NOM Fractionation and Fouling of Low-Pressure Membranes in Microgranular Adsorptive Filtration (µGAF)

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Membrane fouling is the major challenge limiting the performance and even wider adoption of MF/UF.

Natural Organic Matter (NOM) is a major foulant of membranes.
Conventional Pretreatment for MF/UF Membranes

Pretreatment

Foulants

Membrane filtration

Polysaccharides

LMW organics

Colloids

T&O

Particles

Membrane filtration

Pretreatment
Microgranular Adsorptive Filtration ($\mu$GAF)
Research Question

Does $\mu$GAF work for other adsorbents?

1. Powdered Activated Carbon (PAC);
2. Ion Exchange (IX) Resin;
3. Heated Aluminum Oxide Particles (HAOPs);
Heated Aluminum Oxide Particles (HAOPs)

\[ \text{Al}_2(\text{SO}_4)_3 + \text{NaOH} \rightarrow \text{pH 7.0} \]

110 °C, 24 hrs

Particle Size Distribution: 1.5~30µm, mean@7.5µm
Point of Zero Charge: pH 7.7
BET Surface Area: 116 m²/g
Aluminum Content: 25% (Al(OH)_3·H₂O)
Experimental Setup

Data Acquisition

Autosampler

UV, SEC

Transmembrane Pressure

Filter Unit

Pump

100 LMH

FEED
Performance: Fouling Control
Performance: UV Removal

![Graph showing UV removal performance vs. sp (L/m²)]

- **Normalized UV<sub>254</sub>**
- **V<sub>sp</sub> (L/m²)**
- Key indicators:
  - Bare Membrane
  - HAOPs
  - PAC
  - IX resin
Research Questions

- What fraction(s) of the NOM are removed by \( \mu \text{GAF} \) using various adsorbents?
- Could fouling control be associated with removal of one or more of those fractions?
SEC Profiles

- LW Feed
- 50 L/m²
- 250 L/m²
- 650 L/m²
- 1050 L/m²
- 1450 L/m²

Retention time (min) vs. UV254 (A.U.)
Breakthrough of Peak 1

Normalized UV$_{254}$ vs. $V_{sp}$ (L/m$^2$)

Legend:
- HAOPs
- PAC
- IX resin
Breakthrough of Peak 4

The graph shows the normalized UV$_{254}$ against $V_{sp}$ (L/m$^2$) for IX resin, HAOPs, and PAC. The data indicates that IX resin has the highest normalized UV$_{254}$, followed by HAOPs, and then PAC.
Summary #1

1. Membrane foulants comprise only a small fraction of the bulk NOM
2. Neither UV$_{254}$ of bulk NOM nor that of a particular MW fraction is correlated with membrane fouling
3. Membrane foulants are partially removed by PAC or HAOPs in µGAF systems, but are not removed by IX resin
SEC of Column Effluents

UV$_{254}$ (A.U.)

Retention time (min)

Effluent of IX resin column_10X
Effluent of PAC column_10X
## UV Removal with Pretreatment Columns

<table>
<thead>
<tr>
<th>Pretreatment</th>
<th>IX pretreatment, % removed</th>
<th>PAC pretreatment, % removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>column</td>
<td>84</td>
<td>77</td>
</tr>
<tr>
<td>Bare Membrane</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>HAOPs + Membrane</td>
<td>8</td>
<td>14</td>
</tr>
</tbody>
</table>
SEC of NOM on Membrane
SEC Profile

Meylan et al. Water Research 2007
Batch Adsorption of Alginate
Filtration Tests of Alginate Amended LW
\( \mu \text{GAF Tests Feeding Only Alginate} \)
Conclusions

- PAC and HAOPs remove some foulant NOM, but IX resin removes only NOM with low or no fouling potential.
- Membrane foulants comprise only a small fraction of the bulk NOM, and the key foulants do not absorb UV light.
- Alginate-amended LW water significantly exacerbates membrane fouling, suggesting polysaccharides could be key foulants.
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Questions and Comments