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Natural Organic Matter Membrane Fractionation: A new Approach

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Natural organic matter membrane fractionation: a new approach

Dejaeger Karlien

24th November 2022

Marjolein Vanoppen, Gabriel Billon, Justine Criquet, Cécile Vignal, Emile R. Cornelissen

Why membrane fractionation?

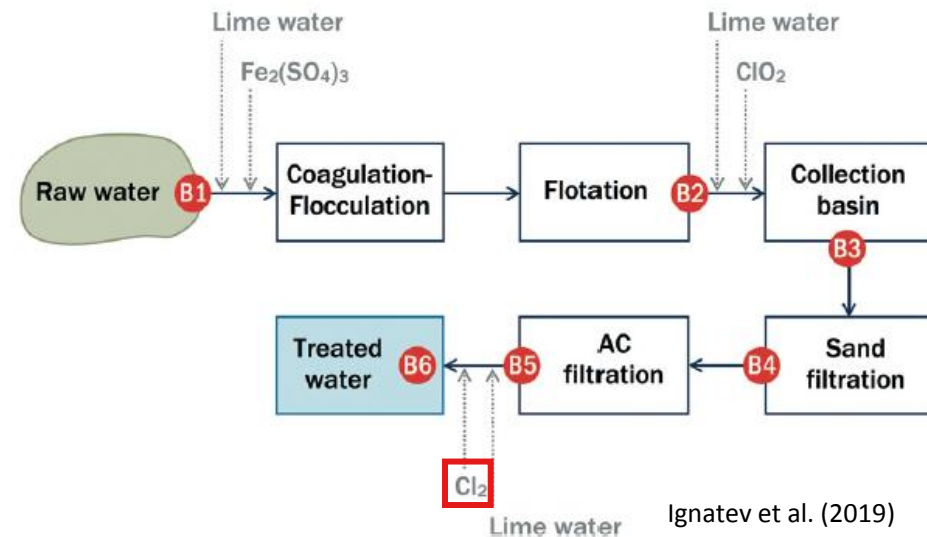
1. To split the **complex organic matter** mixture into fractions with **similar physical properties**
2. To **correlate** these properties to certain **water-related issues** such as disinfection by-product formation

Regulated ($\mu\text{g/L}$)

Trihalomethanes (THM)	Haloacetic acids (HAA)
$\begin{array}{c} \text{H} \\ \\ \text{X}-\text{C}-\text{X} \\ \\ \text{X} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{X}-\text{C}-\text{C}-\text{OH} \\ \\ \text{X} \end{array}$

Unregulated (ng/L)

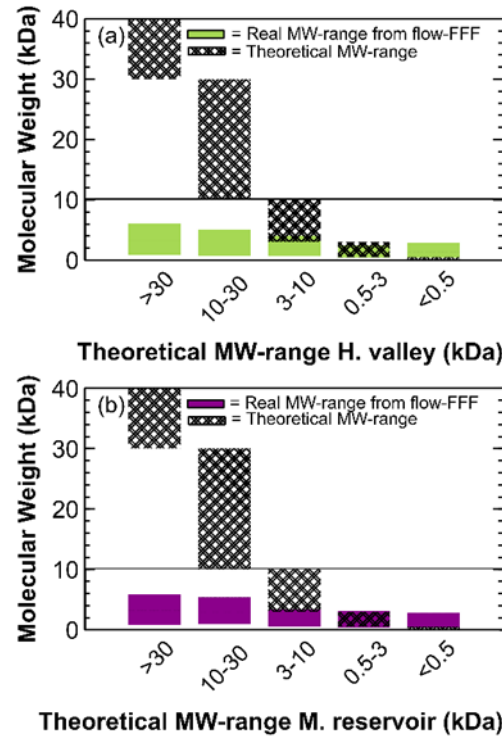
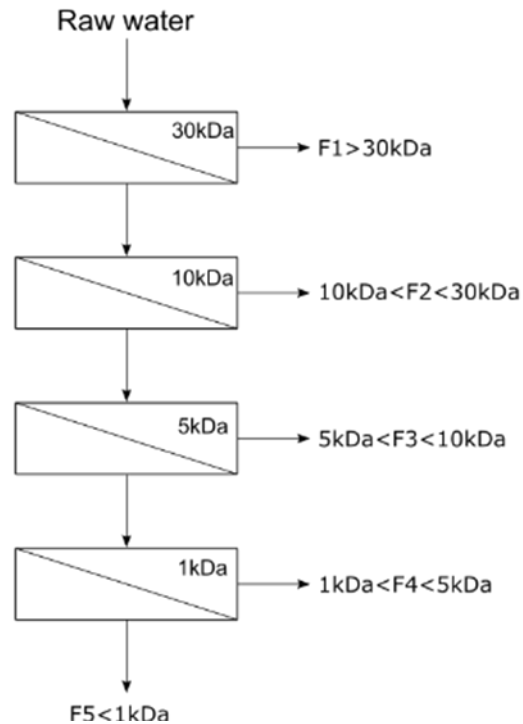
Haloacetonitriles (HAN)	Haloacetamides (HAcAm)
$\begin{array}{c} \text{X} \\ \\ \text{X}-\text{C}-\text{C}\equiv\text{N} \\ \\ \text{X} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{X}-\text{C}-\text{C}-\text{N}-\text{H} \\ \\ \text{X} \\ \\ \text{H} \end{array}$





Current approach

- Fractionation based on the MWCO of a series of ultrafiltration membranes



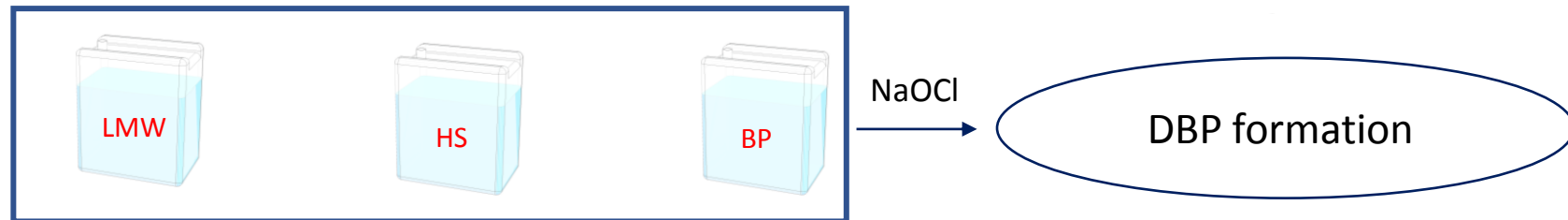
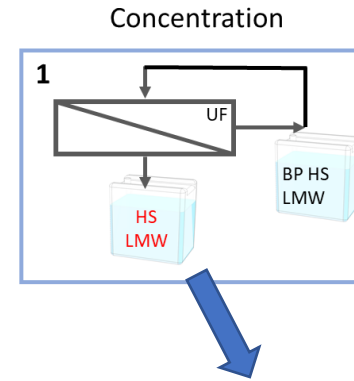
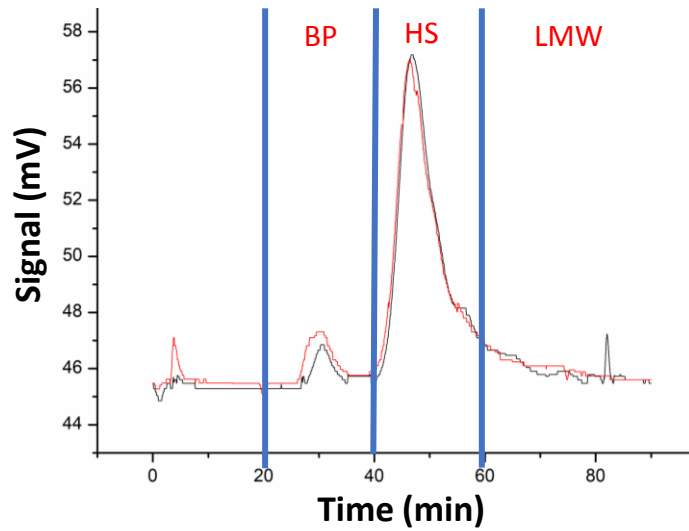
Identification of disinfection by-product precursors by natural organic matter fractionation: a review

Karlien Dejaeger^{1,2,3} · Justine Criquet² · Marjolein Vanoppen^{1,4} · Cécile Vignal³ · Gabriel Billon² · Emile R. Cornelissen^{1,4,5}



The new approach

- Fractionation based on HPSEC-TOC





STEP 1: Membrane selection

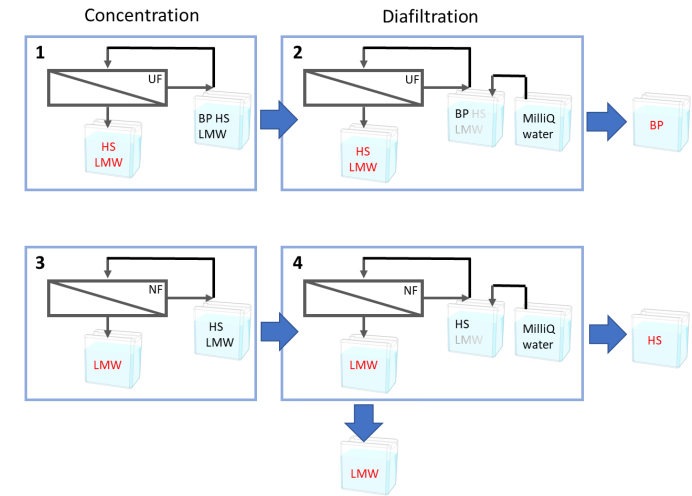
• Ultrafiltration membrane screening



Separation efficiency factor:

$$\alpha = 1 - \frac{1 - Retention_{BP}}{1 - Retention_{HS}}$$

	1 BAR	2 BAR
MT MEMBRANE	0.72	0.85
XT MEMBRANE	0.78	0.91



• Nanofiltration membrane screening



Separation efficiency factor:

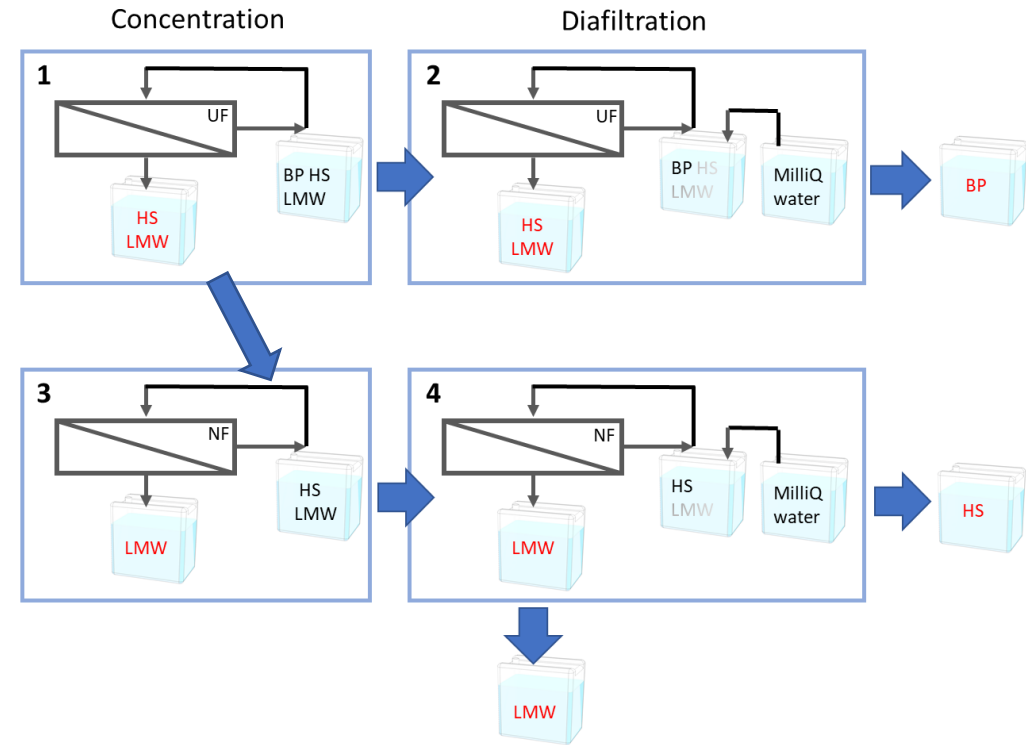
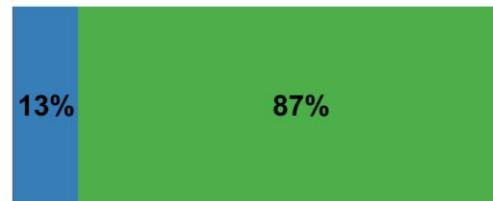
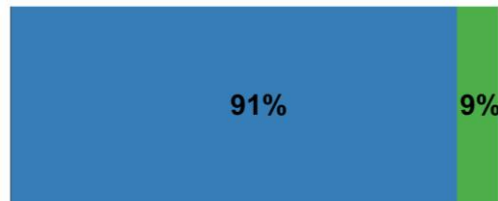
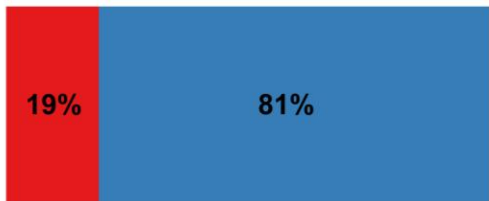
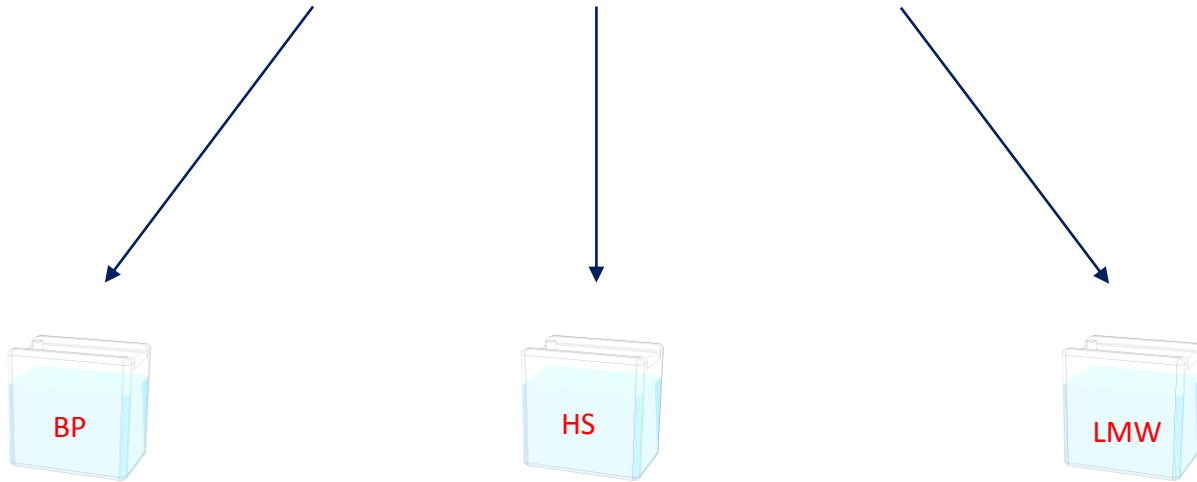
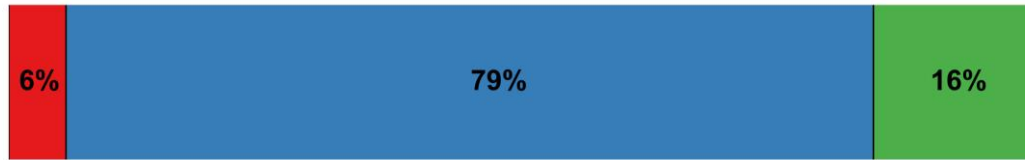
$$\alpha = 1 - \frac{1 - Retention_{HS}}{1 - Retention_{LMW}}$$

	3 BAR	5 BAR
NFW MEMBRANE	0.93	0.92
NFX MEMBRANE	0.90	0.91



STEP 2: Fractionation of surface water

Start composition:

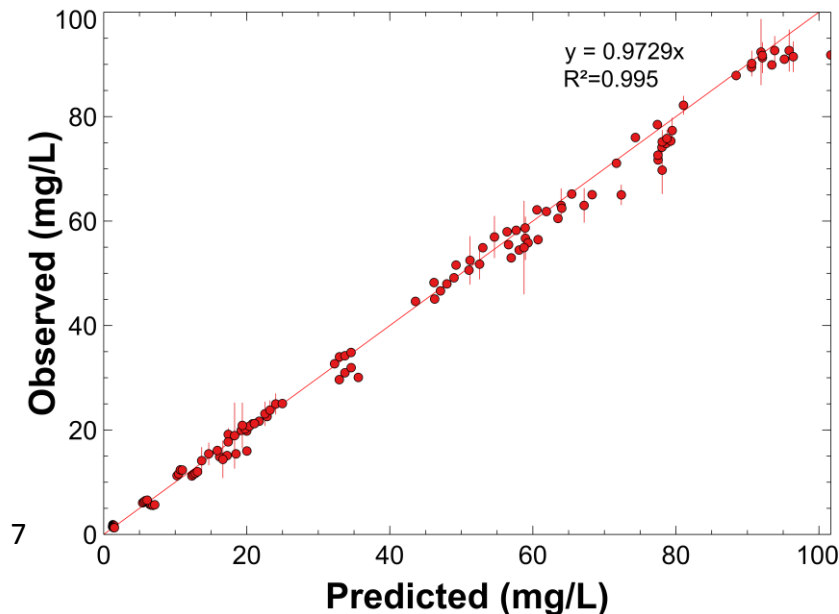




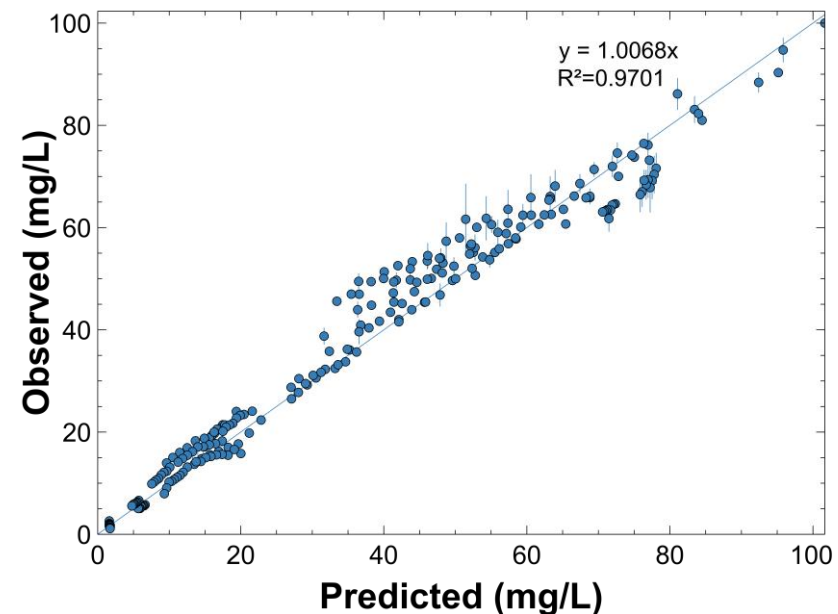
STEP 3: Massbalance model (black box) to predict fractionation

- Input variables:
 - Flux
 - Start concentration
 - Retention
- Validated during nanofiltration with a synthetic ionmatrix

Concentration



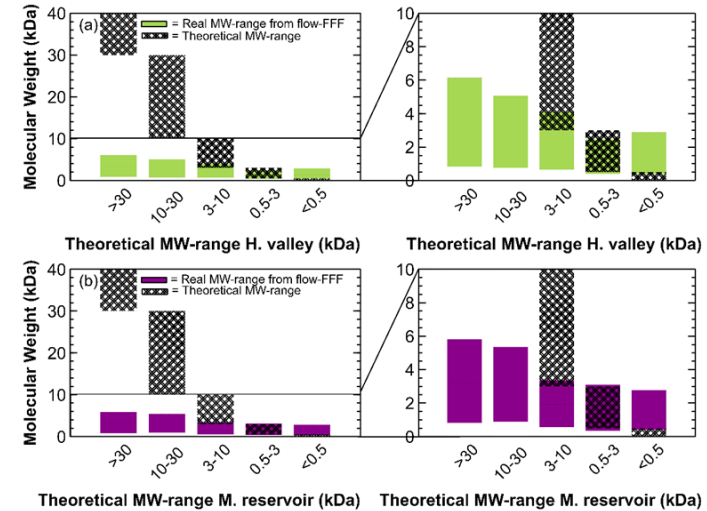
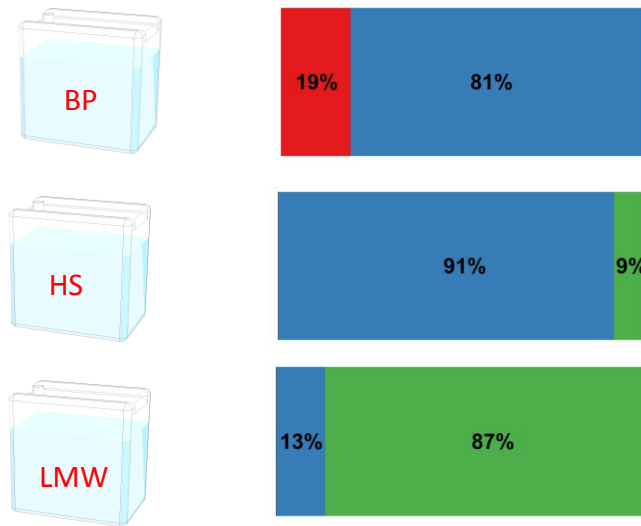
Diafiltration





Conclusions and outlook

- Fractionation based on HPSEC-TOC yields better separated fractions compared to the fractionation based on MWCO



- Improvements needed in terms of recovery

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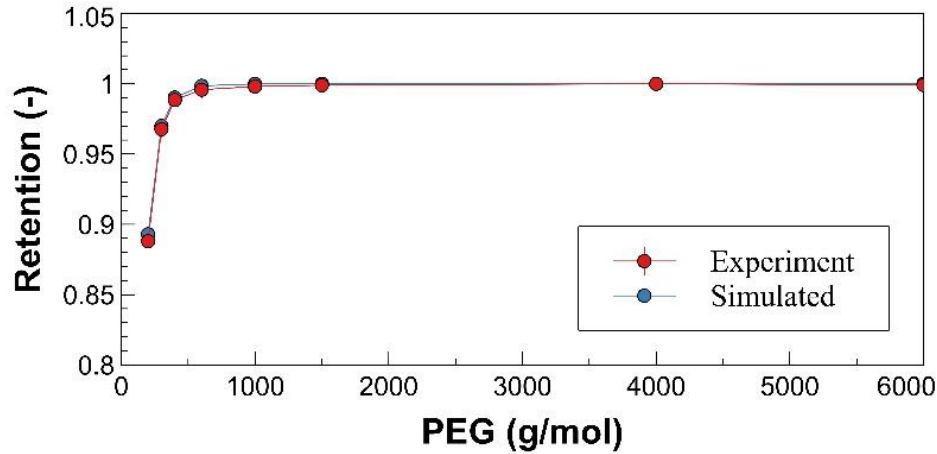
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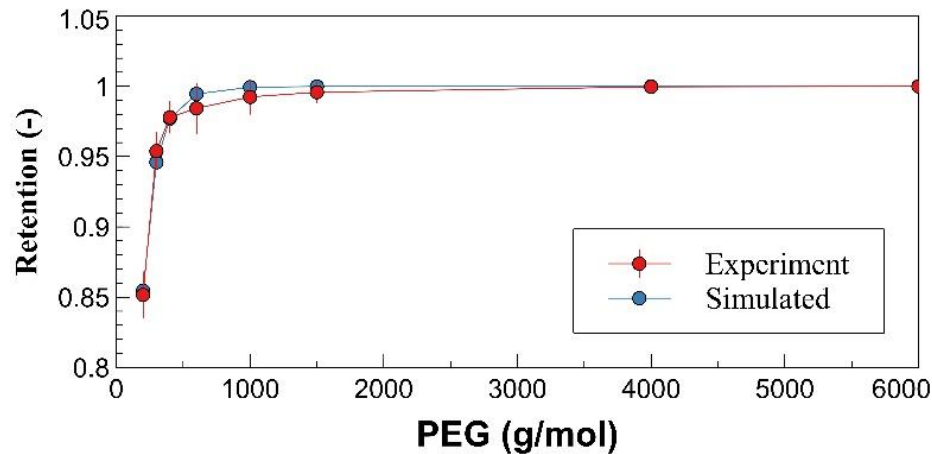
Supporting info: MWCO determination

$$R(MW^*) = \int_0^{MW^*} \frac{1}{s_{MW} * \sqrt{2\pi}} * \frac{1}{MW} * e^{-\frac{(\ln(MW) - \ln(MWCO) + 0.56 * s_{MW})^2}{2 * s_{MW}^2}} dMW$$



NFX

150-300 Da membrane → MWCO: 130 g/mol



NFW

300-500 Da membrane → MWCO: 139 g/mol



Supporting info: Flux during fractionation

