ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

20-80% water-in-diesel emulsion fuel formulations and stability study for duration of two weeks

Souleyman A. Issaka, Abdurahman H. Nour, and Rosli M. Yunus

Faculty of Chemical and Natural Resources Engineering University Malaysia Pahang 12, 25000, Kuantan, Pahang, Malaysia

Manuscript Info

Manuscript History:

Received: 14 May 2015
Final Accepted: 19 June 2015
Published Online: July 2015

Key words:

Stabilizers, Emulsion fuel, water-in-diesel emulsions, nonionic surfactants

Corresponding Author

Souleyman A. Issaka

Abstract

New surfactant formulations were prepared at FKKSA Lab at University Malaysia Pahang; the formulation consists of synthesized polyol based non-ionic surfactants combined with different concentrations of commercial stabilizers and co surfactants. Six different compositions denoted as Samples (A, B, C, D, E, F) were tested on 20-80% water-in-diesel emulsion fuel samples for duration of fortnights. Results showed that emulsions prepared with formulations C, D, E and F were very stable and showed no water separation for two weeks. Followed by B, which started separation after 13 days and lost 15% of the water, while sample A, which appeared to be the least stable of all, lost 15% of oil in the first day. From these data one can conclude that the samples (C, D, E and F) surfactant formulation could be used as tailored stabilizers for synthesizing diesel based emulsion fuels.

INTRODUCTION

With ever-increasing environmental concerns on pollutant emissions of diesel fueled machineries, there have been a lot of concerns on techniques and ways that could abate the emission of toxic gases without altering the performance and combustion effectiveness of diesel based internal combustion engines. One of the very sustainable solutions is the emulsion fuel, which is produced via mixing water and fossil diesel (Jae W. Park, Kang Y. 2000). The massive emission of greenhouse gases as result of human activities is claimed to be responsible for sever changes in the ecosystem. Thus, including rise of ocean level, flooding, drought, decreasing snow and ice covers. Around 60% of the greenhouse gases are produced from the fossil based fuel combustion that is largely emitted from industries and transportation (Ahmad Muhsin Ithnin et al., 2014). Although diesel engines (combustion ignition engines) are widely used worldwide because of their massive power output and lower fuel consumption, yet, they are not sustainable from environmental perspectives, that is because they are responsible for emitting massive amounts of nitrogen oxides (NO_x) and particulate matters (PM) (Ahmad Muhsin Ithnin et al., 2014).

The importance of using emulsified fuel relays mainly on its ability to reduce unwanted combustion products such oxides of nitrogen and particulate matter form diesel fueled machineries (Omar Badran et al., 2011).

Injection of water through the engine injector was found to decrease nitrous oxides (NOx) and smoke (Patricia A. Strandell and henry W.schab 1986), Some emulsified fuels were able to reduce the sulfur content in higher sulfur fuels, thus, adding soda ash to the emulsifying water had reduced the smoke emissions by as much as 50% (Patricia A. Strandell and henry W.schab, 1986).

During the combustion process, water causes the fuel atomization, which results from the occurrence of the micro-explosion, a process through by the water droplets, which normally evaporate at 100 °C causes explosion that exceeds the interfacial tension between the fuel and water vapor leading to better fuel air mixture. Water also causes ignition delay during combustion, which leads to increase in pressure rise within the engine cylinder, increasing thermal efficiency and reduces thermal stress within the engine components. During the combustion process, the elevated level of micro-explosion is witnessed by the reduction of flame height to be more intense around its axis. The NO_x reduction process is governed by the elevated local excess air factor due to the manifestation of larger and denser water droplets (Ali M.A. Attia et al, 2014). Micro-explosion occurs because of the differences in boiling points between the continuous phase (oil) and dispersed phase (water). In a typical water-in-oil emulsion fuel sample introduced to a combustor the oil plus surfactant encapsulated water droplets are heated due to the elevated air temperature (in combustion chamber), and since water have lower boiling point it can be overheated and starts to boil inside the oil capsules, this state is referred to as metastable and water would boil vigorously. Soon after this vigorous boiling, water would cause explosion of the encapsulating parent oil layer of the droplet. This is known as explosive boiling of micro-explosion phenomena which almost always encountered in the combustion of emulsion fuel (J. Shinjo, J. Xia et al., 2014). Currently, researchers are embarked more than ever before in the emulsion fuel related subjects because of its potential advantage as alternative and sustainable fuel. Kajima and colleagues have studied the effect of ultrasonic emulsification techniques in the stability of water-in-diesel emulsion. They have studied the effect of the ultrasonic horn tip position in the sample, emulsification time (mixing time), and water content by measuring viscosity, droplet sizes and droplet surface area of the produced emulsion (Kojima Y, Imazu H et al., 2013). Yang and colleagues have synthesized very stable nano-emulsion fuel sample consisting of 5% by volume water, 12.6% by volume nano-organic additives and the rest is diesel. The nono-organic additive sample consisted of water soluble oxygenates including glycerin, polyethoxyester and water soluble nonionic surfactants (e.g. nonylphenolethoxylte). They also found that emulsion fuel viscosity is higher than that of the original emulsion and decrease rapidly with increasing temperature. (W.M.Yang, H. An et al., 2013). Owing to the storage and marketability criterion, a good emulsion fuel must be stable at least for one week (10,000 hours). Andrew Simon and co-researchers have incorporated the water soluble polymeric nonionic surfactants such as polyhydric alcohols and ethoxylated fatty acid esters in the surfactant formulation. Their surfactant concentration was as high as 4% and water content of 25% (Andrew Simon et al., 2010). Others have created and tested emulsion fuel with 7.5% water using span-20 and tween-20 as emulsifiers, their study revealed that emulsion fuel causes slight decrease in break specific fuel consumption of the engine and increased the break thermal efficiency (Hrishikesh et al., 2014). Similar results were reported by R.venkatesh and colleagues who synthesized emulsion fuel via mixing aqueous metal solution, diesel oil, surfactants, and water. The concentration of the aqueous solution was 10% (0.4% mol/dm^3 mixture of salt and distilled water), tween 80 was used as emulsifiers at 1% concentration, the total emulsification or mixing time was 45 minutes. Although many technologies and methods of synthesizing emulsion fuel have been introduced, yet, very few studies were conducted regarding the stability and shelf life aspects of emulsion fuel. Therefore, this current study is aimed to assess the performance of newly formulated surfactants on stability of emulsion fuel for duration of two weeks.

Experimental procedures

in this study 6 different formulations were tested, the test was performed by preparing emulsions for each of these six surfactant formulations and study the stability carefully by observing and recording the water separation from the emulsions. The water separation was recorded every 24 hours (daily), for two weeks (14 days). Materials used in this study were commercial diesel fuel which was purchased from local fuel station as oil or external phase, tap water as aqueous phase, and the newly formulated emulsifiers which given the code names (SA, SB, SC, SD,SE and SF), S is stand for sample (e.g. sample A(SA), Sample B (SB) and so on.

Results and discussions

Table 1: Rate of water separation from stable emulsions of Samples (A, B and C)

Time (days)	The amount Water and oil separation with time (ml)

	S A		**S B**		**S C**	
	O	**W**	**O**	**W**	**O**	**W**
01	3	0	0	0	0	0
02	3	0	0	0	0	0
03	3	0	0	0	0	0
04	3	0	0	0	0	0
05	3	0	0	0	0	0
06	3	0	0	0	0	0
07	3	0	0	0	0	0
08	3	0	0	0	0	0
09	3	0	0	0	0	0
10	3	5	0	0	0	0
11	3	6	0	0	0	0
12	3	6	0	0	0	0
13	3	6	0	3	0	0
14	3	6.5	0	3	0	0

Table 1 reveals the experimental results obtained from the stability study of three different emulsion fuel samples denoted as (Samples (A, B and C)), the bold letters **O** and **W** on the table stand for oil and water respectively. As depicted clearly on the table, samples C was more stable than the others, followed by sample B then sample C. Thus, sample C does not show either oil or water separation within this designated period of two weeks. Meanwhile, sample B emulsion had retained its water for 12 days without any separation, then a constant amount of water (3ml or 15%) was resolved in days 13 and 14. However, sample 3 showed 3 ml (15%) separation from the day 1 and stayed constant (3 ml) until day 14, while oil uptake of Sample A was very loose, yet its water uptake was quite firm because water separation was observed only after day 11.

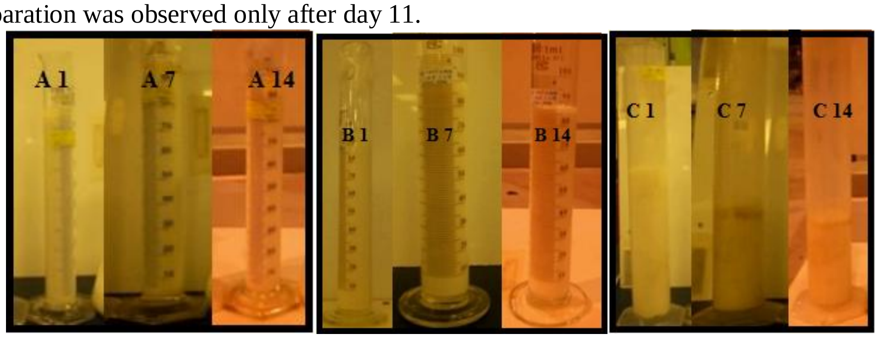

Figure 1: Samples of some selected pictures of emulsion fuels at different intervals

Figure 1 shows the pictures of the emulsion fuels samples (A, B and C) whose quantitative stability assessment was given earlier in table 1 at different time intervals. Actually, these pictures show the visual changes in the emulsion fuel color with time. It is a known fact that stable emulsion fuel should retain its water unresolved and its color unchanged at least for one week. In figure 1, the letters A, B and C, refer to Samples (A, B and C) respectively while the numbers (1, 7 and 14) refer to retention or stability time (days), thus, in figure 1, picture with label A1 means emulsion prepared with Sample A surfactant formulation at it first day. Meanwhile, picture with label A7 means the same sample (sample A) after one week (seven days), similarly, picture with label A14 was taken after 14 days (two weeks).

Table 2: Quantitative monitoring of water separation

rate from stable emulsions prepared from Samples (D,E and F)

Time (days)	The amount Water and oil Separation with time (ml/day)					
	S D		**S E**		**S F**	
	O	**W**	**O**	**W**	**O**	**W**
01	0	0	0	0	0	0
02	0	0	0	0	0	0

03	0	0	0	0	0	0
04	0	0	0	0	0	0
05	0	0	0	0	0	0
06	0	0	0	0	0	0
07	0	0	0	0	0	0
08	0	0	0	0	0	0
09	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0

Table 2 shows the results of the stability test for three emulsion fuel samples prepared from Samples (D, E and F) formulations. All the three samples showed zero separations, which indicate that there was neither oil nor water separation at all within two weeks (14 days). This means, the samples (D, E and F) could produce quite stable emulsion fuel; therefore, it might be a good candidate to be considered as potential emulsion fuel stabilizers.

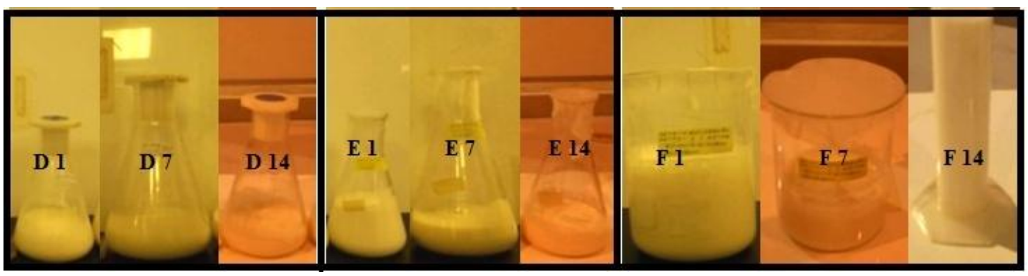

Figure 2: Samples of some selected pictures of emulsion fuels at different intervals

Figure 2 shows some selected pictures of emulsion fuel samples whose quantitative results were given in table 2. Labels on samples (D, E and F) represent the different formulations of the surfactant, as mentioned earlier, D1 refers to emulsion fuel sample prepared from Sample D formulation and aged one day. D7 denotes the picture of the same sample after 7 days and D14 after fortnight. Similarly, the labels E1, E7, E14 and F1, F7, F14 represents emulsion fuel samples prepared using Samples E and F formulations at different intervals (1, 7, 14 days).

Conclusions

Polyol based surfactant was successfully synthesized and tested at university malaysia pahang (UMP), These synthesized surfactants then combined with some commercial stabilizers and used to stabilize water-in-diesel emulsions (emulsion fuel). Six different compositions of surfactants were produced, each given specific name as sample A, sample B until sample F. The stability study was performed by reading the amount of water separated from the emulsion in a daily basis for fortnights. Results showed that emulsions prepared with formulations C, D, E and F were very stable and showed no water separation for two weeks. Followed by B, which started separation after 13 days and lost 15% of the water, while sample A, which appeared to be the least stable of all, lost 15% of oil in the first day. From these data, one can conclude that the samples (C, D, E and F) surfactant formulation could be used as tailored stabilizers for synthesizing diesel based emulsion fuels.

Acknowledgement

The authors would like to acknowledge the financial support from University Malaysia Pahang.

References

1. Patricia A. Strandell and henry W.schab, a review of water emulsified fuel investigations for shipboard applications, Naval engineering journal (1986); Page 53-69.

2. Omar Badran, Sadeq Emeish, Mahmoud Abu-Zaid, Tayseer Abu-Rahma,Mohammad Al-Hasan, Mumin Al-Ragheb, Impact of water/diesel mixture on engine performance and environment (2011), international journal of thermal and environmental engineering; 3:1-7

3. Jae W. Park, Kang Y. Huh and Kweon H. Park, Experimental Study on the Combustion Characteristics of Emulsified Diesel in a RCEM, Seoul 2000 FISITA World Automotive Congress, Seoul, Korea (2000), F2000A073.

4. Ahmad Muhsin Ithnin , Hirofumi Noge , Hasannuddin Abdul Kadir ,Wira Jazair, An overview of utilizing water-in-diesel emulsion fuel in diesel engine and its potential research study, Journal of the Energy Institute (2014); 87:273–288

5. Ali M.A. Attia , A.R. Kulchitskiy, Influence of the structure of water-in-fuel emulsion on diesel engine performance, J. of Fuel (2014);116: 703–708

6. J. Shinjo, J. Xia, L. C. Ganippa, and A. Megaritis, Physics of puffing and microexplosion of emulsion fuel droplets, Physics of Fluids (2014);26: 103302; doi: 10.1063/1.4897918

7. Kojima Y, Imazu H, Nishida K., Physical and chemical characteristics of ultrasonically-prepared water-in-diesel fuel: effects of ultrasonic horn position and water content, Ultrason Sonochem. (2014);2:722-8.doi: 10.1016/j.ultsonch.2013.09.019. Epub 2013 Oct 7

8. W.M. Yang , H. An, S.K. Chou, K.J. Chua, B. Mohan, V. Sivasankaralingam, V. Raman, A. Maghbouli, J. Li, Impact of emulsion fuel with nano-organic additives on the performance of diesel engine, Applied Energy (2013);112: 1206–1212

9. Andrew simon oldfield, saltburn by sea (GB), Lee thompson, Trimdon grange (GB), Diesel Fuel Emulsion, United State Patent (2010), US 7,731 B2.

10. Hrishikesh Sane, Neil Purandare, Omkar Barve, Aakash Todakar, Emission reduction of ic engines by using water -in-diesel emulsion and catalytic converter, International Journal of Research in Engineering and Technology (2014); 03:378-383

11. By R.Venkatesh Babu , Dr.S.Sendilvelan, Reduction of Pollutants in CI Engine Using Emulsion Fuels To Reduce Overall Traffic-Induced Emissions, Global Journal of Research Engineering (2011);11; ISSN: 0975-5861.