POTENTIALS OF NON-IONIC SEMI-RIGID POLYMER ASSISTED BY CATIONIC SURFACTANT AS DRAG REDUCTION AGENT AND ITS APPLICATION ON FLOW ENHANCEMENT IN PIPELINES

AINOON BINTI SHABIRIN

DOCTOR OF PHILOSOPHY
(CHEMICAL ENGINEERING)

UNIVERSITI MALAYSIA PAHANG

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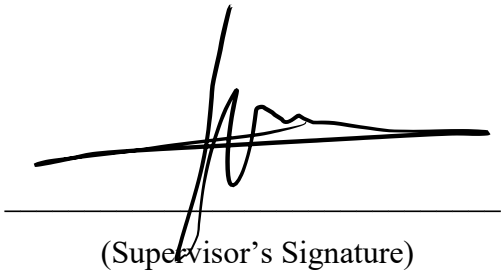
I hereby declare that I have checked this thesis, and, in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy (Chemical Engineering).



(Supervisor's Signature)

Full Name : DR. HAYDER A ABDULBARI

Position : PROFESSOR

Date :

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(Student's Signature)

Full Name : AINOON BINTI SHABIRIN

ID Number : PKC12005

Date :

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ABSTRAK

Polimer separa tegar, Hydroxypropyl Cellulose (HPC) dan kompleksnya dengan surfaktan kationik Benzyl-dimethyl-tridecyl-azanium Chloride (BZK) dicirikan dan dikaji sebagai agen pengurangan seretan berpotensi (DRA) dalam sistem peredaran gelung cecair tertutup (gelung paip). Pencirian dilakukan dengan menggunakan Transmission Electron Microscopy (TEM) untuk melihat kompleks HPC dan HPC-BZK dalam larutan, dan rheometer untuk menentukan ciri reologi. Prestasi pengurangan seretan bergelora dilakukan dalam gelung paip menggunakan air sebagai cecair pengangkut untuk mensimulasikan saluran paip komersial. Setiap kompleks HPC dan HPC-BZK mengalami derajat pergolakan yang berbeza (Re: 49540, 59448, 63694 dan 70771), kepekatan (200 ppm, 300 ppm, 500 ppm, 800 ppm, dan 1000 ppm), dan panjang paip (ujian bahagian: 1, 2, 3 dan 4 m). Gambar TEM menunjukkan bahawa zarah HPC tidak saling berinteraksi secara fizikal antara satu sama lain dan tidak ada penghubung antara zarah, sedangkan gambar TEM BZK mengesahkan adanya misel. Memandangkan HPC bukan ionik dan BZK bersifat kationik, interaksi fizikal tidak dijangka akan berlaku. Walau bagaimanapun, gambar TEM kompleks HPC-BZK menunjukkan gambar yang serupa dengan mikroemulsi yang menunjukkan interaksi fizikal yang bertentangan dengan jangkaan awal. Data reologi untuk kedua-dua HPC dan kompleks HPC-BZK menunjukkan bahawa kelikatan tertinggi diperoleh pada kadar ricih terendah dan kelikatan terendah diperoleh pada laju ricih tertinggi. Berdasarkan data reologi, oleh itu dijangkakan bahawa prestasi pengurangan seretan tertinggi dapat diperoleh pada kadar ricih terendah (darjah turbulensi minimum, Re) dan pada kelikatan cecair tertinggi. Hasil kajian saluran paip adalah seperti berikut: Pertama, antara Re yang diuji, Re sederhana 59448 menghasilkan prestasi pengurangan seretan tertinggi untuk kedua-dua HPC dan kompleks HPC-BZK. Kedua, kepekatan tertinggi diperhatikan menghasilkan prestasi pengurangan seretan tertinggi (1000ppm HPC dan 1000-1000 ppm HPC-BZK complex). Dan ketiga, kedua-dua HPC dan kompleks HPC-BZK menunjukkan prestasi pengurangan seretan tertinggi dalam panjang paip terpendek (1m). Selanjutnya, diperhatikan bahawa semua hasil menunjukkan bahawa kompleks HPC-BZK menunjukkan prestasi pengurangan seretan yang lebih tinggi daripada HPC. 1000-1000ppm menunjukkan pengurangan seretan hingga 30.81% berbanding HPC 1000 ppm yang menunjukkan 27.24% penurunan seretan pada panjang paip 1 m apabila dikenakan Re: 59448. Perbezaan utama antara kompleks HPC-BZK dan HPC adalah kehadiran BZK, dan ketiadaan interaksi kimia menunjukkan bahawa BZK dikaitkan dengan peningkatan pengurangan seretan antara HPC dan kompleks HPC-BZK. Secara keseluruhan, HPC adalah agen pengurangan seretan yang berpotensi, dan prestasi pengurangan seretnya dapat ditingkatkan dengan adanya surfaktan walaupun dengan interaksi fizikal HPC-surfaktan yang minima.

ABSTRACT

A semi-rigid polymer, non-ionic Hydroxypropyl Cellulose (HPC) and its complex with cationic surfactant Benzyl-dimethyl-tridecyl-azanium Chloride (BZK) were characterized and investigated as a potential drag reduction agent (DRA) in a closed-loop liquid circulation system (pipe loop). The characterizations were carried out using Transmission Electron Microscopy (TEM) to view the HPC and HPC-BZK complex in solution, and a rheometer to determine its rheology characteristics. The turbulent drag reduction performances were carried out in the pipe loop using water as the transporting liquid to simulate a commercial pipeline. Each HPC and HPC-BZK complex was subjected to different degrees of turbulence (Re: 49540, 59448, 63694 and 70771), concentrations (200 ppm, 300 ppm, 500 ppm, 800 ppm, and 1000 ppm), and pipe lengths (testing sections:1, 2, 3 and 4 m). The TEM images showed that HPC particles were not physically interacting with each other and no inter-particle bridging was observed, whereas the TEM images of BZK confirmed the presence of micelles. Given HPC was non-ionic and BZK was cationic, not physical interaction was expected. However, the TEM images of HPC-BZK complex showed an image similar to a micro-emulsion which suggested a physical interaction that contradicted the initial expectation. The rheology data for both HPC and HPC-BZK complex showed that highest viscosity was obtained at the lowest shear rate and the lowest viscosity was obtained at the highest shear rate. Based on the rheology data, it was therefore expected that the highest drag reduction performances should be obtained at the lowest shear rate (minimal degree of turbulence, Re) and at the highest liquid viscosity. The results of the pipeline study were as follows: First, among the tested Re, moderate Re: 59448 produced the highest drag reduction performance for both HPC and HPC-BZK complex. Second, the highest concentration was observed to produce the highest drag reduction performance (1000ppm HPC and 1000-1000 ppm HPC-BZK complex). And third, both HPC and HPC-BZK complex were shown to display the highest drag reduction performance in the shortest pipe length (1m). Furthermore, it was observed that all the results indicated that HPC-BZK complex showed higher drag reduction performance than HPC. 1000-1000ppm showed up to 30.81% of drag reduction compared to 1000 ppm HPC which showed 27.24% of drag reduction in the 1 m pipe length when subjected to Re: 59448. The major difference between HPC-BZK complex and HPC was the presence of BZK, and the absence of any chemical interaction suggested that BZK attributed to the drag reduction enhancement between HPC and HPC-BZK complex. Overall, it was concluded that HPC is a potential drag reduction agent for pipe flow enhancement, and its drag reduction performance could be enhanced in the presence of BZK.

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LIST OF SYMBOLS

m	Meter
ppm	Part per million
ρ	Fluid density
μ	Dynamic viscosity of fluid
L	Pipe length
V	Average velocity
% DR	Percentage drag reduction
C	Concentration
L	Liter
ΔP	Pressure loss
TEM	Transmission Electronic Microscopy

LIST OF ABBREVIATIONS

Re	Reynolds Number
DR	Drag Reduction
DRA	Drag Reducing Agent
MW	Molecular weight
I.D	Internal diameter
ΔP	Pressure Drop (Pressure Different)
RDA	Rotating disk apparatus
oC	Degree Celsius
%	Percent
L	Liter
wt	Weight

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