days, while it is reached after 10 days in formation water at 60 °C. After reaching equilibrium, the swelling rate of NC-PPG remains constant in both fresh water and formation water for 30 days at 60 °C, with values of 20 and 13.4, respectively. This indicates that NC-PPG exhibits good salt tolerance and compatibility with highly saline formation water under reservoir conditions.

The ability of NC-PPG to maintain its swelling rate and absorbency in the presence of high salinity in formation water is promising for potential applications in oil and gas reservoirs where the water can be highly saline. This information can be valuable in designing NC-PPG-based materials for oilfield applications, such as water control in enhanced oil recovery (EOR) processes or for other applications where exposure to high salinity environments is expected.

3.9. Blocking ability of NC-PPG in porous medium

The experimental results from the sand-pack flowing experiment reveal that NC-PPG exhibits a significant plugging capacity to the high-permeability zone of the formation. Table 3 shows that as the concentration of NC-PPG increases, the plugging rate also increases. At a concentration of 0.25% NC-PPG solution injected into the sand-pack, the plugging rate reaches above 94%, with a Residual Resistance Factor (RRF) of 17.6. Furthermore, the RRF increases with higher NC-PPG concentration, indicating that the difficulty of water flow in the sand-pack is enhanced with increasing NC-PPG concentration. This suggests that NC-PPG has excellent plugging capacity to the high-permeability zone

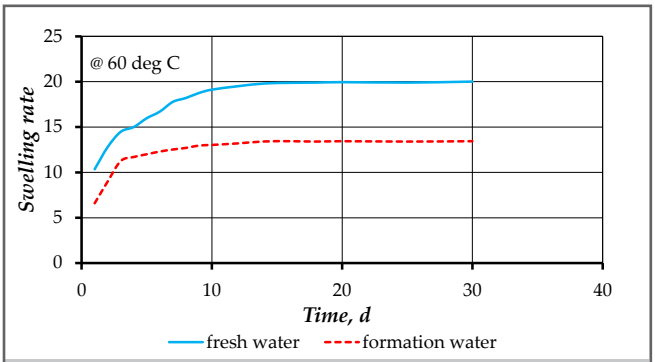

Fig. 9. Impact of formation water on long-term stability of NC-PPG

of the formation, making it a promising candidate for applications in mature reservoirs or other oilfield scenarios where plugging of high-permeability zones is desired. The ability of NC-PPG to effectively plug high-permeability zones in reservoirs can potentially contribute to enhanced oil recovery (EOR) strategies by diverting injected fluids to less permeable zones, thus improving sweep efficiency and overall recovery of hydrocarbons.

Table 3

Blocking ability of NC-PPG in porous medium

Experiment N	NC-PPG concentration, %	Permeability, mD		Plugging rate, %	RRF
		before	after		
1	0.25	1549	88.2	94.3	17.6
2	0.5	1672	71.6	95.7	23.4

Conclusions

The synthesis of NC-PPG was carried out through free radical polymerization of AM, AMPS, and nanoclay. Nanoclay nanoparticles were found to act as physical cross-linkers in the polymer network, leading to smaller pore sizes and slightly enhanced thermal stability compared to PPG without nanoclay. The addition of an appropriate amount of nanoclay nanoparticles significantly improved the swelling rate and mechanical properties of NC-PPG. NC-PPG also exhibited pH sensitivity, with the swelling rate reaching 27 times at a pH value of 9 at 60 °C.

NC-PPG also showed good salt tolerance, as evidenced by its compatibility with highly saline formation water and the plugging rate and RRF of 0.25% NC-PPG solution, which were 94.3% and 17.6, respectively, in the sand-pack flowing experiment. These results suggest that NC-PPG has the potential to effectively plug the high permeability zones in mature reservoirs, making it a suitable candidate for water shutoff treatment and enhanced oil recovery (EOR) strategies. The ability of NC-PPG to improve sweep efficiency and control water flow in reservoirs can contribute to more efficient oil production and reservoir management practices.

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Лабораторная оценка нового нанокомпозитного геля для изоляции водопритоков в скважину

Э. Ф. Велиев[1, 2], А. А. Алиев[1]
[1]НИПИ «Нефтегаз», SOCAR, Баку, Азербайджан;
[2]Научно-исследовательский центр композитных материалов, Азербайджанский государственный экономический университет (UNEC), Баку, Азербайджан

Реферат

При добыче нефти и газа из нефтяных и газовых пластов для вытеснения часто закачиваются такие жидкости, как вода, CO_2, растворы полимеров и ПАВ. Однако наличие высокопроницаемых слоев, каналов и трещин в пластах может препятствовать эффективности процессов вытеснения. Вытесняющие жидкости стремятся пройти через эти высокопроницаемые слои, оставляя значительные объемы углеводородов в низкопроницаемых зонах, которые остаются невытесненными. Последние разработки в области нанокомпозитных гидрогелей показали многообещающие результаты для перекрытия воды благодаря их термической стабильности и деформируемости. В данном исследовании был разработан предварительно сформированный гель частиц с нанодобавкой (NC-PPG) путем свободнорадикальной полимеризации AM, AMPS и наноглины. Было обнаружено, что наночастицы наноглины действуют как физические сшиватели в полимерной сети, что приводит к уменьшению размеров пор и увеличению термостабильности. Добавление соответствующего количества наночастиц наноглины значительно улучшило скорость набухания и механические свойства NC-PPG. Представленный состав также показал хорошую солеустойчивость, о чем свидетельствует его совместимость с высокосоленой пластовой водой и степень закупорки и RRF 0.25% раствора NC-PPG, которые составили 94.3 и 17.6 %, соответственно, в эксперименте с песчаной пачкой. Эти результаты свидетельствуют о том, что NC-PPG обладает потенциалом для эффективного закупоривания зон высокой проницаемости в зрелых коллекторах, что делает его подходящим кандидатом для водоизоляционной обработки и увеличения нефтеотдачи (EOR). Способность NC-PPG повышать эффективность вытеснения и контролировать поток воды в пластах может способствовать повышению эффективности добычи нефти и совершенствованию методов эксплуатации пластов.

Ключевые слова: повышение нефтеотдачи; изоляция избыточной воды; блокирование поровых каналов; гель предварительно сформированных частиц; наноглина; профиль уплотнения.

İstismar quyularında su təzahürünün qarşısının alınması məqsədilə yeni nanokompozit gel tərkibinin laboratoriya tədqiqatı

E. F. Vəliyev[1, 2], Ə. A. Əliyev[1]
[1]«Neftqazelmitədqiqatlayihə» İnstitutu, SOCAR, Bakı, Azərbaycan;
[2]Kompozit Materiallar Elmi Tədqiqat Mərkəzi, Azərbaycan Dövlət İqtisad Universiteti (UNEC), Bakı, Azərbaycan;

Xülasə

Neft-qaz yataqlarının işlənməsi zamanı nefti, qazı quyudibinə sıxışdırmaq üçün adətən su, CO_2, polimer məhlulları, SAM məhlulları laya vurulur. Lakin, layda yüksək keçirici kanalların, çatların mövcudluğu sıxışdırılma prosesinin effektivliyini azaldır. Laya vurulan mayelər adətən bu kanallar, çatlar ilə hərəkət edərək nefti yan keçir və beləliklə yüksək miqdarda neft layda sıxışdırlmamış qalır. Nanokompozit nanogellər sahəsində aparılmış son tədqiqatlarda onların su kanallarının izolyasiyası məqsədilə istifadəsində perspektiv nəticələr əldə olunmuşdur. Hazırki məqalədə, AM, AMPS və nanogilin sərbəst radikal polimerləşməsi hesabına yaradılmış nano əlavəli qabaqcadan hazırlanmış hissəcik geli (NC-PPG) tədqiq olunmuşdur. Nanogil hissəcikləri gel tərkibində fiziki tikici rolunu oynamış, polimer şəbəkəsinin məsamələrinin kiçilməsinə və termiki stabilliyin artmasına səbəb olmuşdur. Həmçinin müvafiq miqdarda əlavə olunmuş nanogil gelin şişməsini və mexaniki parametrlərini yaxşılaşdırmışdır. Lay suyu ilə uyğunluq testi və məsaməli mühitdə aparılan testlər göstərmişdir ki, təqdim olunmuş tərkib həm də duzluluğa qarşı dözümlüdür. Bütün əldə olunmuş nəticələr onu göstərir ki, NC-PPG işlənmənin son mərhələsində olan yataqlarda yüksək keçiricilikli kanalları bloklamaq potensialına malikdir, bu da öz növbəsində təqdim olunmuş gel tərkibinin su kanallarının izolyasiyası və Neftveriminin artırılması texnologiyaları üçün yararlı tərkib olduğunu sübut edir.

Açar sözlər: neftverimin artırılması; izafi suyun izolyasiyası; məsaməli kanalların bloklanması; qabaqcadan hazırlanmış hissəcik geli; nanogil; sıxışdırılma profili.