

**DEVELOPMENT OF GRAPHENE OXIDE
INCORPORATED POLYSULFONE/PEBAX
THIN-FILM COMPOSITE MEMBRANES FOR
ISOPROPANOL DEHYDRATION**

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To examiners, readers and fellow knowledge seekers, you will have a beautiful life ahead. Always aim for the moon, even if you miss, you'll land among the stars. Alhamdulillah, without His blessing, this journey couldn't be easier. I dedicated this thesis to my late Mom.

Al Fatihah..

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Doctor of Philosophy

College of Engineering
UNIVERSITI MALAYSIA PAHANG

JANUARY 2022

ACKNOWLEDGEMENTS

I would like to thank the following people who have helped me throughout this journey:

My supervisor AP. Ts. Dr Sunarti Abd Rahman., for her enthusiasm for the project, for her support, encouragement, motherly loving and patience, for her time and ear, the endless motivational talk, for her always be there whenever I am weeping in tears.

Not to forget, my co-supervisor – Dr Rozaimi Abu Samah – for his friendliness, input, and time.

The College of Engineering, Institute of Postgraduate Studies, Department of Chemical Engineering, laboratory personnel, and the place I used to call home – Universiti Malaysia Pahang – it is 10 years of warm and comfy live.

The good people of Sulai Semput – to name few, Mahadi Bahari, Aiman Hamdan, Abu Hannifa, Nazarni Che Isa, Ridzuan Kamaruzaman, Hadi Sulaiman, Amira Rosli, Hanani Rushan, Aisyah Latip, Maryam Aini, and Ashikin Jamin who contribute to the experimental design, idea and time, and the rest of the gang – they knew exactly who they are – we laugh, cry, go on vacation, do experiment and the cycle continues – this is not my journey, it is ours – your name tattooed on my heart.

My wife, Salwa Karim – who patiently waiting for our big day. I simply could not have done this without you, special thanks.

My best friend, Hamdi Jamaludin.

Dear friends and family.

And to my parents, Abdul Wahab Hamid and Rohani Majid who set me off on the road a long time ago.

ABSTRACT

Polymeric membranes separation among the new and reliable separation and purification techniques in term of energy consumption, ease of process, and high selectivity due to polymer properties which can be tailored to specific needs. Recent works on thin film nanocomposite (TFNC) showed that there is still a gap on factors or parameters involved in TFNC synthesis, which the same old weakness of membrane swelling, flux loss and selectivity deficit seem left to be discovered. In this work, graphene oxide (GO) was embedded to both selective hydrophilic layer and porous Polysulfone (PSF) hydrophobic substrate creating a mutual bridge between the two surfaces. Pristine 1-3 μm microporous PSF prepared via dry/wet phase inversion techniques with contact angle of 74.12° has been further studied with GO embedded Pebax dense selective layer. This dual nature thin film nano composite TFNC membranes managed to reduce the water contact angle down to 37.18°. As for the IPA dehydration study, the total flux up to $1.19 \text{ kgm}^{-2}\text{h}^{-1}$ and 0 wt% IPA detected in permeate was achieved with 20 wt% water feed at 30 °C. A two-level full factorial design (FFD) was used to analyze several factors involved in PSF–GO–Pebax TFNC membranes development. Permeate flux was chosen as a single response for four possible factors: Pebax selective layer concentration, amount of GO loads to Pebax selective layer, Pebax–GO selective layer thickness, and amount of GO load to PSF substrate. R^2 obtained from the analysis of variance (ANOVA) is 0.9937 with Pebax concentration as the highest contributing factor. Pebax concentration–amount of GO load to PSF substrate is the only interaction contributing to the highest flux. A regression analysis concluded the study with model development and an optimized condition for the membrane design. There are two operating conditions for the pervaporation (PV) studied within this system – the amount of water contents in binary feed mixture and operating temperature. The highest possible flux obtained from this study is at 12 wt% – 14 wt% of water in IPA and 61 °C – 65 °C operating temperature with permeate of $1.514 \text{ kgm}^{-2}\text{h}^{-1}$ – $1.562 \text{ kgm}^{-2}\text{h}^{-1}$. A permeate flux model for this system also been generated and validated with error margin less than 1 % proving the genuine of the developed model and the ability of data prediction.

ABSTRAK

Teknik pemisahan membran polimer antara teknik pemurnian yang baru dan boleh dipercayai dari segi penggunaan tenaga, kemudahan proses, dan selektiviti yang tinggi kerana sifat polimer yang dapat disesuaikan dengan keperluan bahan. Penyelidikan terkini pada filem nipis nano komposit (TFNC) menunjukkan bahawa masih ada jurang pada faktor atau parameter yang terlibat dalam sintesis TFNC, yang mana kelemahan lama seperti pembengkakan membran, kehilangan fluks dan selektiviti defisit masih belum dapat ditemukan. Dalam penyelidikan ini, Grafina oksida (GO) disisipkan ke dalam lapisan hidrofilik selektif, Pebax 1657 dan substrat hidrofobik PSF dan mewujudkan jambatan bersama antara kedua permukaan. PSF dengan liang mikro 1-3 μm yang disiapkan melalui teknik penyongsangan fasa kering- basah dengan sudut sentuhan 74.12° telah dikaji lebih lanjut dengan lapisan selektif Pebax yang tertanam GO. Membran TFNC ini berjaya mengurangkan sudut sentuhan air sehingga 37.18° . Bagi kajian dehidrasi IPA, jumlah fluks hingga $1.19 \text{ kgm}^{-2}\text{h}^{-1}$ dan 0 wt% IPA telah berjaya dicapai dengan 20 wt% air dan 30°C . Reka bentuk faktorial penuh dua peringkat digunakan untuk menganalisis beberapa faktor yang terlibat dalam pengembangan membran filem nipis nano komposit PSF – GO – Pebax. Fluks dipilih sebagai tindak balas tunggal untuk empat faktor: kepekatan lapisan selektif Pebax, jumlah GO di dalam lapisan selektif Pebax, ketebalan lapisan selektif Pebax-GO, dan jumlah GO di dalam substrat PSF. Kajian ini bertujuan untuk memgkaji interaksi factor terhadap kadar serapan melalui pendekatan FFD dan RSM. R^2 yang diperoleh dari ANOVA adalah 0.9937 dengan kepekatan Pebax sebagai faktor penyumbang tertinggi. Kepekatan Pebax – jumlah GO di dalam substrat PSF adalah satu-satunya interaksi yang menyumbang kepada fluks tertinggi. Analisis regresi menyimpulkan kajian ini dengan pembentukan model dan kondisi optimum untuk reka bentuk membran. Terdapat dua keadaan operasi yang dikaji dalam sistem PV ini – jumlah kandungan air di dalam campuran binari dan suhu operasi. Fluks tertinggi yang diperoleh dari kajian ini ialah pada 12 wt% –14 wt% air dan suhu operasi 61°C - 65°C iaitu $1.514 \text{ kgm}^{-2}\text{h}^{-1}$ - $1.562 \text{ kgm}^{-2}\text{h}^{-1}$. Model fluks untuk sistem ini juga dihasilkan dan disahkan dengan margin ralat kurang dari 1% membuktikan kemampuan model ini meramal data.

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