UNIVERSITI PUTRA MALAYSIA

PREPARATION AND CHARACTERIZATION OF TRITON-WATER DIESEL NANOEMULSION WITH AND WITHOUT CERIUM OXIDE

BIDITA BINTE SALAHUDDIN

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By

BIDITA BINTE SALAHUDDIN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

March 2014

DEDICATION

To my beloved parents…

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chair : Associate Professor Suraya Binti Abdul Rashid, PhD
Faculty : Engineering

Water-in-diesel nanoemulsions are considered as alternative fuels for internal combustion engines, to enhance combustion efficiencies and reduce exhaust emissions. A high energy emulsification process using a range of ultrsonication amplitudes (20 to 35 % with 10 minutes processing time) was employed to prepare nanoemulsion fuels. Nanoemulsion fuels were formulated by using a range of surfactant (Triton X-100) concentrations (0.31 % to 0.49 % w/w) with varying water concentrations (0.80% to 1.15% w/w). Cerium oxide (CeO_2) was also incorporated into the nanoemulsion fuels in order to evaluate the effect of fuel additive on the nanoemulsion properties. A screening method was carried out to determine the most suitable experimental conditions for the formation of nanoemulsion fuel in terms of improved combustion and emission properties. The screening process was conducted by analysing the emission of fuels from an engine test bed, namely CO_2, CO and NOx. It was found that nanoemulsion fuels have the ability to reduce exhaust emissions compared to that of neat diesel. The exhaust temperature of neat diesel was found to be 290 °C along with the CO_2, CO and NO emission concentrations of 21784, 766, and 276 ppm, respectively. A significant reduction of exhaust temperature (up to 33%) as well as NOx emission (up to 61%) was obtained during the combustion of cerium oxide enriched nanoemulsions compared to those without. The physico-chemical properties of screened nanoemulsions such as color, density, fuel stability, kinematic viscosity, flash point, pour point, acid number, calorific value and cetane number were determined and comparison was made to neat diesel. The destabilization methods; mainly Ostwald ripening was discussed to investigate the stability of nanoemulsions. The morphology of the nanoemulsions was studied by using the micrographs obtained from transmission electron microscopy (TEM). The size of the droplets formed in the prepared nanoemulsion fuel was found in the range of 1.5 nm to 74.0 nm. Overall, nanoemulsion fuels show great potential as alternative fuels.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia Sebagai memenuhi keperluan untuk ijazah Master Sains.

PENYEDIAAN DAN PENCIRIAN BAHAN API NANOEMULSI TRITON-AIR-DIESEL DENGAN DAN TANPA SERIUM OKSIDA

Oleh

BIDITA BINTE SALAHUDDIN

Mac 2014

Pengerusi : Profesor Madya Suraya Binti Abdul Rashid, PhD
Fakulti : Kejuruteraan

Nanoemulsi air-dalam-diesel dianggap sebagai bahan api alternatif bagi enjin pembakaran dalaman, untuk meningkatkan kecekapan pembakaran dan mengurangkan pelepasan ekzos. Bahan api nanoemulsi disediakan melalui proses pengemulsian tenaga tinggi dengan menggunakan pelbagai amplitud ultrsonifikasi (20 hingga 35% dengan 10 minit masa pemprosesan). Bahan api nanoemulsi dirumuskan dengan menggunakan kandungan surfaktan (Triton X-100) yang pelbagai (0.31% kepada 0.49% w/w) serta kandungan air yang berbeza (0.80% kepada 1.15% v/v). Serium Oksida (CeO_2) juga dimasukkan ke dalam bahan api nanoemulsi untuk menilai kesan aditif bahan api ke atas sifat nanoemulsi. Satu kaedah saringan telah dijalankan untuk menentukan kondisi kajian yang paling sesuai untuk pembentukan bahan api nanoemulsi yang boleh menghasilkan pembakaran dan mempunyai kandungan pelepasan yang lebih baik. Proses saringan telah dijalankan dengan menganalisis pelepasan bahan api dari katil ujian enjin, iaitu CO_2, CO dan NOx. Analisis ini menunjukkan bahawa bahan api nanoemulsi mempunyai keupayaan untuk mengurangkan pelepasan ekzos berbanding dengan diesel asal. Suhu ekzos diesel asal yang diperolehi ialah 290 °C bersama-sama dengan perlepasan CO_2, CO dan NO pada 21784, 766, dan 276 ppm masing-masing. Pengurangan ketara suhu ekzos (sehingga 33%) dan juga pelepasan NO (sehingga 61%) telah diperolehi dari pembakaran bahan api nanoemulsi yang mengandungi serium oxida berbanding dengan tanpanya. Ciri-ciri fiziko-kimia bagi nanoemulsi seperti warna, ketumpatan, kestabilan bahan api, kelikatan kinematik, takat kilat, titik tuang, nombor asid, nilai kalori dan bilangan setana ditentukan dan perbandingan dengan diesel asal telah dibuat. Kaedah ketidakstabilan; terutamanya pematangan Ostwald telah dibincangkan untuk menyiasat kestabilan nanoemulsi. Morfologi nanoemulsi telah dikaji dengan menggunakan mikrograf yang diperolehi daripada mikroskop pancaran elektron (TEM). Saiz titisan ditemui pada bahan api nanoemulsi yang disediakan didapati dalam julat 1.5 nm ke 74.0 nm. Secara keseluruhan, bahan api nanoemulsi menunjukkan potensi yang bagus sebagai bahan api alternatif.

ACKNOWLEDGEMENTS

I am profoundly grateful to Almighty Allah S.W.T for giving me the strength and patience that assist me to complete this thesis.

Here, I would like to express my gratitude to my research advisor, Associate Professor Dr. Suraya Abdul Rashid, for giving me the opportunity to join her research group, and for her constant support, guidance, idea and inspiration throughout my research program. In the field of nanomaterials and nanotechnology, her knowledge and expertise will prove to be inestimable throughout the rest of my scientific career. I am also grateful to the other committee member, Professor Dr. Azni b. Idris and Dr. Mohamad Amran Mohd Salleh for their valuable suggestions, criticisms and helpful instructions during my research period which helped me to accomplish this work with success.

Secondly, I would like to acknowledge the support from Department of Chemical and Environmental Engineering, Faculty of Engineering, Universiti Putra Malaysia. I also intensely appreciate the help given by the staff members of Material Science Lab, Analytical Lab and Thermodynamic Mechanical Lab in Faculty of Engineering and Laboratory of Molecular Biomedicine in Institute of Bioscience. I am pleased to receive their reliance in handling the instruments during the experimental approaches.

Last but not least, I owe my sincere gratitude to my family, friends, and colleagues, especially my mother, Sufia Aktar, and my husband, Shazed Md Aziz for their constant help, guidance, and endless encouragement and blessing.

I certify that a Thesis Examination Committee has met on 28 January 2014 to conduct the final examination of Bidita Binte Salahuddin on her thesis entitled "Preparation and Characterization of Triton-Water-Diesel Nanoemulsion with and without Cerium Oxide" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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