EFFECT OF SYNTHESIS PARAMETERS OF POLYPROPYLENE MELT BLOWN NANOFIBERS FOR OIL SORPTION

ZYKAMILIA BINTI KAMIN

FACULTY OF ENGINEERING
UNIVERSITI MALAYSIA SABAH
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ZYKAMILIA BINTI KAMIN

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_____ _____

ZYKAMILIA BINTI KAMIN (Tandatangan Pustakawan)
PK1211012T

Tarikh : 29 September 2023

_____
(Professor Ir. Dr. Roslam Hj. Sarbatly))
Penyelia Utama

DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, equations, summaries, and references, which have been duly acknowledged.

3 November 2022

Zykamilia binti Kamin
PK1211012T

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CERTIFICATION

NAME	:	**ZYKAMILIA BINTI KAMIN**
MATRIC NO.	:	**PK1211012T**
TITTLE	:	**EFFECT OF SYNTHESIS PARAMETERS OF POLYPROPYLENE MELT BLOWN NANOFIBERS FOR OIL SORPTION**
DEGREE	:	**DOCTOR OF PHILOSOPHY IN ENGINEERING**
FIELD	:	**CHEMICAL ENGINEERING**
VIVA DATE	:	**3 NOVEMBER 2022**

CERTIFIED BY;

Signature

1. **MAIN SUPERVISOR**
   Professor Ir. Dr. Rosalam Hj. Sarbatly

   _____

2. **CO-SUPERVISOR**
   Professor Dr. Duduku Krishnaiah

   _____

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ABSTRACT

Nanofiber is an effective oil sorbent for hydrocarbon crude oil spill clean-up operations. However, techniques to mass–produce nanofibers using melt blowing technique have not yet been fully developed to produce nanofibers with high oil sorption capacity. Subsequently, it needs a detailed study on the correlation between production, structures, properties, and applications. Hence, this study focuses on nanofibers synthesis using polypropylene by varying melt blowing variables, i.e., melt flow rate, air pressure, and die-to-collector distance, with ranges of 1 - 5 Hz, 0.25 - 0.50 Mpa and 0.15 - 0.45 m respectively. This work studied the interaction between process variables and nanofibers' physical properties (average fiber diameter, specific surface area, pore volume, and average pore diameter) and the interaction between the nanofibers' physical properties and oil sorption capacity. The SEM and BET characterize the fiber's physical properties, and a standard method was used to quantify oil sorption capacity. The response surface methodology was used to analyze the interactions. In addition, selectivity studies over water were conducted using Pseudo Ideal Monolayer theory on heavy metals Pb^{2+}. The results obtained for physical properties for average fiber diameter, specific surface area, pore volume, and average pore diameter were in the ranges of 370.84 - 1885.00 nm, 1.3669 - 4.3188 m^2/g, 0.002143 - 0.08283 cm^3/g, and 61.93 - 93.00 Å, respectively. The finding shows that the most significant factor for all responses is melt flow rate except for average pore diameter, where melt flow rate and die collector distance interaction are the most significant factors. The oil sorption capacity was in the range of 11.37 - 36 g/g, with which the highest value was obtained at 1 Hz, 0.45 m, and 0.5 Mpa due to voids among fibers by fiber entanglement induced by the die-to-collector distance. At a low solute concentration, the maximum preference for the Pb^{2+} was at a 9.0 x 10^{-5} mole fraction, and the adsorption capacity, $N_{s,}$ was 5.0758 x 10^{-5} mg/g. These indicate that the selectivity towards Pb^{2+} is high, despite a low adsorption capacity, making the nanofibers effective for oil-water separation for an oil spill clean-up operation. This knowledge contribution provides an avenue for future research in adsorption studies for hydrocarbons, oil and heavy metals.

ABSTRAK

KESAN PARAMETER SINTESIS TIUPAN CECAIR GENTIAN NANO POLIPROPILENA UNTUK SERAPAN MINYAK

Gentian nano adalah penyerap minyak berkesan membersih tumpahan minyak. Namun, teknik penghasilan gentian nano berskala besar secara teknik tiupan cair untuk menghasilkan gentian nano penyerapan minyak berkapasiti tinggi belum dibangunkan sepenuhnya. Hubungan antara fabrikasi, struktur, sifat dan aplikasi memerlukan kajian. Kajian ini berfokus kepada sintesis gentian nano menggunakan polipropilen dengan pembolehubah tiupan cecair, berkadar aliran, tekanan angin dan jarak berjulat 1-5 Hz, 0.25-0.5 Mpa dan 0.15-0.45 m. Kajian menjelaskan interaksi antara pembolehubah dan sifat fizikal gentian nano (purata diameter gentian, luas permukaan spesifik, isipadu liang dan purata diameter liang), dan interaksi antara sifat fizikal gentian nano dan kapasiti serap minyak. Kajian selektiviti logam berat Pb^{2+} ke atas air dijalankan menggunakan teori Pseudo Ideal Monolayer. SEM dan BET mencirikan sifat fizikal gentian nano dan kaedah standard digunakan untuk mengukur kapasiti serapan minyak. Response Surface Methdology digunakan untuk menganalisis interaksi ini. Keputusan purata diameter gentian, luas permukaan spesifik, isipadu liang dan purata diameter liang, adalah berjulat 370.84 - 1885.00 nm, 1.3669 - 4.3188 m^2/g 0.002143 - 0.08283 cm^3/g, dan 61.93 - 93.00 Å. Didapati, kadar aliran cair adalah faktor yang paling penting untuk semua respon, kecuali purata diameter liang, di mana kadar aliran cecair dan jarak alat tekan ke pengumpul adalah faktor terpenting. Kapasiti minyak berjulat 11.37 - 36 g/g, yang mana serapan minyak tertinggi diperolehi pada 1 Hz, 0.45 M, dan 0.5 Mpa. Serapan minyak tinggi disebabkan ruang di antara gentian oleh keterikatan gentian, akibat jarak ke pengumpul. Pada larutan yang cair, selectivity maksimum Pb^{2+} adalah pada pecahan mol 9.0×10^{-5}. Kapasiti penyerapan, N_s ialah 5.0758×10^{-5} mg/g. Ini menunjukkan walaupun kapasiti penyerapan rendah, selektiviti ke arah Pb^{2+} adalah tinggi. Sumbangan pengetahuan ini memberi panduan untuk penyelidikan masa depan dalam kajian penyerapan untuk hidrokarbon, minyak, dan logam berat.

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BET	-	Brunauer–Emmett-Teller
DCD	-	Die to collector distance
DMF	-	Dimethylformamide
DTA	-	Diethylenetriamine
EDA	-	Ethylenediamine
EG	-	Ethyleneglycol
MWCNT	-	Multi-walled carbon nanotube
PA6	-	Polyamide 6
PAN	-	Polyacrylonitrile
PEI	-	Poly(ethyleneimine)
PES	-	Poly (ether sulfones)
PP	-	Polypropylene
PS	-	Polystyrene
PVDF	-	Polyvinylidene fluoride
SEM	-	Scanning electron microscopy
TGA	-	Thermogravimetry analysis
THF	-	Tetrahydrofuran