Anion exchange for NOM removal and the effects on micropollutants adsorption competition on activated carbons

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Difference between NOM and micropollutants

- **Concentration:** mg/L vs. µg/L (or ng/L)
- **Composition:** Heterogeneous mixture vs. Specific compound
- **Molecular size:** Board range vs. Small size
- **Charge:** Mostly negative vs. Compound dependent
- **Polarity:** Water sources dependent vs. Compound dependent
Adsorption competition mechanisms

Pore blocking (micropore entrance)

Rapid small scale column tests (RSSTCs)

Batch equilibrium isotherm tests

Direct site competition (micropore)
NOM removal in prior to activated carbon

- Coagulation & flocculation ×
- Tight membrane filtration √
- Anion exchange ?

Q: is the preceding anion exchange good for less site competition or less pore blocking?
1. Anionic exchange resin (AER) dose response NOM removal

Strong base, gel type AER: Lewatit VP OC 1071

Treated water: 10ml/L AER after 1h
1. Molecular weight distribution of RW and TW
2. Micropollutants in batch adsorption

<table>
<thead>
<tr>
<th>Compounds</th>
<th>MW (Da)</th>
<th>Diameter (Å)</th>
<th>logKow (pH=7)</th>
<th>Charge (pH=7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrazine</td>
<td>215.7</td>
<td>7.4</td>
<td>2.63</td>
<td>neutral</td>
</tr>
<tr>
<td>Caffeine</td>
<td>194.2</td>
<td>6.9</td>
<td>-0.13</td>
<td>neutral</td>
</tr>
</tbody>
</table>

Atrazine

Caffeine

![Atrazine molecule](image)

![Caffeine molecule](image)
2. Activated carbons in batch adsorption

<table>
<thead>
<tr>
<th>Carbon</th>
<th>Specific surface area (m²/g)</th>
<th>Specific pore volume (cm³/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_{\text{BET}}$</td>
<td>$S_{\text{micro}}$</td>
</tr>
<tr>
<td>HD4000</td>
<td>729</td>
<td>513.10</td>
</tr>
<tr>
<td>UC830</td>
<td>819</td>
<td>727.14</td>
</tr>
</tbody>
</table>
2. Batch simultaneous adsorption: Site competition

- Significant competition in NOM matrix;
- AER TW exerted the same competing impact as Schie RW.

- Micropollutants initial concentration: 5µg/L;
- Activated carbon dosages: 0.5mg/L- 30mg/L;
- Three matrixes: DW, Schie RW and AER TW.
2. Modelling competitive adsorption: Carbon selection

The relative removal of target micropollutant in NOM is dependent on the applied adsorbent dosage. Estimated dosages for 90% compounds removal:

- Atrazine
  - 5.21 mg/L HD4000 or 4.58 mg/L UC830
- Caffeine
  - 7.25 mg/L HD4000 or 4.23 mg/L UC830
3. Rapid Small Scale Column Test (RSSCT): Atrazine adsorption breakthrough

- Microporous F-400 was applied;
- Packed density: 0.4 g/ml with 1.15g F-400;
- Flow rate: 1.0 l/h;
- Empty bed contact time: 10.4 seconds.

- Improved atrazine breakthrough by AER pretreatment;
- The more DOC removed the better atrazine adsorbed.

AER removed “HS and BB” serves to block adsorption pores.
3. Rapid Small Scale Column Test (RSSCT): A subset of micropollutants

- Improved micropollutants breakthrough by AER pretreatment;
- The largest MW compound benefits the most.
Conclusion

- AER is not effective to reduce site competition in batch adsorption;
- Microporous carbon outperformed mesoporous carbon for less site competition.
- AER is effective to prevent pore blocking in column filtration;
- In practice, the preceding AER could possibly prolong GAC lifetime for micropollutants removal.
Thanks!
Questions?
2. Activated carbons in batch adsorption

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<td>$S_{meso}$</td>
</tr>
<tr>
<td></td>
<td>&lt;1nm</td>
<td>1-2nm</td>
<td></td>
</tr>
<tr>
<td>HD4000</td>
<td>729</td>
<td>513.10</td>
<td>70.03</td>
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Competing pore regions
- Atrazine: secondary micropore
- Caffeine: primary micropore (presumably)

UC830 with higher micropores is effective for lessening site competition.

Challenge the future