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Performance Evaluation of Locally Synthesized Cement Retarder at Surface Temperature

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Abstract
Agro waste from wood processing known as sawdust is one of the major environmental pollution challenges in environmental management and control, in order to address this environmental menace this study was carried out to develop an oilfield chemical cement retarder from sawdust, the sawdust was sourced from Iguruta timber market in Ikwerre local government area of Rivers state, the samples were characterized, hydrolyzed using acid and the product was sulphonated at different temperatures in a chemical reaction to form a product that has capacity to retard oil well cement slurry, the specific gravity of the different Samples A, B,C and D formed were determined to be as follows, 1.19, 1.233, 1.19, and 1.09 while the imported retarder specific gravity was 1.23, the thickening time test which determine the performance efficiency of the products were conducted at surface temperature of 80^oF and the following results were obtained for neat slurry, the samples and the imported retarder to be as follows: 300 mins, 420 mins, 450 mins, 450mins, 330mins, 530mins respectively. Therefore, from the results obtained it shows that sawdust can be utilized in the oil and gas industry in developing of useful chemicals for economic sustainability and curb indiscriminate disposing into the environment.

Key words: *Sawdust, cement slurry, thickening time test, Retarder*

1. Introduction

Agro waste from wood processing known as sawdust is one of the major environmental pollution challenges in environmental management and control. However, it is one of the main sources of biomass for the production of solid fuels for heat generation for home and industrial use most especially in classic boilers for thermal energy generation. The popular ways of reducing this agro waste in Nigeria has been burning or leaving them to decompose (Olorunnisola, 1998; Jekayinfa and Omisakin, 2005). Several researchers have suggested that sawdust be burnt to generate energy for in-house use by the wood industry (Peter et al., 1990). This has been one of the methods of reducing the sawdust waste, but these methods pose another environmental problem due to the poisonous gases being released to the environment such as CO_2, SO_2 and NOx. These gases that are released to the environment cause greenhouse effects that lead to global warming. Other viable and promising technologies by which sawdust can be converted to biomass energy is through the process of briquetting (Wilaipon, 2008). Briquetting is a process of producing a biofuel from agro waste, such as sawdust, groundnut shell, and paper, etc., for easy handling by binding the waste with a combustible binder to generate heat for home and industrial use. Though briquetting has some challenges in the process of its production and usage.

Converting biomass in general to biofuel for heat generation has beneficial effects on the environment. However, as with other sources of energy such as crude oil their use often poses environmental challenges due to the emission of pollutants as the bye-products into the environment with negative impact on the environment and on the biological systems (Anaele et al., 2019). Pollutants from sawdust briquettes conversion into heat energy are ash and air pollutants that results from the combustion gases such as carbon monoxide (CO), volatile organic compounds (VOCs), nitrogen oxides (NOx), sulfur oxides (SOx) and particulate emissions (PE). According to Annamalai and Puri (2006), NOx and SOx are dominant components in the emissions process. NOx has the most adverse impact on human health because it damages the human respiratory system. De Sjaak et al. (2012) and Grübler (2004) show that NO >3ppm causes a measurable damage to the lungs, and a value of 0.1ppm can cause lung irritation which may lead to asthma development. High concentration of NO_2 affect haemoglobin production thereby reducing oxygen level in the tissues. Furthermore, NOx emissions have adverse impacts on the ozone layer and destruction of naturally occurring ozone high in the atmosphere (Annamalai and Puri, 2006; Grübler, 2004). The emissions of SOx react with atmospheric oxygen causing the formation of acid rains and snowfalls. The CO_2 produced is not regarded as air pollutant because it is seen as part of carbon cycle. Over 80% of the particulate matter which are release are in the form of ash driven by the combustion gases (fly ash) out of which 40% have a diameter <10ppm. Of these, 20% lies on the ground and the rest is released into the atmosphere where it poses health problems (De Sjaak et al., 2012). Hence, in this study locally sourced sawdust material was used to formulate oilfield cement retarder with application on class G cement to determine its retarding effect.

2. Cement additives

The rate of chemical reaction known as hydration process which occurs as a result of water coming in contact with cement particles can be altered by the application of cement additives. The cement additives that slow the hydration rate of the cement slurry are known as retarders. These retarders delay the setting time of the cement slurry (Anaele et al., 2019). These cement additives slow down the rate of the reaction by undergoing chemical reactions that involve phases of cement that is not hydrated or by building a film layer on the cement that are not hydrated thereby hindering the cement coming into play with water (Joel, 2009). There are over one hundred additives which come in solid or liquid form. These additives are in eight categories, namely Accelerator, Extender, Fluid loss, Lost circulation materials, retarder, weighting agent, dispersant and special additives such as deformer, etc. (Anaele etal, 2019).

Retarders are oil well cement additives applied to decrease the rate of cement hydration. Retarders prevent cement hydration and delay hardening process for the cement slurry for a given period of time, giving enough time for slurry placement in a high pressure and high temperature zone in an oil well (Michaux et al., 1990). In actual sense, it increases the setting time for the cementing operation (Nguyen, 1996; Huwel et al., 2014). Retarders do not decrease the ultimate compressive strength of cement but do slow the rate of strength development (Joel, 2009; Bett, 2010). The most common retarders are natural lignosulfonates and sugars derivatives. Lignosulphonates and hydroxyl carboxylic acids are retarders that are believed to perform well for oil well cements with low tricalcium aluminate (C_3A) contents. The newest retarders are made from various synthetic compounds such as Maleic anhydride, 2-Acrylamido-2-methylpropanesulfonic acid (AMPS) copolymers and inorganic compound like borax. Michaux et al. (1990), Anon (2014) and Bentz et al. (1994) reported on the use of carbohydrates such as sucrose as a retarder. According to Bentz et al. (1994), the addition of carbohydrates such as sucrose can significantly extend thickening time or even prevent setting completely. However, they are not commonly used in oil and gas well cementing because of the sensitivity of the degree of retardation to small variations in concentration (Nelson et al., 1990; Bermudez, 2007). As a result of processing, three grades of lignosulphonate are available for the retardation of cement slurries. Each grade is available as calcium/sodium or sodium salts. According to Joel (2009), the three grades can be described as filtered, purified and modified. Also, Adams et al. (1985) stated that the most common retarder among the three types may be calcium lignosulphonate.

Retarders do not promote hydration but prolong setting of cement slurry, providing enough time for cementing operation in both deep and hot wells. The technology of retarder is well developed, and several types are used. Retarding mechanisms of these retarders is something mysterious and seems impossible to understand completely though many theories have been proposed. The most abundant retarders are obtained from wood pulp. They comprise calcium and sodium salts of lignosulphonic acids and contain some saccharides. They are believed to attach onto initial layer of C-S-H gel, causing it to be hydrophobic and prolonging the induction period. Added in concentrations 0.1 to 1.5 percent By weight of cement (BWOC), they delay hydration reaction at temperatures up to 122^oC (250^oF). When treated with other chemicals like borax, lignosulphonates can be used up to 315^oC (600^oF). Hydroxycarboxylic acids, such as glucoheptonate and gluconate salts, also retard hydration but are not used when the bottom-hole temperature is below 93^oC (200^oF). Cellulose sources like carboxymethyl hydroxyethyl cellulose (CMHEC) have been used for many years as cement retarder.

2. Materials and methods

2.1. Production of local cement retarder

40 grams of sawdust which was sourced from Igwuruta timber market in Ikwerre local government area of Rivers State was measured using electronic weighing balance, the weighed sample was transferred into 500ml heating flask, and sodium hydroxide was poured into the flask and the sawdust was completely covered with the alkaline solution to achieve delignification of the sawdust. The solution was allowed to boil for 5 hours at a regulated temperature of 100^oC to increase the yield of lignin. The sample was filtered to remove the cellulose and hemicellulose component and the filtrate was neutralized with sulphuric acid until the pH reached the value of 2 according to Heradewi (2007). 1g of yeast was then added to the mixture to enhance fermentation of the sugar content of the sawdust which was dissolved with the lignin content of the sawdust for 24hours. The fermented solution was filtered further to separate the alcohol and water content from the lignin solution. Thereafter the filtrate was oven dried at 70^oC for 3hours to remove the remaining water content in the lignin. The lignin solution was subjected to sulphonation reaction with sodium bisulphite for 5hours to form the local cement retarder (Anaele et al., 2019).

2.2. Specific gravity determination at room temperature

The specific gravity bottle of 25ml capacity was weighed to estimate the mass as M_1, then the samples produced were poured into specific gravity bottle and their mass were taken for each of the sample as M_2. Further, the specific gravity was estimated by applying Equation (1).

$$Specific\ gravity = \frac{M_{2} - M_1}{25} \quad (1)$$

2.3. Testing the thickening time effect of the product on class G cement at surface temperature of 80^{o}F.

The laboratory quantities of cement, fresh water, deformer for neat cement slurry by weight and volume is presented in Table 1 while the compositions of cement slurries with the formulated sample as an additive are shown in Tables 2, 3, 4, 5 and 6.

2.3.1. Cement slurry preparation

The laboratory quantities of cement, fresh water, deformer and the samples as shown in table 1-6 were measured and blended according to API recommended practice 13B-2 standard using a warring blender as shown in Figure 1.

Fig. 1: Warring blender for blending the cement slurry

2.3.2. Setting of the surface sample

The blending cups presented in Figure 2 were used to carry out blending of the cement slurries while the blended samples were poured into plastic bottles as shown in Figure 3.

Fig. 2: Blending cup used to blend the cement slurry

Fig. 3: Surface samples at 80^{o}F for the setting time experiment

Table 1: Showing the laboratory quantity of the additive for neat slurry

Components	Weight (g)	Volume (ml)
G-Cement	770.2	242.81
Fresh Water	364.12	355.23
Deformer	0.87	0.96
Total	1136.69	600
Mix Fluid		357.19

Table 2: Slurry recipe for laboratory test with 5ml of sample A

Components	Weight (g)	Volume (ml)
G-Cement	770.13	242.79
Fresh Water	360.03	351.25
Deformer	0.87	0.96
Sample A	5.66	5.00
Total	1136.69	600.00
Mix Fluid		357.21

Table 3: Slurry recipe for laboratory test with 5ml of sample B

Components	Weight (g)	Volume (ml)
G-Cement	769.38	242.55
Fresh Water	360.28	351.49
Deformer	0.87	0.96
Sample B	6.16	5.00
Total	1136.69	600.00
Mix Fluid		357.45

Table 4: Slurry recipe for laboratory test with 5ml of sample C

Components	Weight (g)	Volume (ml)
G-Cement	769.70	242.65
Fresh Water	360.18	351.39
Deformer	0.87	0.96
Sample C	5.95	5.00
Total	1136.69	600.00
Mix Fluid		357.35

Table 5: Slurry recipe for laboratory test with 5ml of sample D

Components	Weight (g)	Volume (ml)
G-Cement	770.44	242.89
Fresh Water	359.93	351.15
Deformer	0.87	0.96
Sample D	5.45	5.00
Total	1136.69	600.00
Mix Fluid		357.11

Table 6: Slurry recipe for laboratory test with 5ml of imported

Components	Weight (g)	Volume (ml)
G-Cement	769.40	242.56
Fresh Water	360.27	351.49
Deformer	0.87	0.96
Imported Sample	6.15	5.00
Total	1136.69	600.00
Mix Fluid		357.44

3. Results and discussion

3.1. Setting time

The setting time of the slurries shows that the neat slurry setting time at 80^{o}F approximates that setting time which was proposed by the America Concrete Institute for neat slurry at 80^{o}F to be around 4hrs depending on the type of cement (ACI 116R (America concrete institute). For this experiment, the obtained setting time for the neat slurry was 300mins. Also, other slurry samples formulated at 5ml addition of the synthesized retarders A, B, C, D and the imported retarder; the setting time obtained were 420mins, 450mins,450mins 330mins and 530mins respectively as presented in Table 7.

3.2. Specific gravity of the formulated cement retarder

Specific gravity of all cementing additives values is very important in cement slurry design because the laboratory quantities require for any cementing design is dependent on the specific gravity. The specific gravity of the formulated cement retarder was measured, and the values are presented in Figure 4. There is a relationship between the specific gravity of the product formed and the temperature of the system at which the products are formed. From Figure 4, it was observed that the best temperature for the product formation was at 140^{o}C which gave specific gravity of 1.233 when compared with the imported which has specific gravity of 1.23.

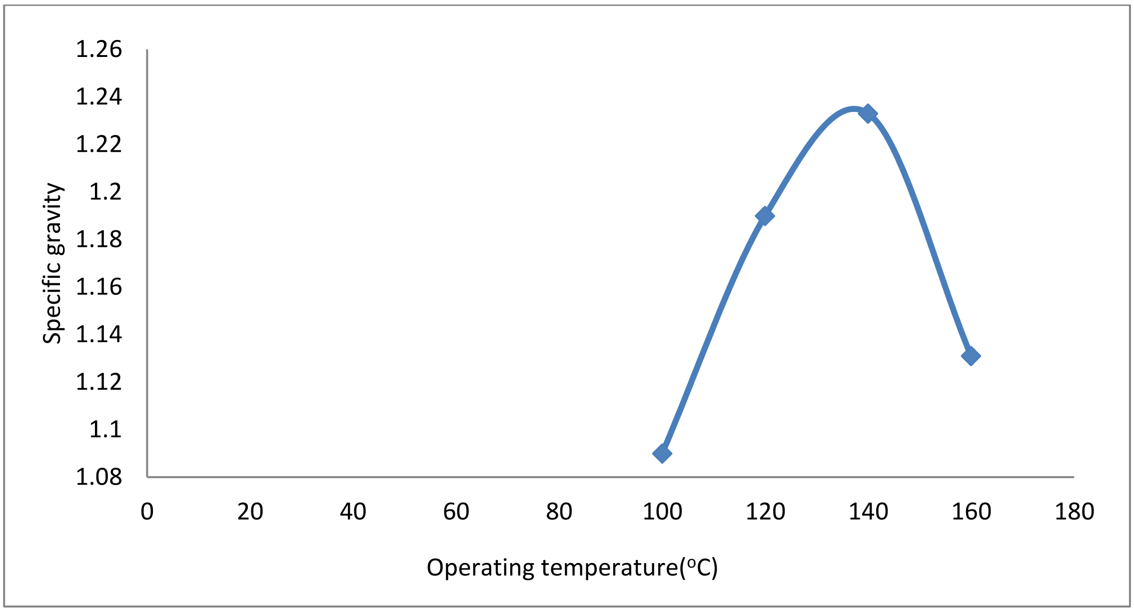

Fig. 4: Specific gravity of the product against the operating tmeperature

Table 7: Setting time of the samples at surface temperature (80°F)

Samples	Specific Gravity	Setting time @ 80°F (Mins)
Neat Slurry	No sample addition	300
A	1.131	420
B	1.233	450
C	1.19	450
D	1.09	330
Imported	1.23	530

4. Conclusions

The results obtained from the experiment shows the following:

a. That sawdust can be converted to a useful oilfield chemical with the capacity to cause retardation in setting time of cement slurries as demonstrated here with class G cement.
b. This emphasizes how sawdust a waste material from the pulp industry can be converted to a useful resource for wealth creation and alternative source to imported oilfield cement chemical.
c. That the best operating temperature to produce the locally cement retarder was 140°C.

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