Effects of Immobilized AgNO$_3$ in Composite Polysulfone-Polyethyleneimine Membrane towards Antibacterial Properties

Khairul Anwar Mohamad Said
Department of Chemical Engineering and Energy Sustainability, Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS)
Office: 082583235
Phone: 0189792066
Email: mskanwar@unimas.my

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Scope

- What make a membrane?
- How to prepare a membrane?
- How antibacterial agent work?
- Analyzing the membrane
- Future of membrane technology

The statistics

<table>
<thead>
<tr>
<th>Environmental Protection Expenditure, 2011-2014, RM Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
</tr>
<tr>
<td>RM1,316</td>
</tr>
</tbody>
</table>

Environmental Protection Expenditure, 2014

- 32.2% Manufacturing
- 21.6% Education
- 8.4% Wastewater & Sewage
- 1.6% Agriculture, Forestry & Fishing
- 1.4% Environment Monitoring

In 2014, operating expenditure dominates the Environmental Protection Expenditure.

Environmental Protection Expenditure by Type of Expenditure, RM Million

<table>
<thead>
<tr>
<th>Type of Expenditure</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPE</td>
<td>RM56.0</td>
<td>RM64.2</td>
<td>RM20.5</td>
<td>RM11.1</td>
</tr>
<tr>
<td>Air</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundwater</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Noise</td>
<td></td>
<td></td>
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</tbody>
</table>

Pollution prevention incurred the highest expenditure of RM75.5 million

Manufacturing sector was the highest contributor for EPE, at RM 56.0 million.

Environmental protection expenditure for air media recorded more than 50 per cent from the total expenditure for media.

Forecast

Growing acceptance of wastewater management

"The necessity for safe, usable water has created the demand for water recycling, which has led to an increase in demand for membranes in the desalination and wastewater management industries. Also, rising awareness regarding health and safety and stringent environmental regulations are further boosting the adoption of membranes," says Mahitha, a lead analyst at Technavio for plastics, polymers, and elastomers research.²


Summary

• The membrane technology is far from saturated (replacement and desalination plant).

• The waste management expenditure was RM642.8 mil. for 2015 which show the increase need for membrane to provide clean water.
Objective

- To investigate the effect of silver nitrate to membrane morphology
- The relationship of membrane morphology to flux
- The effect of silver nitrate content to antibacterial properties

What make a membrane?

In definition
- A membrane is a thin layer of semi-permeable material that separates substances when a driving force is applied across the membrane.
Preparing a membrane

Composition of silver nitrate varied from 0.5, 1.0, 1.5 & 2.0%

Dope solution: Polysulfone, N-Methyl-2-pyrroldone, Polyethylenimine, activated carbon

Sample of flat sheet membrane

Antibacterial mechanism

In general, there are three mechanism stipulated contribute to silver antibacterial properties.

a. Disruption of cell wall
b. Reactive oxygen species
c. Interruption of electron transport


Membrane morphology

<table>
<thead>
<tr>
<th>Membrane type</th>
<th>Composition (wt %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AgNO₃</td>
</tr>
<tr>
<td>CM A</td>
<td>-</td>
</tr>
<tr>
<td>CM B</td>
<td>0.5</td>
</tr>
<tr>
<td>CM C</td>
<td>1.0</td>
</tr>
<tr>
<td>CM D</td>
<td>1.5</td>
</tr>
<tr>
<td>CM E</td>
<td>2.0</td>
</tr>
<tr>
<td>CM F</td>
<td>-</td>
</tr>
</tbody>
</table>

- ¹PEI act as pore forming agent
- Exist in polymer-rich
- All composite membrane show a sponge-like structure
- Appearance of macrovoid might be caused by Marangoni Effect

Flux, \( J_0 = \frac{V}{A \Delta t} \) is pure water flux (Lm⁻² h⁻¹). Q is the permeate volume (L), A is the membrane area (m²) and \( \Delta t \) is the time (h).

Increasing the concentration of silver nanoparticles on the membrane resulting low water flux due to barrier created by the presence of silver nanoparticles or agglomeration of nanoparticles on the membrane surface.

Antibacterial result

- Diameter of each membrane samples were 17 mm
- Incubated at 36°C for 24 hours
- Kirby Bauer test carried out to investigate effective inhibition
- We believed the sponge-like structure help to retain the silver nanoparticles inside the membrane matrix therefore contribute to 27mm inhibition area

Summary

- Sponge-like structure has affect the membrane flux considerably with highest flux around 22 L/m².h
- The sponge-like structure help retain silver in membrane matrix
Possible future study

Effect of silver antibacterial agent to gram negative and gram positive bacteria

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IMPORTANT DATES

Full paper submission deadline: 20th April 2017
Notification of Acceptance: 31st May 2017
Camera-ready Submission Deadline: 30th June 2017
Early Bird Registration Deadline: 30th June 2017
Normal Registration Deadline: 20th July 2017