FABRICATION OF HYBRID GRAPHENE-POLYETHERSULFONE SUPPORTED LIQUID MEMBRANE FOR ACETIC ACID REMOVAL FROM OIL PALM FROND BIOMASS HYDROLYSATE

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We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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Penukaran biojism lignoselulosa kepada bahan bakar bio memberi sumbangan hebat kepada pembekalan sumber tenaga boleh diperbaharui. Untuk mencapai matlamat ini, penguraian asid telah digunakan untuk menguraikan bahan lignoselulosa kepada gula fermentasi. Penguraian asid adalah kaedah yang cekap, mudah dan pantas berbanding penguraian enzim. Walau bagaimanapun, masalah utama yang ditemui semasa proses penguraian adalah pembebasan kumpulan asetil seperti asid asetik (AA) sebagai hasil sampingan bersama komponen gula. AA boleh bertindak sebagai perencat kepada penukaran enzim gula ke dalam produk akhir etanol atau bahan kimia lain. Maka, AA perlu dikeluarkan daripada hidrolisat biojism untuk memaksimumkan penghasilan produk akhir. Kajian ini menumpukan terhadap pembinaan sokongan membran hibrid yang digunakan di dalam ceai memran bersokong (SLM) proses untuk penyekirkan AA menggunakan teknik pemisahan fasa induksi wap (VIPS). Membran hibrid telah dicirikan dari segi morfologi dengan menggunakan pengimbas mikroskop elektron (SEM) dan pelepasan medan pengimbas mikroskop elektron (FESEM), hidrofobisiti membran dan kekuatan mekanikal. Ceaai organik membran untuk pengestrakkan AA telah diformulasikan di bahagian pertama kajian ini. Ceaai membran dan agen pelucutan terbaik adalah pada pembawa 0.5 M tri-n-octylamine (TOA) di dalam pelarut 2-ethyl-1-hexanol dan 0.5 M NaOH. Penggabungan 0.1 wt% graphene di dalam hibrid polyethersulfone (PES) lemaran rata sokongan membran didapati ketara meningkatkan tekanan tegangan memb hibrid dari 740 kPa kepada 1790 kPa, peningkatan sebanyak 140% kekuatan mekanikal berbanding memb PES yang asli. Sudut sesentuh membran juga meningkat dari 81.92º kepada 122.35º dan menjadi sokongan membran yang sangat tinggi hidrofobik yang dapat memperbaiki kestabilan SLM. PES-0.1 graphene (G) sokongan membran kekal stabil lebih daripada 116 jam (12 kitaran SLM) tanpa rendaman semula dalam ceai memran berbanding dengan memb asli yang hanya stabil untuk 16 jam (2 kitaran SLM). Keadaan terbaik untuk penghasilan memb hibrid lemaran rata melalui VIPS adalah menggunakan suhu rendaman 50 °C, 30 saat masa pendedahan dan 80% kelembapan udara. Ia menunjukkan 95% penyekiran AA daripada larutan akueu 10 g/l. Semasa penghasilan sokongan memran gentian berongga, masa rendaman membran ceai dan mod operasi aliran suapan PES-0.1G gentian berongga telah dikaji. Masa rendaman terbaik untuk penyediaan modul gentian berongga adalah 4 jam. Fasa suapan yang mengalir di sisi lumen (Mod I) menunjukkan prestasi pemisahan yang lebih baik dibandingkan dengan sisi shell (Mod II). Peratusan penyekiran AA menggunakan gentian berongga yang dikendalikan dengan Mod I dan Mod II masing-masing adalah 80.1% dan 42.4%. Kebolehan proses SLM dalam mengeluarkan AA dari hidrolisat biojism pelepas kelapa sawit (OPF) telah diuji menggunakan memb PES-0.1G lemaran rata dan gentian berongga. Kepekatana AA dalam OPF hidrolisat dikerangkan dari 6.83 g/l kepada 1.33 g/l dan 2.01 g/l dengan menggunakan lemaran rata dan gentian berongga SLM. Kedua-dua sistem SLM memenuhi kepekatana minimum AA yang perlu wujud dalam hidrolisat biojism untuk memastikan penghasilan etanol yang tinggi yang kurang daripada 5 g/l. Oleh itu, sistem SLM yang menggunakan sokongan memb hibrid G-PES yang dihasilkan dalam kajian ini terbukti berkesan menyengingkiran AA daripada larutan akueu dan hidrolisat biojism OPF.
ABSTRACT

Conversion of lignocellulosic biomass to biofuel gives a great contribution to the supplement of renewable energy source. To achieve this purpose, acid hydrolysis was used to hydrolyze the lignocellulosic materials to fermentable sugars. Acid hydrolysis is efficient, simple and fast method compared to enzymatic hydrolysis. However, the major problem encountered during the hydrolysis process is the releasing of acetyl group such as acetic acid (AA) as byproducts with the hydrolyzed sugar component. AA can act as inhibitors to the enzymatic conversion of sugar into the final product of ethanol or other chemicals. Therefore, AA needs to be removed from the biomass hydrolysate to maximize the yield of products. This study focused on development of the hybrid membrane support for used in the supported liquid membrane (SLM) process for AA removal using vapor induced phase separation (VIPS) technique. The hybrid membrane were characterised in term of morphology by scanning electron microscope (SEM) and field emission scanning electron microscope (FESEM), porosity, membrane hydrophobicity and mechanical strength. The organic liquid membrane phase for extraction of AA was formulated in the first part of the study. The best liquid membrane phase and stripping agent were 0.5 M tri-n-octyl-amine (TOA) carrier in 2-ethyl-1-hexanol diluent and 0.5 M NaOH, respectively. Incorporation of 0.1 wt% graphene in the hybrid polyethersulfone (PES) flat sheet membrane support was found significantly improved the tensile stress of the hybrid membrane from 740 kPa to 1790 kPa, an improvement about 140% in mechanical strength compared to pristine PES membrane. The contact angle of the hybrid membrane also increased from 81.92º to 122.35º and becoming highly hydrophobic membrane support that improved the SLM stability. PES-0.1G membrane support remains stable for more than 116 hours (12 SLM cycles) without requires reimpregnation in the liquid membrane phase compared to the pristine membrane that only stable for 16 hours (2 SLM cycles). The best condition to prepare the flat sheet hybrid membrane through VIPS are using 50 °C coagulation bath temperature, 30 second air exposure time and 80% air humidity. It showed 95% removal of the AA from 10 g/l aqueous solution. During production of hollow fiber membrane support, impregnation time of liquid membrane and feed flow operating modes of PES-0.1G hollow fiber membrane was studied. The best impregnation time for preparing hollow fiber module was 4 hours. The feed phase flowed in lumen side (Mode I) showed better separation performance compared to the shell side (Mode II). The removal percentage of AA using hollow fiber operated with Mode I and Mode II were 80.1% and 42.4%, respectively. The capability of SLM process in removing of AA from oil palm frond (OPF) biomass hydrolysate was tested using PES-0.1 G flat sheet and hollow fiber membrane. The concentration of AA in the OPF hydrolysate was reduced from 6.83 g/l to 1.33 g/l and 2.01 g/l using flat sheet and hollow fiber SLM, respectively. Both SLM systems meet the minimum concentration of AA that should present in the biomass hydrolysate for ensuring highest ethanol production which is less than 5 g/l. Thus, the SLM system using hybrid G-PES membrane support developed in this study is proven effective for removing AA from aqueous solution and OPF biomass hydrolysate.
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REFERENCES


Zambare, R. S., Dhopte, K. B., Patwardhan, A. V., & Nemade, P. R. (2017). Polyamine functionalized graphene oxide polysulfone mixed matrix membranes with


