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FOREWORD

It is our great pleasure to present the ninth volume and first issue of the ESTEEM Academic Journal UiTM (Pulau Pinang): a peer-refereed academic journal devoted to all engineering disciplines. Since the beginning of the year, a number of articles have been sent to us, some of which are still under review in their first or second phase and the first five of them are being published now. Article submissions came from UiTM campuses across the country, with topics covering most, if not all, of the subfields of electrical, mechanical, civil and chemical engineerings. We celebrate our good fortune in having a strong group of people who created the opportunity for this volume to be born and who made it happen.

First and foremost, we would like to extend our sincere appreciation and utmost gratitude to Associate Professor Mohd Zaki Abdullah, Rector of UiTM (Pulau Pinang), Associate Professor Ir. Bahardin Baharom, Deputy Rector of Academic Affairs and Dr. Mohd Subri Tahir, Deputy Rector of Research, Industry, Community & Alumni Network for their unstinting support towards the successful publication of this volume. Not to be forgotten also are the constructive and invaluable comments given by the eminent panels of external reviewers and language editors who have worked assiduously towards ensuring that all the articles published in this volume are of the highest quality. A special acknowledgement is dedicated to all committees, publication department, and many other relevant parties for making this volume a success. Their affective commitment and close cooperation have facilitated the realization of this volume. Last but not least, our greatest thanks go to all the authors for their interest in publishing their work with us. Their manuscripts are an expression of their commitment towards research and development which, in due course, would benefit the local, national and international communities. Hence, we would like to extend our warm invitation to all researchers who are actively involved in the field of engineering to publish their work with us.

Dr. Chang Siu Hua
Chief Editor
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DEVELOPMENT OF FUEL ADDITIVES TO ENHANCE THE PERFORMANCES OF FOUR-CYLINDER SPARK-IGNITION ENGINE

Mohd Khaizalfitri Mhd Yaakob[1], Mohd Azahar Mohd Ariff[2], Mahamad Hisyam Mahamad Basri[3], Sharzali Che Mat[4] and Azmi Husin[5]

[1,2]*Faculty of Chemical Engineering, Universiti Teknologi MARA (Pulau Pinang), Jalan Permatang Pauh, 13500 Permatang Pauh, Pulau Pinang, Malaysia.*
[3,4,5]*Faculty of Mechanical Engineering, Universiti Teknologi MARA (Pulau Pinang), Jalan Permatang Pauh, 13500 Permatang Pauh, Pulau Pinang, Malaysia.*
[1]*yaakob.khaizalfitri@yahoo.com;* [2]*azahar.ariff@ppinang.uitm.edu.my;*
[3]*mhisyam.mbasri@ppinang.uitm.edu.my;* [4]*sharzali.chemat@ppinang.uitm.edu.my;*
[5]*azmih@ppinang.uitm.edu.my*

ABSTRACT

The increasing demand for fuel has forced the world to adapt and seek alternatives. This paper studied the most effective blend of fuel additives which can reduce fuel consumption and increase engine performance. Firstly, fuel additives used in the aftermarket were analysed using GC-MS (Gas Chromatography-Mass Spectrometry). The analysis indicated that the fuel additives chemical compositions consist of combustion improver, antiknock, deposit control, oxygenates and also fuel stabilizer. After that, new formulated blends of fuel additives were produced based on the result data obtained from the GC-MS. The dynamometer test using 4 cylinders spark ignition (SI) engine was carried out in order to compare the baseline fuel and the new formulated blends of fuel additives. It was found that the additives blend of 29.03% kerosene, 10.75% acetone, 38.71% methanol and 21.51% toluene, was proven to be the most promising. The blend helped increase engine torque performance and also reduced fuel consumption up to 13%. This finding shows a huge potential to reduce our dependency on fossil fuel.

Keywords: fuel additives; blend; engine performances; fuel consumption; dynamometer.

1. INTRODUCTION

The use of fossil fuels is commonly known nowadays as a non-environmental friendly energy source because combustion of fossil fuels leads to the accumulation of greenhouse gases such as carbon dioxide. Fossil fuels reserves were also becoming more depleted from day to day (Schenk et al., 2008).

The declining of oil and gas reserves will eventually lead to new discovery, innovation, invention or alternative methods by the oil companies to meet the demands for such products. Many researchers all around the world have started to develop alternative energy sources which are renewable and sustainable compared to fossil fuels. Some of them have started to

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develop new and improved methods such as fuel additives, which can be used to enhance and manipulate the physical and chemical properties of the fuel gas itself (Chen, Tang, Ma, Holland, Ng & Salley, 2011).

Additives refer to a substance or any compounds added into something in order to improve certain properties of the original materials or to preserve it. The improved fuel such as blended with additives should be invented in order to improve the process of engine combustion (US Patent No. 4,022,589).

In the early years of fuel production, lead was introduced to act as an additive to increase the octane number. However, due to the negative effects that it brought into the environment and health, many countries phased out leaded fuel (Jack, 1985).

For internal combustion engine, the role of additives in petrol blending is increasing (Patent No. 198809284). The numbers of respective publications especially patents have grown as well. Almost all of the latest patents mostly concentrated on deposit control and cleanliness additives which are mainly detergent (US Patent No. 3,346,355, US Patent No. 3,902,868 & US Patent No. 4,294,586). Antiknock additives come second in the largest class of patents but the number of these grown on the basis of metal such as manganese and iron compounds which can be regarded as not one of the modern fuel additives. Combustion catalyst and octane booster also have an important role to play. Common fuel additives are oxidation inhibitors or antioxidants, which is essential for petrol which mainly consists of cracking blending components (Patent No. 198809284). These additives prevent oxidation, polymerization and polycondensation process in petrol. It further reduces gum and deposit formation.

In year 2002 alone, published patents and patents applications, 57% described as deposit control additives, 26% as antiknock agent, 5% as combustion improver, 5% as water stabilizer in petrol, 3% as antioxidants, inhibitors, stabilizer and others (emission reducing additives, anti-wear agents, de-emulsifier and etc.) (Patent No.198809284). Modern additives nowadays consist of many chemical compounds or can be referred to as a blend of chemical additives. The type and amount of additive to be used in petrol is determined by the contents of hydrocarbons (mainly alkenes and aromatics) and also oxygenates (methyl tert-butyl ether, ethanol and etc.) (Sachivko, Tverdokhlebov, Demyanenko & Polyakov 1998). It was shown by Flynn, Ityokumbul and Bochman (2001), that 1, 3-dioxolane has the ability to be an effective oxygenate for petrol and its blending cost is equivalence to those of ethanol. It was shown that C_5-C_{10} and carboxylic amide C_5-C_{10} as additive stabilized the water content up to 10-40% in hydrocarbon fuel. It is worth mentioning that 10-40% of water contents in hydrocarbon fuel didn't bring any positive effect toward the combustion process (Australian Patent No. AU2000046001, 2000).

Basically, biofuels are the fuel that made from petrol and alcohol substituents. It is normally suggested that ethanol, which is one of the alcohol substituents used to formulate the biofuels, should act as additives for fuel. It was added into the petrol to achieve desired energy generated from combustion. Thus, ethanol is used as fuel additives but not as a fuel substitute (Alan, Luiz, Denise & Henrique, 1999).

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Additives such as paraffin and benzene which can be found in jet fuel can greatly reduce the wear and tear of internal engine parts during energy generation process by petrol combustion (George, 1967).

Almost all fuel additives were formulated or produced in the interest of environmental protection, reducing emissions from internal engine combustion and increasing mileage (Jeffrey, 2007). But fuel additives also act as an agent to promote desired effects inside internal combustion engine which are powered by fuel gas. The additives act as an agent to increase the petrol octane rating, corrosion inhibitors, anti-knocking agent or metal deactivators (Patent No.198809284). Such additives were added to enhance or alter specific attributes of fuel gas itself.

2. EXPERIMENTAL INVESTIGATION

In this research, the identification of the key components and chemical compounds used in the aftermarket fuel additives were performed by using GC-MS analyser. GC-MS is a versatile tool to separate and identify unknown volatile organic compounds and permanent gases. By combining sensitivity and a high resolving power, complex mixture can therefore be analysed.

From the GC-MS data obtained, new blends of fuel additives were formulated. There are four types of additive blends that were formulated with different kinds of chemical compound mixtures. After that the new developed additive blends were tested by using Eddy Current Dynamometer (Dyno) Engine Testing. The testing was conducted in order to compare the baseline petrol performance with the new blended formulated fuel additives. Table 1 shows the composition of newly blended additives.

Table 1: Fuel Additive Blend Compositions

Chemical compound	Volume(ml) of Fuel Additive Blend Type			
	A	B	C	D
Kerosene	13.5	13.5	13.5	13.5
Acetone	5.0	5.0	5.0	5.0
Methanol	12.0	18.0	12.0	18.0
Toluene	0.0	0.0	10.0	10.0

3. RESULTS AND DISCUSSIONS

Figure 1 shows the mass chromatogram for one of the aftermarket fuel additives that had been analysed by using GC-MS. It was found out that the chemical compositions used in the aftermarket fuel additives had functions as a combustion improver, antiknock, deposit control, oxygenates and also fuel stabilizer.

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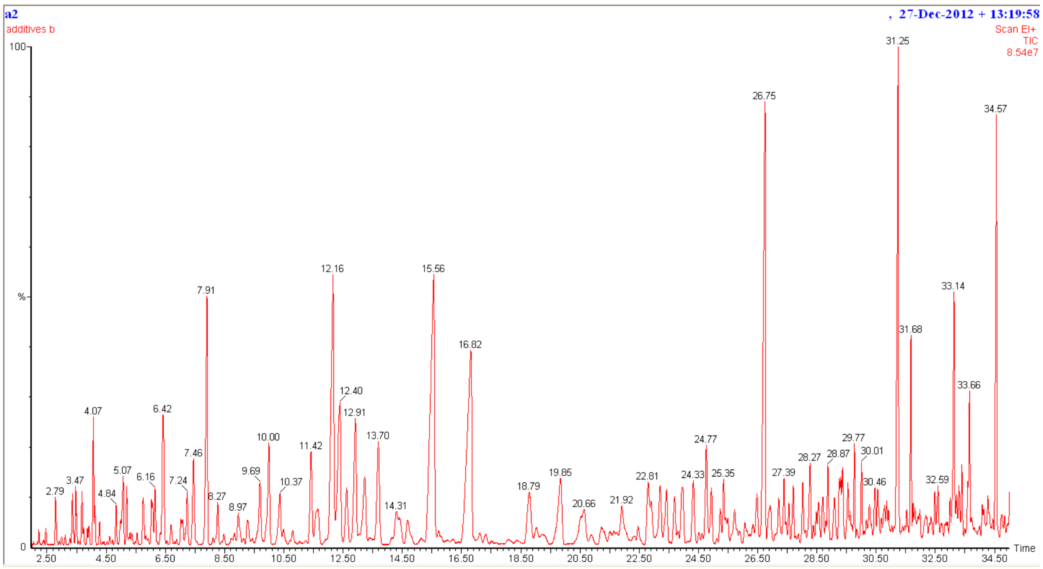

Figure 1: GC-MS Chromatogram for One of the Aftermarket Fuel Additives

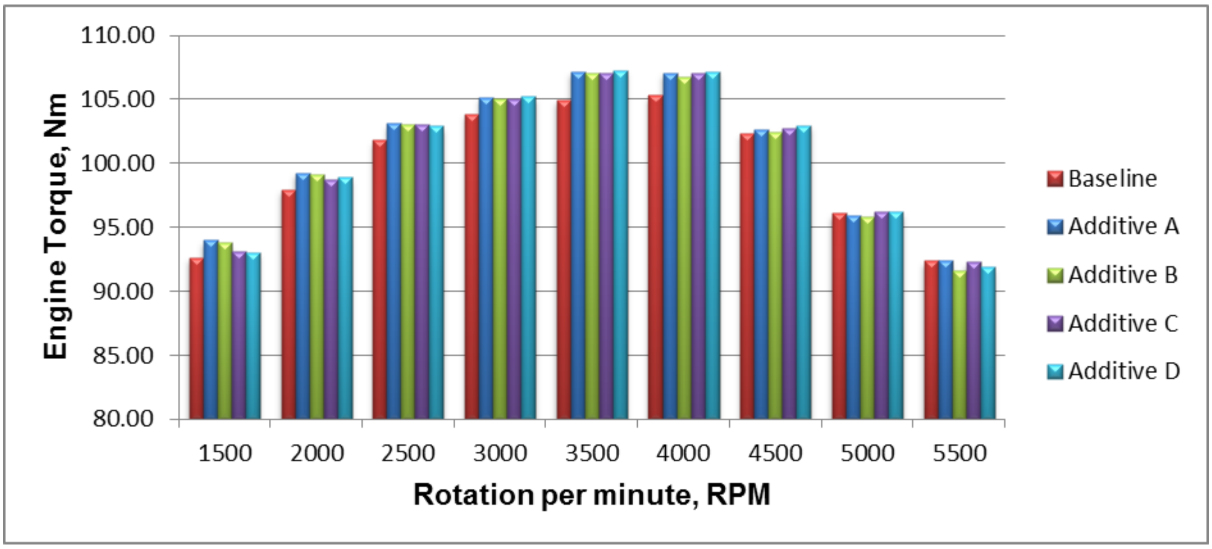

Figure 2: Comparison for Engine Torque between Baseline Fuel (RON 95) and Baseline Fuel Mixed with Several Different Blends of Additives

From Figure 2, it clearly indicates that in between 1500 and 3000 RPM, RON 95 mixed with additives blend A has higher values for engine torque compared to other additives. The high values for torque indicate that more energy is generated from the internal engine combustion compared to pure RON 95. The results obtained from this experiment was supported by one of the additive patent document (Patent No.198809284), stated that alcohol (methanol) used as additives which has a function as oxygenates can increase in promoting water content inside the fuel and if the volume of alcohol used is in a right quantity, it can increase in combustion rate which will result in more energy per cycle of combustion.

While the presence of kerosene used in the additives, which acted as a deposit control, can assist towards achieving higher energy generated per one complete cycle of engine combustion and thus helps explaining the higher values achieved for engine torque (Robert &

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Dickinson, 1972). Meanwhile acetone used in the additives could be functioned as a vaporization additive. Such volatility is important in promoting more fuel exists in vapour form compared to liquid and thus producing more energy generated per one complete cycle of the engine. Basically acetone will help in improving engine operation (Robert & Dickinson, 1972).

However at high value of RPM which is between 5000 and 5500 RPM, almost all additives have shown negative indication towards the engine torque performance. These findings indicate that the additives formulated could not operate and function properly under high engine stress situation due to engine design limitation (Raed & Sharzali, 2011).

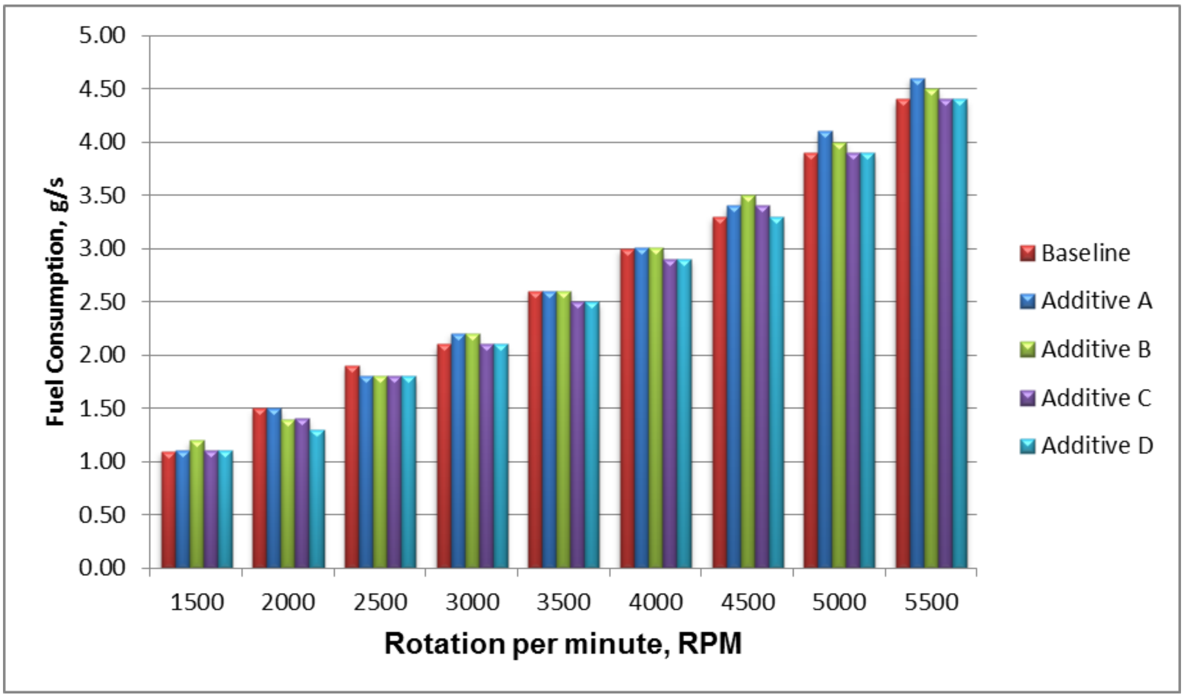

Figure 3: Comparison for Fuel Consumption between Baseline Fuel (RON 95) and Baseline Fuel Mixed with Several Different Blends of Additives

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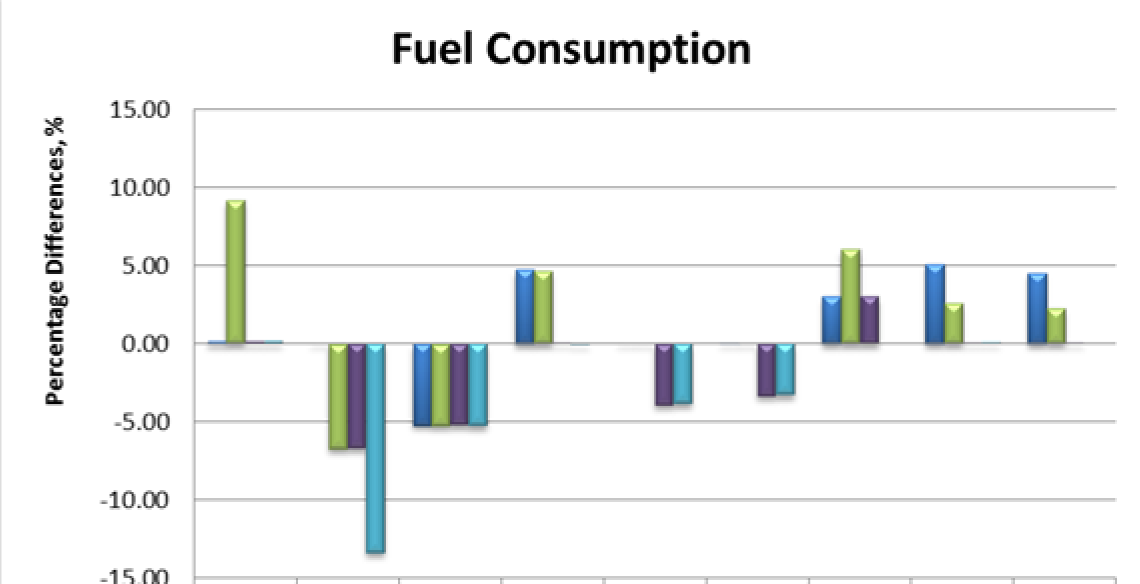

	1500	2000	2500	3000	3500	4000	4500	5000	5500
Additive A	0.20	0.00	-5.23	4.76	0.00	0.05	3.03	5.13	4.55
Additive B	9.16	-6.71	-5.23	4.69	0.06	0.05	6.04	2.61	2.29
Additive C	0.13	-6.67	-5.19	0.03	-3.90	-3.33	3.03	0.02	0.02
Additive D	0.13	-13.38	-5.26	-0.03	-3.85	-3.28	0.00	0.02	0.00

Figure 4: Percentage Different of Fuel Consumption Between Baseline Fuel (RON95) and Baseline Fuel Mixed with Several Different Blends of Additives

From Figure 3, it clearly indicates that at optimum RPM value which is between 1800 and 3000, RON 95 mixed with additives Type D has shown the lowest values of fuel consumption compared to the other additives. The low values achieved indicate that the energy generated from the fuel internal engine combustion is more efficient and effective compared to pure RON 95. The toluene used in the additives could act as an antiknock agent, which reduces or eliminates the pre-detonation and after burning of fuel internal engine combustion (Charles, 1980). Meanwhile the higher alcohol composition used for additives blend Type D, acts as oxygenates which promotes more complete combustion inside internal engine combustion. The high alcohol composition used resulted in more energy being generated, less deposit formed and more efficient fuel combustion for the internal engine combustion.

Based on the result shown in Figure 4.0, the fuel mixed with additive blend Type D can reduce the fuel consumption up to 13%. Normally, the decreases in fuel consumption will influence the engine performance by further decreasing the torque of the engines. However, the results recorded during this experiment for all additives have proven in the other way around.

4. CONCLUSION

Based on the results that were recorded during the experimentation, it can be concluded that additives blend of kerosene, toluene, acetone and methanol can further improve the engine performance in terms of engine torque and further decrease its fuel consumption. Higher amount of oxygenated additives used, such as methanol, decrease the engine performance in

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term of torque but has shown positive results in decreasing the amount of fuel consumption. Such example can be explained by the comparison made from additive blend Type A and additive blend Type B.

Furthermore, additional finding also led to the conclusion that the addition of toluene also further decreases the engine performance and greatly decrease the amount of fuel consumption in internal combustion engine.

These findings led to a conclusion that additive blend Type D was indeed the most effective up to 5000 rpm compared to baseline fuel. This additive achieves the desired objective to increase engine torque and reduce the fuel consumption. These findings can lead to a new improved blend which can be used to further decrease our dependency on fossil fuel.

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REFERENCES

Alan, E.W., Luiz, C. B., Denise, M. G. A., & Henrique, V. A. (1999). Fuel ethanol after 25 years. *Trends in Biotechnology. 17*(12), 482–487.

Bertha, A., & Fulop, L. (2000). *Additive for stabilizing water-containing fuels and a fuel stabilized with this additive*. Australian Patent AU2000046001. Retrieved from Google Patent.

Charles, P. C. Jr. (1980). *Gasoline and diesel fuel additive*. US Patent No. 4,294,586. Retrieved from Google Patent.

Chen, M., Tang, H., Ma, H., Holland, T. C., Ng, K. Y. S., & Salley, S. O. (2011). Effect of nutrients on growth and lipid accumulation in the green algae Dunaliella tertiolecta. *Bioresource Technology, 102*(2), 1649-1655. doi:10.1016/j.biortech.2010.09.062

Flynn, P. J., Ityokumbul, M. T., & Bochman, A. L. (2001). Preliminary investigation on the viability of 1,3-dioxolane as an alternative to MTBE in reformulated gasoline. SAE Technical Paper 2001-01-3683. doi:10.4271/2001-01-3683.

George, W.E. (1967). *Jet fuel composition*. US Patent No. 3,346,355. Retrieved from Google Patent.

Heino, R., & Juri, K. (2003). *Advances in Petrol Additives Research.* Patent No. 198809284. Retrieved from FPO IP Research and Communities.

p-ISSN 1675-7939; e-ISSN 2289-4934

Henry, E. A., & George, D. E. (1974). *Fuel additive package containing polybutene amine and lubricating oil*. US Patent No. 4,022,589. Oct. 1977.

Jack, L. (1985). Lead Poisoning - A Historical Perspective. *11 EPA J. 15*. Retrieved from Heinonline.

Jeffrey, M.B. (2007). *The future of the fuel additive market*. [Adobe Digital Editions]. Retrieved from Ebook Library.

Raed K., & Sharzali C. M. (2011). Assessment of free-rotating air swirling device to reduce SI engine emissions and improve fuel economy. *International Journal of Vehicle Systems Modelling and Testing. 6*(3-4), 283-306.

Robert, M. Z. Jr., & Dickinson, T. (1972). *Fuel additive and method to improving combustion*. US Patent No. 3,902,868. Retrieved from Google Patent.

Sachivko, A. V., Tverdokhlebov, V. P., Demyanenko, E. A., & Polyakov, B. V. (1998). New additives for motor fuels. *Rossiiskii Khimicheskii Zhurnal, 42*(1-2), 176-186.

Schenk, P. M., Thomas-Hall, S. R., Stephens, E., Marx, U. C., Mussgnug, J. H., Posten, C., Kruse, O., & Hankamer, B. (2008). Second Generation Biofuels: High-Efficiency Microalgaefor Biodiesel Production. *Bioenergy Research, 1*(1), 20–43. doi:10.1007/s12155-008-9008-8.

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