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Articles

Laboratory Study of Copper Nanoparticle Effect on Scale and Corrosion Rate in the Oil Field

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Laboratory Study of Copper Nanoparticle Effect on Scale and Corrosion Rate in the Oil Field

(Studi Laboratorium Pengaruh Penggunaan Copper Nanoparticle pada Potensi Scale dan Kecepatan Korosi di Lapangan Minyak)

Reno Pratiwi[1], Lestari[1*], Muhammad Burhannudinnur[2], Syamsul Irham[1], Lukas[1]

[1]Petroleum Engineering Department, Universitas Trisakti, Indonesia
[2]Geological Engineering Department, Universitas Trisakti, Indonesia

Abstract
The occurrence of corrosion and scale on production equipment is an obstacle that often occurs in oil and gas exploration activities. Physical and chemical properties of formation water that come out with oil from production wells are the main variables causing corrosion and scale. In recent years, developing nanotechnology provides many benefits in various industrial activities. One product that is becoming widely known is Copper Nano Particles (CuNPs) which have anti-biotic, anti-microbial, and anti-fungal agents which are soluble in water and can be used to protect / coat metals (superficial conductive coatings of metal and non-ferrous metal). The use of nanoparticles in oil and gas exploration activities is still very limited. Specifically, the CuNPs material, its anti-bacterial and anti-fungal properties have never been researched on the possible use in the oil field. In this study, it was observed the influence of the presence of CuNPs in formation water on the potential for scale formation and corrosion. Formation water obtained from production wells in the Wonocolo region, Cepu, Central Java, is used as a sample to test the effect of CuNPs on the scale and corrosion trends. Observations have shown that the CuNPs content test at various concentrations did not have a significant effect on formation water for its tendency to form scales. While the corrosivity of water seems to be quite influenced by the presence of CuNPs, where the addition of nanoparticle material is optimal at 0.01 ppm which can reduce corrosion rates up to 95%.

Keywords: CuNPs; Scale; Corrosion; Copper Nanoparticles

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Terjadinya korosi dan scale pada peralatan produksi merupakan kendala yang sering terjadi pada kegiatan eksplorasi migas. Sifat fisik dan kimia air formasi yang keluar bersama minyak mentah dari sumur produksi adalah variabel utama yang menyebabkan korosi dan scale. Dalam beberapa tahun terakhir, pengembangan nanoteknologi memberikan banyak manfaat dalam berbagai kegiatan industri. Salah satu produk yang semakin dikenal adalah Copper Nano Particles (CuNPs) yang memiliki agen anti-biotik, anti-mikroba, dan anti-jamur yang larut dalam air dan dapat digunakan untuk melindungi / melapisi logam (lapisan konduktif superfisial logam dan logam non-ferro). Penggunaan nanopartikel dalam kegiatan eksplorasi minyak dan gas masih sangat terbatas. Khususnya material CuNPs, dengan sifatnya yang anti bakteri dan anti jamur, belum pernah dilakukan penelitian tentang kemungkinan penggunaannya di lapangan minyak. Pada penelitian ini diamati pengaruh keberadaan CuNPs di dalam air formasi terhadap potensi terbentuknya scale maupun terjadinya korosi. Air formasi yang diperoleh dari sumur produksi di wilayah Wonocolo, Cepu, Jawa Tengah, digunakan sebagai sampel untuk menguji efek CuNPs pada kemungkinan pembentukan scale dan terjadinya korosi. Data yang didapat menunjukkan bahwa CuNPs pada berbagai konsentrasi tidak memiliki pengaruh yang signifikan terhadap kecenderungan air formasi membentuk scale. Sementara korosifitas air tampaknya cukup dipengaruhi oleh keberadaan CuNPs, di mana penambahan bahan nanopartikel terlihat optimal pada nilai 0,01 ppm, dimana mampun mengurangi kecepatan korosi hingga 95%

Kata-kata kunci: CuNPs; Scale; Korosi; Partikel Nano Copper

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I. INTRODUCTION

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Technologies that use nano-sized particles are increasingly being used because the effect of increasing surface area up to 1 million fold will significantly increase the performance of these particles. In the gas and petroleum industry, the use of nanoparticles has begun to be considered for their use. Research that has been done generally discusses the use of nanoparticles in the EOR field which among others discusses decreased viscosity, improves fluid rheology and fluid stability, decreases interfacial tension, oil wettability, and rock permeability [5, 6].

The drilling fluid field also uses nanotechnology to improve performance, particularly in the aspects of fluid rheology, lubricity and improved filtration characteristics, as well as thermal and heat transfer aspects that are maintained in stable condition. Cement material is also used by nanoparticles to improve mechanical properties, compressive strength, and setting time [5, 6].

Applications of the use of nanoparticle material are also tried to solve the corrosion problem that often occurs in oil and gas fields. Previous research tried to use the magnetic properties of ferro nanoparticles as a corrosion inhibitor. The Ferromagnetic particle has the ability to attract acid ions contained in the fluid, to then make it react chemically until the corrosive properties of these ions can be reduced [4, 6, 7, 8].

This research examines the effect of using CuNPs nanoparticles on formation water fluids, how their behavior changes in terms of the tendency to form scale or corrosion. Nano CuNPs particles are known to have quite effective antibacterial properties [9, 10], so taking into account the possibility of SRB bacterial content in formation water, the effect of the presence of CuNPs in formation water will be observed. In addition, the presence of sulfate ions in CuNPs will also be observed whether it affects the tendency of formation water to form scales.

III. METHOD

Formation water samples used in the study were taken from production wells in the Wonocolo region, Cepu, Central Java. Material preparation is done by adding a solution of CuNPs at concentrations 0.01, 0.02, and 0.05 ppm. Physical properties observed in the sample include measurement of density and viscosity at various temperatures, with a temperature range of 86 - 150 ^oC.

Testing the effect of CuNPs content on formation water on the potential for scale is observed by determining changes in the concentration of Na^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, $SO_4^=$, and Cl^- ions in formation water. Testing the rate of corrosion on metals in contact with formation water contained in CuNPs was carried out electrochemically using EDAQ 163 software, to determine the effect of additive concentration on corrosion rates. The schema of the research conducted is shown in Figure 1.

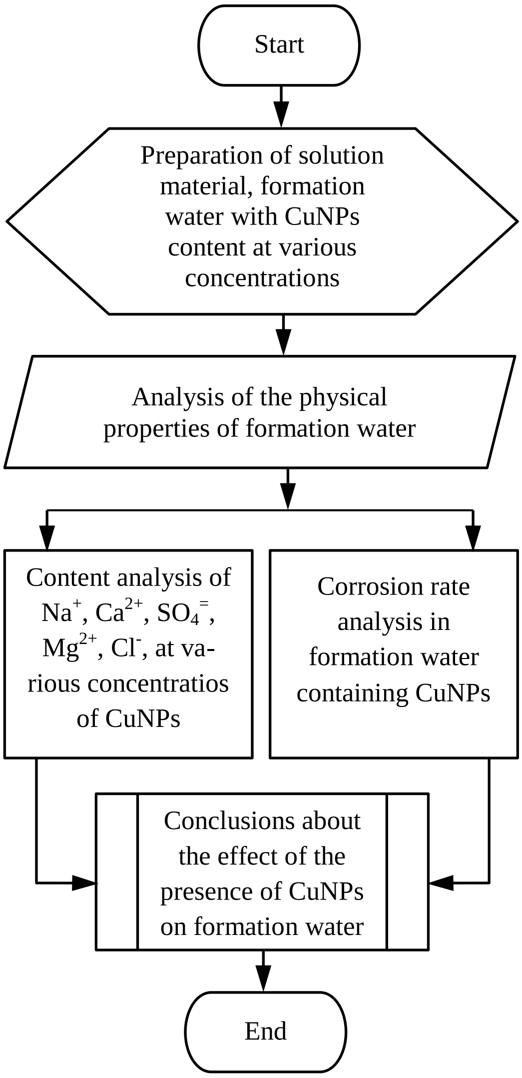


Figure 1. Observation and analysis process flowchart

IV. RESULTS AND DISCUSSION

Observation of the physical properties of formation water solutions containing CuNPs at various concentrations including density and viscosity at temperatures of 86, 100, and 150^oC. The results obtained are shown in Table 1, with notations A, B, and C representing formation water solutions containing CuNPs containing 0.01, 0.02, and 0.05 ppm, respectively. Notation D is a formation water solution without the addition of CuNPs as a comparison.

As can be seen in Table 1, the density does not change significantly when the temperature is increasing, as well as the presence of CuNPs at several concentrations, so that the physical behavior related to the density is analyzed also does not change significantly when CuNPs are added to formation water until at 0.05 ppm. Observation of changes in viscosity to temperature and concentration of CuNPs shows that the addition of temperature will cause viscosity to decrease by an average of 15%, where greater changes occur when temperatures are higher. The effect of CuNPs concentration will increase the viscosity by an average of 1%. An illustration of the effect of temperature and concentration of CuNPs on the viscosity of the formation water solution can be seen in Figure 2.

Table 1. Density of Formation Water Solution + CuNPs at Various Temperatures, gr/ml

Solution	Temperature (°F)		
	86 °F	100 °F	150 °F
A	1.008180	1.0044	0.9909
B	1.008208	1.0044	0.9908
C	1.008264	1.0044	0.9906
D	1.008592	1.0047	0.9908

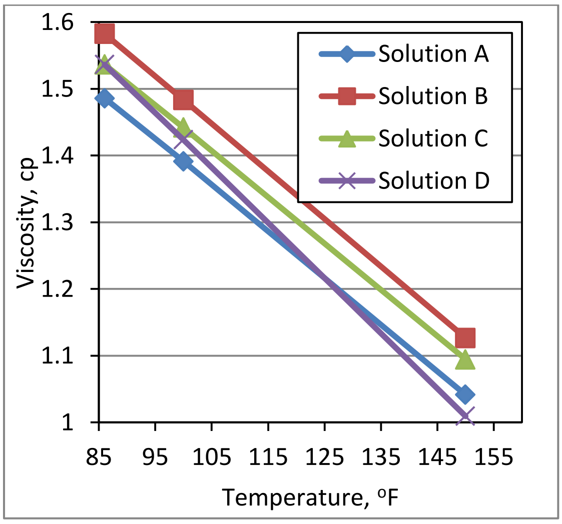


Figure 2. Viscosity of Formation Water Solutions + CuNPs at Various Temperatures

The occurrence of scale in systems with formation water is mainly due to the presence of mineral salts with certain concentrations. Based on this, an analysis of the content of the cation or anion causing the scale is performed and a calculation is performed to determine whether there is a change in the value of the scaling index, as a parameter of the potential scale of the solution.

The Addition of CuNPs with a concentration range of 0 to 0.05 ppm did not significantly change the anion or cation content, as shown in Figure 3. Ions concentrations tend to be constant, with no significant change. Calculation of the potential scale with the Langelier Saturation Index (LSI) and Ryznar Stability Index (RSI) method produces an average value that tends to be constant, which is around the value of 2.3 for the LSI method, and 4.5 for the RSI method. Both of these values, for each method, showed a tendency to scale, even at a high enough level.

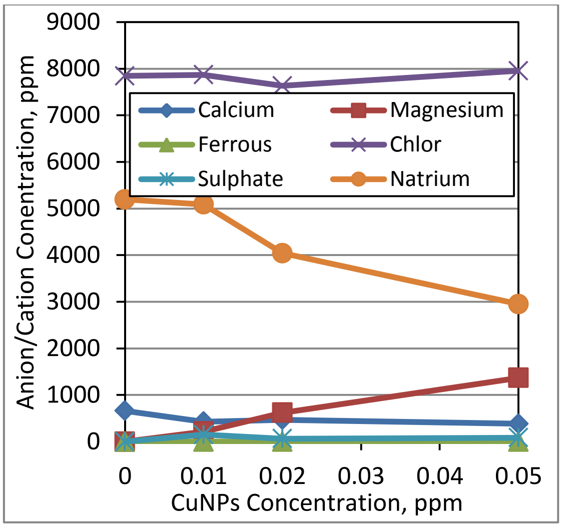


Figure 3. Changes in the concentration of anions and cations at various values of the addition of CuNPs

In observing the effect of CuNPs content on the formation water corrosion potential, the results obtained are shown in Table 2 and Figure 4. As seen, the addition of CuNPs to formation water has a significant effect on reducing the speed of corrosion. Using EDAQ 163 software, electrochemical data observed from formation water samples give results that show optimal CuNP addition at 0.01 ppm, while greater content increases corrosion rates. CuNPs containing sulfate anions, which in excessive concentrations will increase the tendency of corrosion.

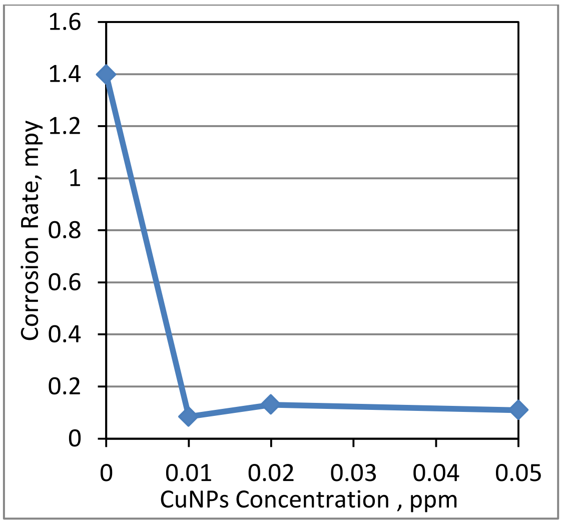
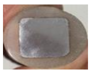


Figure 4. The Results of Observations of the Influence of CuNPs on the Formation Water Corrosion Rate

Table 2. Display the Effect of CuNPs Content in the Water on the Corrosion Rate

No	CuNPs Concentration in Water,ppm	Corrosion Rate, mpy	Plat	
			Before	After
1	0	1.4		
2	0.01	0.07624		
3	0.02	0.12221		
4	0.05	0.10458		

IV. CONCLUSIONS

Observations that have been made produce the conclusion that the use of CuNPs up to 0.05 ppm is not enough to affect reducing the ability of formation water in forming scales. Whereas in observing the effects of corrosion, the use of CuNPs has a significant effect until formation water has a corrosion rate that enters the allowable level in the oil field.

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Laboratory Study of Copper Nanoparticle Effect on Scale and Corrosion Rate in the Oil Field

by Muhammad Burhannudinnur

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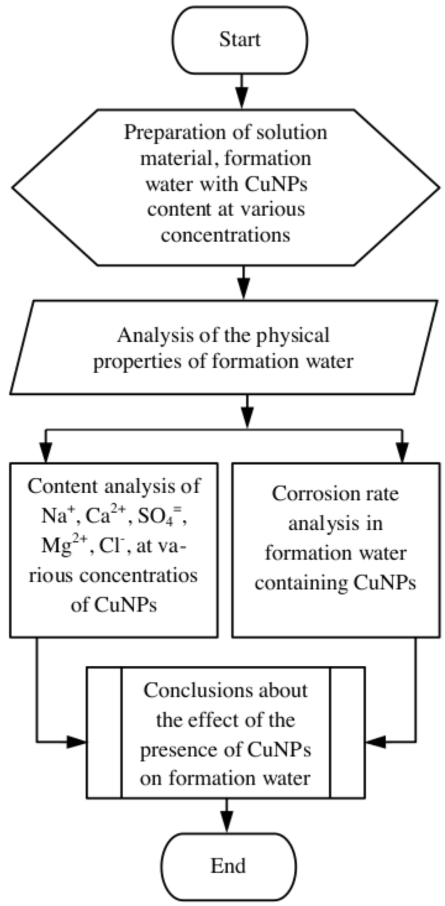

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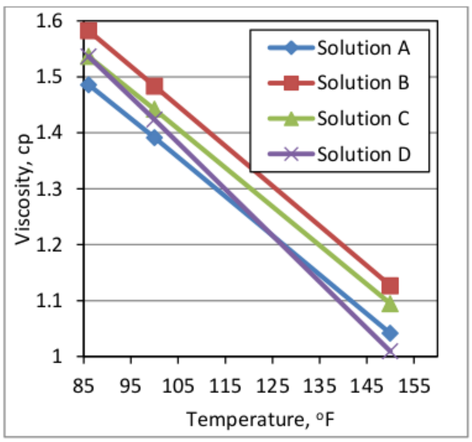

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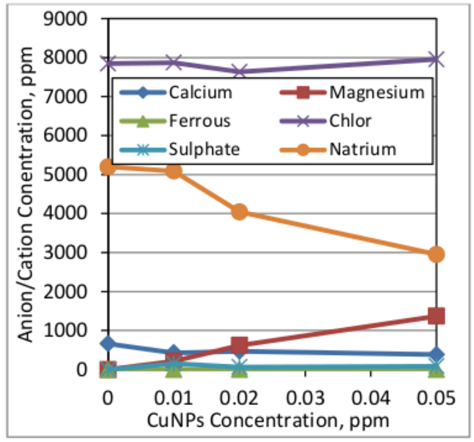

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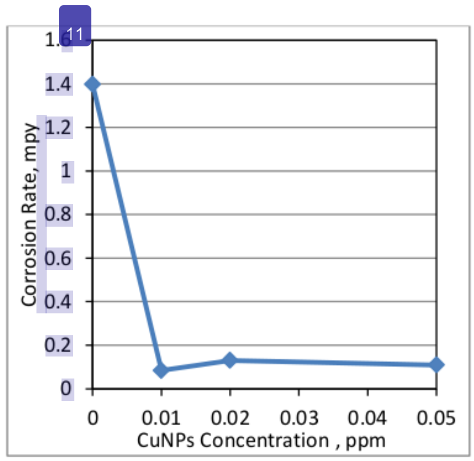

Figure 4. The Results of Observations of the Influence of CuNPs on the Formation Water Corrosion Rate

Table 2. Display the Effect of CuNPs Content in the Water on the Corrosion Rate

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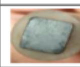
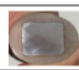
			Before	After
1	0	1.4		
2	0.01	0.07624		
3	0.02	0.12221		
4	0.05	0.10458		

IV. CONCLUSIONS

Observations that have been made produce the conclusion that the use of CuNPs up to 0.05 ppm is not enough to affect reducing the ability of formation water in forming scales. Whereas in observing the effects of corrosion, the use of CuNPs has a significant effect until formation water has a corrosion rate that enters the allowable level in the oil field.

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