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INNOVATIVE CEMENT FOR GAS APPLICATIONS

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ABSTRACT

Currently, the cement industry imposes challenging requirements for compressive strength for gas wells. The market trend started to replace traditional cement with economic products of high quality. One of those products is Geopolymer. This research merges nanotechnology with Geopolymer material to obtain the highest quality at the lowest price. The high compressive strength is obtained by mixing nanlime with geopolymer. The final compressive strength of nanolime-geopolymer was compared for different mixtures and concentrations of nanolime.

Keywords: nanotechnology, cementing, gas wells, nano.

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INTRODUCTION

Nanoparticles (NPs) technology has wide and modern applications in the field of petroleum engineering because of the higher area to volume ratio which establishes a stronger and light weight product. To achieve high weight requirements, nanofluids are designed by mixing NPs with a solvent. The reference size is 1-100 nm.

This study is an experimental work to introduce the nanolime (NL) effect on geopolymers. Before moving to the methodology of preparing nanolime-geopolymer (NLGP) experimentally and testing the resulting material, the following literature review introduces previous works and shows the need for NLGP.

All the literature review works were chosen to show the development stages of nanotechnology and the economic and environmental importance of geopolymers. The methodology will take advantage of all the literature review works by showing the effect of applying nanotechnology on geopolymers. Therefore, the final product is called “nanolime-geopolymer” (NLGP). The final results have to show the high value of compressive strength, less thickening time, and less permeability. NLGP will be compared with other cement types.

Nanotechnology has wide applications in petroleum engineering. Nanoparticles’ applications extend to drilling, completion, production, and enhanced oil recovery. They are used in the drilling fluid to plug formation pores to control the drilling mud invasion into freshwater zones. In addition, shale swelling can be reduced by such a plugging technique. The high area-to-volume ratio of NPs means that the area of exposure is high, making it more suitable for drilling reactive, pliable, and tenacious shale. Those shale types would cause bit balling and reduce the penetration rate. In completion, NPs are used in hydraulic fracturing fluids to control the gel-breaking time after the end of the hydraulic fracturing job. Besides that, NPs help in better distribution of the proppant, which in turn leads to higher production. In the production stage, nanotechnology is used in two techniques for more efficient production. The first technique is the protective technique, in which the reservoir is less damaged by nano-based drilling fluid. The second technique involves the use of NPs in the polymer fluid as an enhanced oil recovery technique. Therefore, the resulting areal sweep efficiency of nanopolymer fluid increases, and residual oil saturation decreases.

In 2012, when Roige et al. added nano-calcium silicates to cement, they found a significant change in the cement hydration process. The structure of the produced cement was crystalline (like ductile fiber), which in turn minimized capillary pores. Therefore, the risks of micro-cracking and oil seepage were reduced.

In 2016, Chimaroke *et al*. demonstrated the effect of NPs in the drilling fluid experimentally. They recorded a substantial reduction in the drilling fluid loss inside the test samples, which represented the pay zone. Finally, the calculated value of the skin factor was minimal compared to the values resulting from normal drilling fluid invasions. They explain the resulting economic advantages as follows:

In drilling, the lost drilling fluid creates an additional cost, so minimizing losses “by using nano drilling fluids” results in higher savings. In production, if the pay zone is drilled with normal drilling fluid, fluid contamination would be higher, and less production is expected. In low-porosity pay zones, such oil production would be minimal because of oil phase trapping by the capillary forces of drilling fluid invasions. In addition, an emulsion is formed by the interaction between the oil and the filtrate. The authors selected mica and alumina nanoparticles. Mica was sieved in three different sizes and four samples of drilling fluid were formulated. The samples consisted of no fluid loss additives (sample#1), 20-235 micron sizes mica (sample#2), 20-200 micron sizes mica (sample#3), and alumina NPs (sample#4).

Filter tests showed that sample#4 had the least volume of filtrate invasion and the least permeable filter

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cake. Compared to sample#1, the percentages of reduction in fluid loss were 43.48 % for sample#4, 26.09 % for sample#3, and 13.04 % for sample#2.

Consequently, the percentages of reduction in fluid loss from samples #1 to #3 were equal, but there was a large difference between samples #3 and #4. Therefore, alumina NPs proved to be efficient in reducing the volume of filtrate invasion.

From operations, the cement bond log is an important part of a well-completion program and is also recommended for most work-over programs. Most of the cementing-related problems encountered can be diagnosed by use of the CBL. However, successful interpretation of a CBL depends on certain minimum requirements as follows: the tool must be run strictly centralized, a transit-time curve must be recorded and a wave train or VDL display must be available. Consequently, it is worthwhile to review the principles of oil-well cementing, since many problems can be traced back to the primary cement job and the way it was conducted. Principles of Oil-Well Cementing Oil-well cementing is the process of mixing a slurry of cement, water, and additives and pumping it down through the casing to the annular space between the well bore and the outside of the casing.

METHODOLOGY

The ash (waste material) (Percent = 75 %) and limestone (purity = 9.15 %) powder were ground together. Then, the NaOH and NaSi were mixed too as a liquid component with water. Finally, the formulation was put in 5 c.cm metallic cubes. Finally, metalic cubes were placed inside an oven (65 degrees Celsius). The compressive strength tests were tested on the third, seventh, and twenty-eighth days (for the 1%, 3%, 6%, and 12% concentration of NLGP and different rations) [24-25].

RESULTS AND DISCUSSIONS

The nanolime size is .453 nm. Compressive strength was calculated from the force applied to rupture the sample over the area of the samples at various hydroxides to silicates ratios and various M values. At three, seven, and twenty eight days. The results are shown in Figures 1-7.

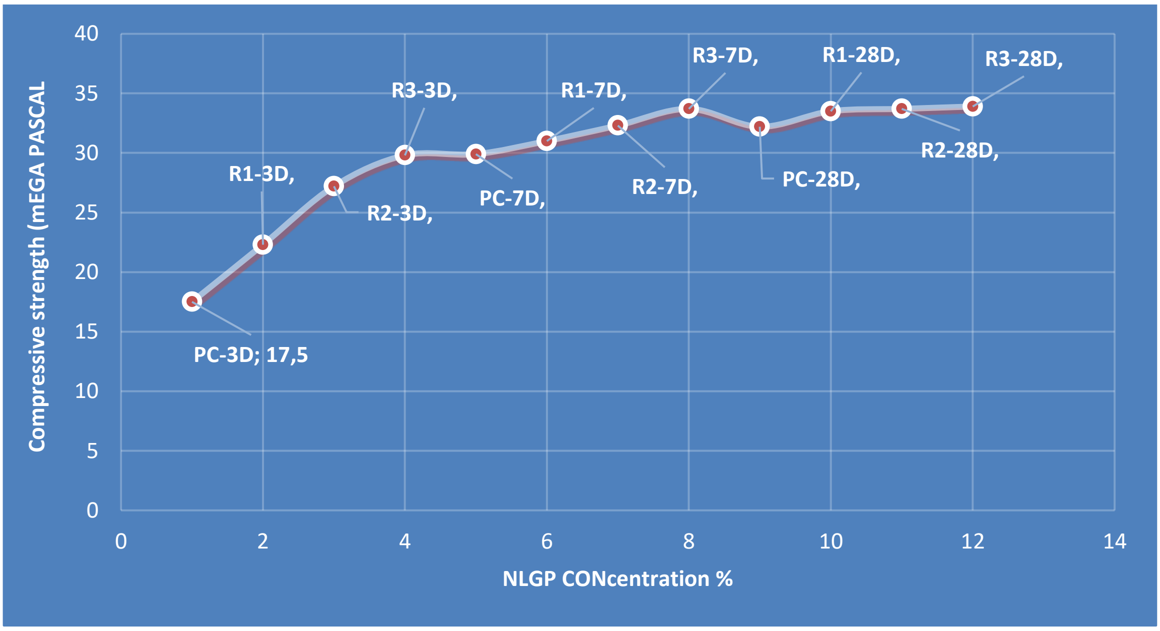

Figure-1. Varying NaSi: NaOH (M10) (for days: three, seven, and twenty eight), compressive strength (MPa).

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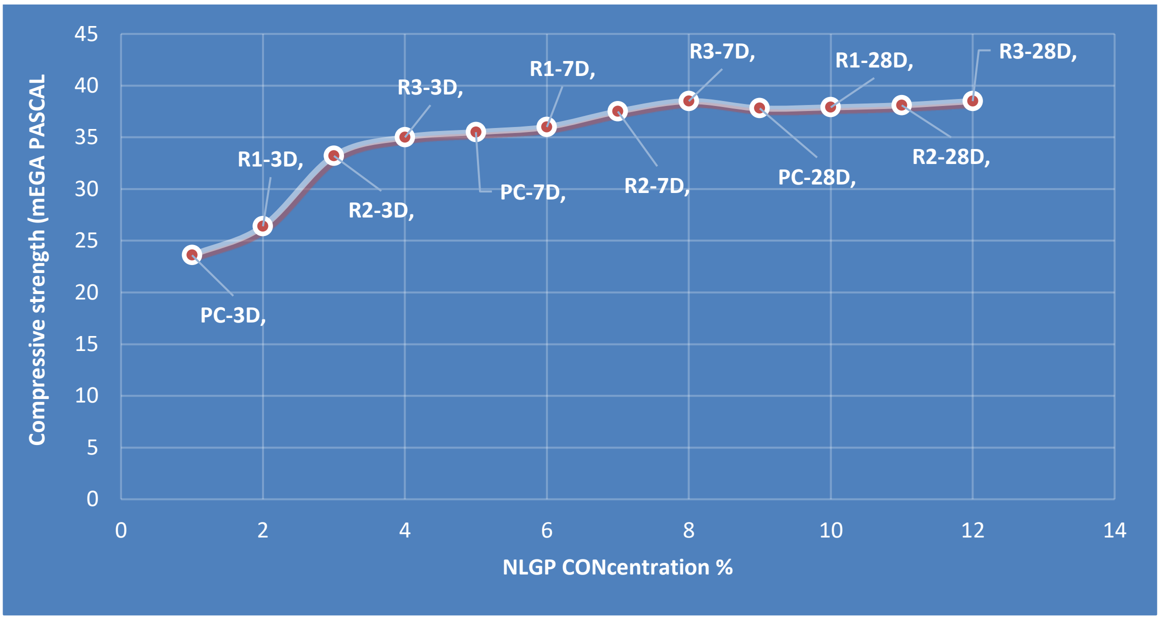

Figure-2. Varying NaSi: NaOH (M14) on compressive strength (for days: three, seven and twenty eight), compressive strength (MPa).

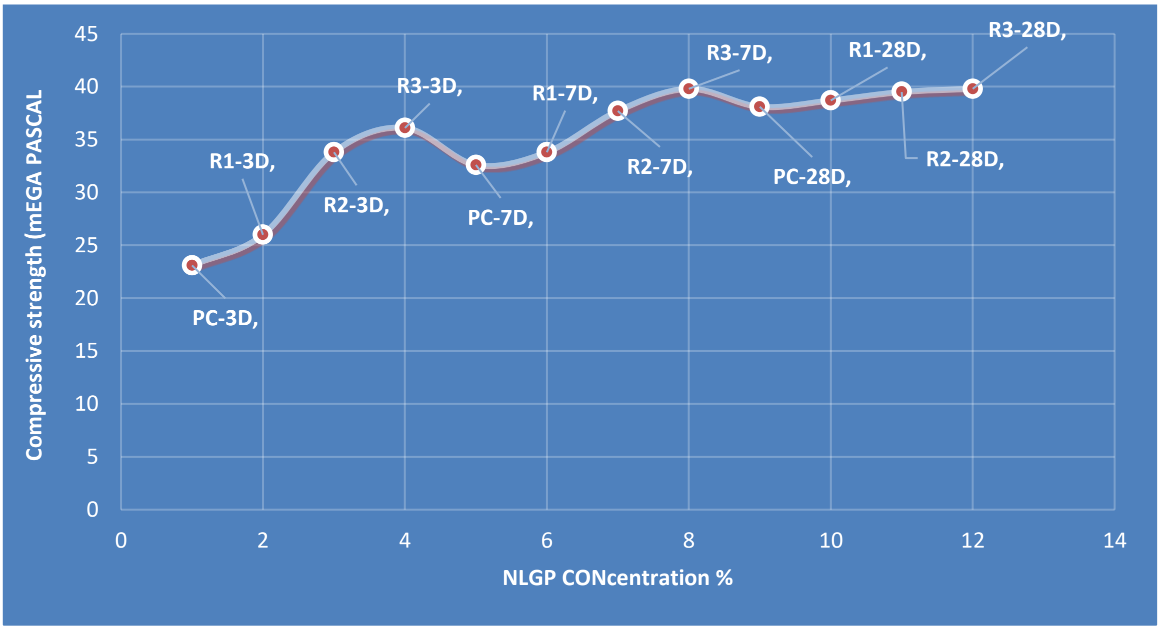

Figure-3. Varying NaSi: NaOH (M16) on compressive strength (for days: three, sevent and twenty eight).

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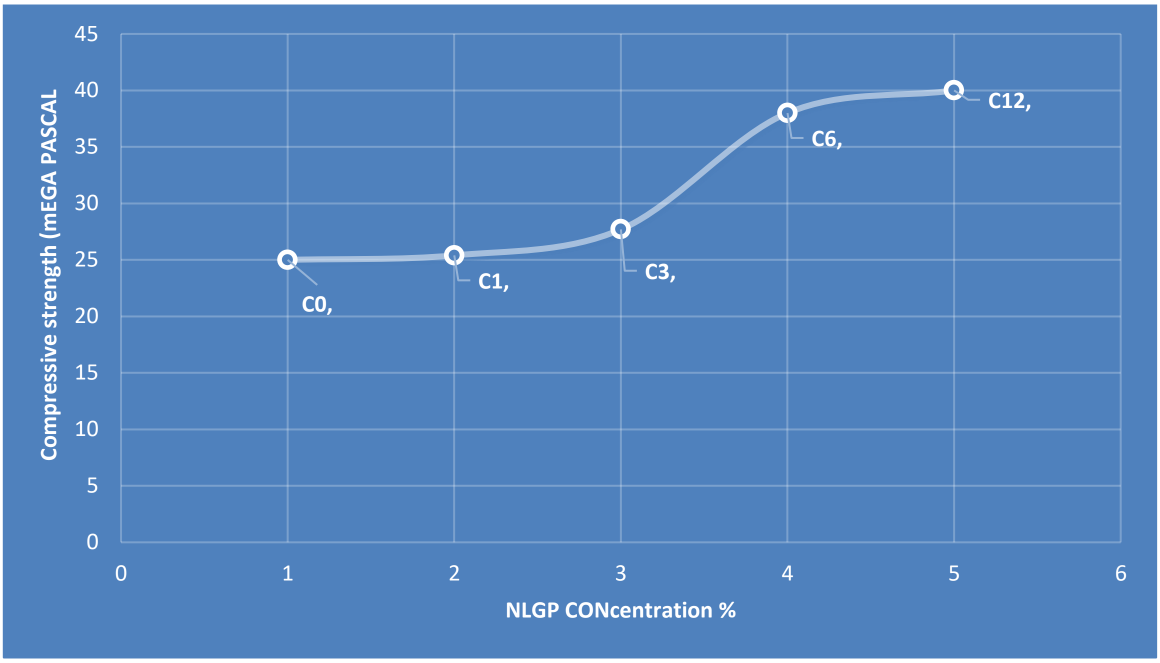

Figure-4. Compressive Strength (0.5 d) (zero%, one%, three%, six% and twelve %).

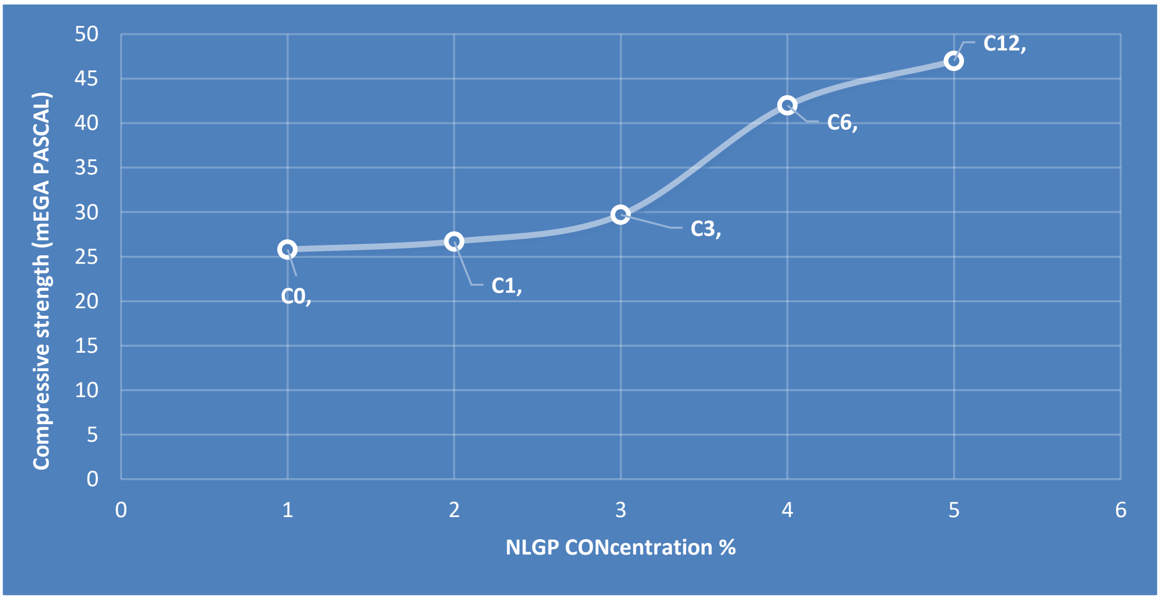

Figure-5. Compressive Strength (3d) (zero%, one%, three%, six% and twelve %).

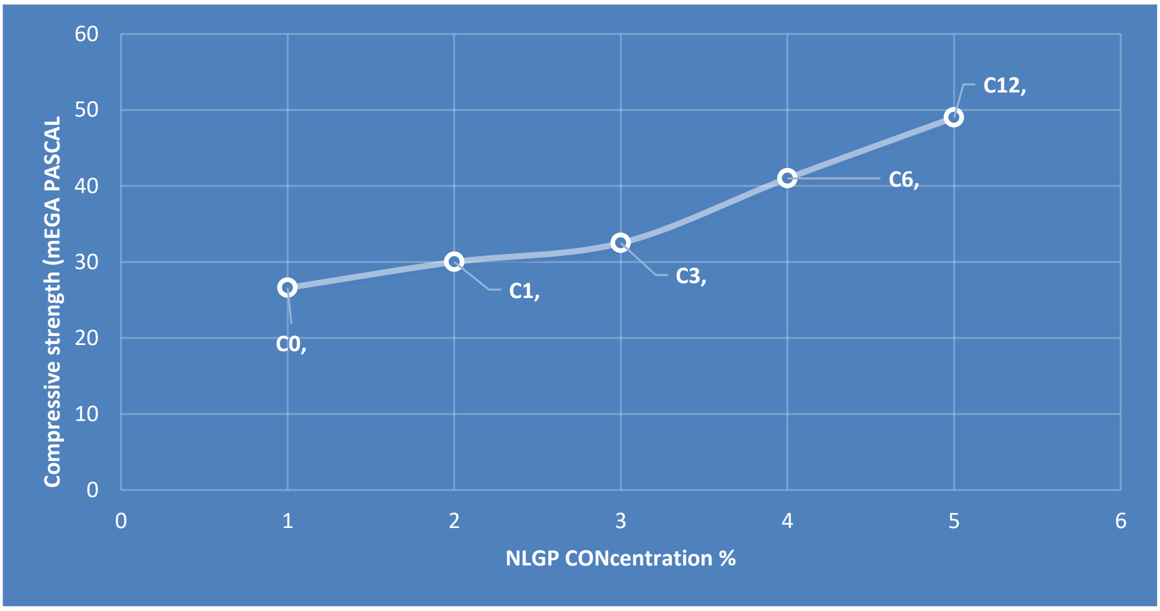

Figure-6. Compressive strength (7 d) (zero%, one%, three%, six% and twelve %).

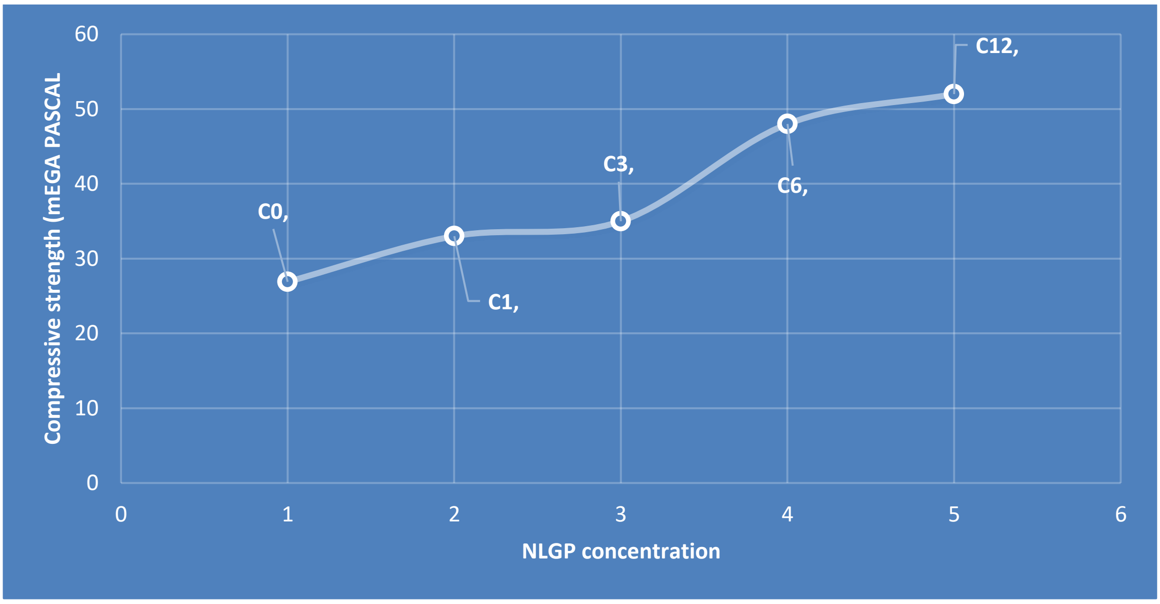

Figure-7. Compressive strength (28d) (zero%, one%, three%, six% and twelve %).

After measuring the compressive strength values on different days, the following results will be explained. When the ratio of NaSi: NaOH is 1:3 (M16), the resulting compressive strength (on the 28th day) is higher than the ratios of 1:1 by 32% and 1:2 by 5.6%. When the molarity increased, the compressive strength increased.

Fly ash is very cheap (waste material) representing the highest percentage component in (NLGP). This makes NLGP economical compared to Portland cement. In addition to its economic advantage, the resulting compressive strength is very sufficient for holding the casing and preventing gas from escaping. All the resulting compressive strength values in this study will be higher in the actual case. This is because the wellbore temperature will be higher which makes the chemical reactions quicker and more complex. This will result in a more complex structure with higher strength. The interpretation is that the particles of fly ash and NaSi liquid become more bonded by NL and more activated by NaOH, which makes the polymer reaction more sophisticated. The final form of molecules is much more compact because NL is neatly formed among larger particles. Therefore, the expectations of the product's performance are higher in the actual situation.

The addition of NL resulted in a noticeable increase in the value of compressive strength, especially, in higher concentrations (6%, 12 %). Although 1 and 3 % concentrations of NL resulted in compressive strength values with minimal differences, the difference between the compressive strength values resulting from 3 and 6% NL was high. In addition, 6 and 12 % NL resulted in approximately similar values of compressive strength. This high compressive strength makes the product very suitable for gas wells.

CONCLUSIONS

Nanolime was obtained in nanosize using a physical process to save the costs of chemicals. The resulting size is 45.3 nanometers. In NLGP, as the ratio between NaSi and NaOH increases, the resulting compressive strength increases. In addition, when NL concentration increases, the compressive strength increases too. This outstanding compressive strength makes NLGP highly qualified for gas wells.

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