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Chemical cleaning of adsorbed pharmaceutical on NF/RO membranes

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ABSTRACT

Nanofiltration (NF) and reverse osmosis (RO) have proved to be effective in the removal of various pharmaceuticals. One of the main rejection mechanisms is interaction/adsorption since pharmaceuticals, especially hydrophobic, adsorb on membrane polymeric matrix. Albendazole as hydrophobic pharmaceutical passed through 6 different NF/RO membranes (NF, NF90, NF270, BW30, UTC-70HA, and XLE) at a pressure of 10 bar. Adsorption was confirmed with increase in concentrations of albendazole in permeate, and therefore decrease in rejection factor, and appearance of new peaks (showing new bonds) on Fourier transformation infrared (FTIR) spectra. Commercially available cleaning solution (Nalco PC99) was used to remove adsorbed albendazole from the membranes. FTIR spectra were used to confirm efficacy of cleaning agent. The results showed that commercially available cleaning solution was not appropriate for removal of adsorbed hydrophobic compound. FTIR spectra after adsorption and after chemical cleaning were similar showing that bonds (direct H-bonding between H of the OH group and N of the heterocyclic ring, stretching of C=C double bond in aromatic ring, string bending of the methyl group) between membrane polymeric matrix and albendazole were still present.

MATERIALS AND METHODS

RO membranes: BW30 and XLE (Dow-Filmtec), and UTC-70HA (Toray)
NF membranes: NF, NF90, and NF270 (Dow-Filmtec)

RO/NF protocol

1. washing conserving agent with demineralized water
   - without pressure
2. membrane pressurizing at 15 bar (2 h)
3. albendazole solution (10 mg/L) recirculation - 4 h
   - to accomplish saturation of the membranes (steady state)
4. membrane cleaning – Nalco PermaClean 99 (PC 99)
   - 1.5% w/w, pH = 12.23, T = 33.2 ± 0.3 °C
   - 30 min recirculation at an elevated temperature, 30 min soaking
5. FTIR analyzes – pristine and cleaned membranes

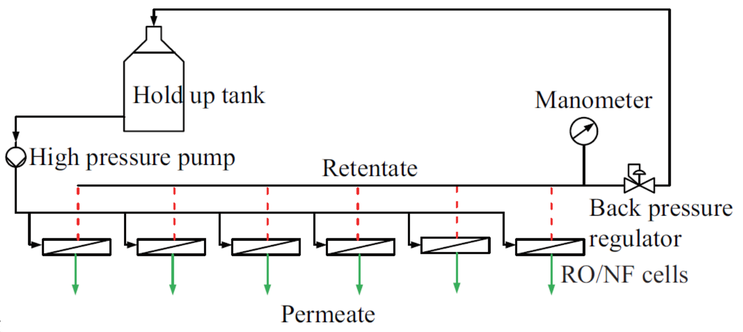
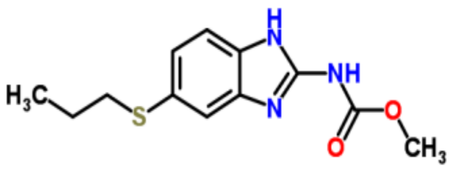
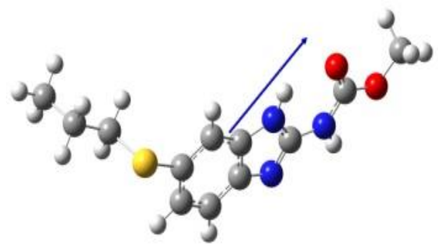


Figure 1. Shematic representation of RO/NF laboratory set-up

Albendazole (CAS number: 54965-21-8)
$C_{12}H_{15}N_3O_2S$
Mw = 265.33 g/mol
water solubility = 46.39 mg/L
μ = 4.33 D

width: 0.482 nm
height: 0.279 nm
length: 1.632 nm





RESULTS

Adsorption of albendazole

Table 1. Rejection factors (R_f) and concentrations of albendazole in permeate (γ) at the beginning (0 h) and the end (4 h) of the treatment

t / h	NF	NF90	NF270	BW30	XLE	UTC-70HA
			R_f / %			
0	73.9	79.1	64.8	78.5	78.3	**77.7**
4	44.9	62.4	45.6	62.8	64.8	**62.4**
			γ(permeate) / mg/L			
0	4.06	3.24	5.36	3.33	3.32	**3.39**
4	5.56	3.79	5.66	3.75	3.66	**3.91**

Table 2. Concentrations of albendazole in feed stream during whole treatment

t / h	γ / mg/L
0	**7.41**
1	**6.57**
2	**6.05**
3	**5.89**
4	**4.94**

Cleaning efficiency

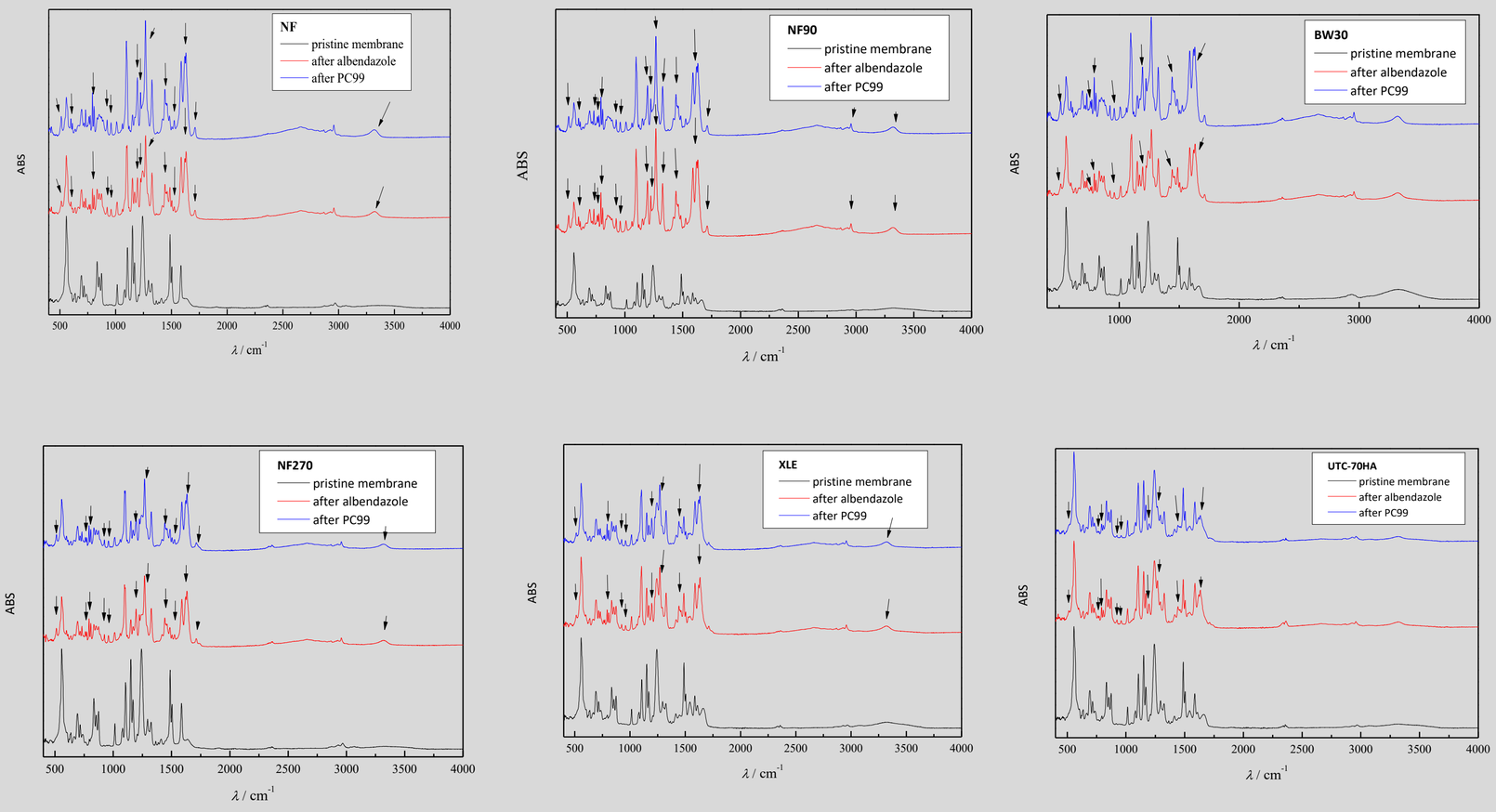


Figure 2. FTIR spectra of pristine membranes, membranes after treatment of albendazole, and after cleaning with Nalco PC99

CONCLUSIONS

- Concentration of albendazole in feed (decrease) and permeate (increase) streams, rejection factors (decrease) and FTIR spectra (new peaks) confirmed adsorption of albendazole on RO (XLE, BW30, and UTC-70HA) and NF (NF, NF90, and NF270) membranes.
- FTIR spectra as a tool to confirm an efficacy of membrane cleaning showed that all created bonds and interactions between membranes and albendazole were still present after cleaning.
- Therefore, it can be concluded that commercial chemical cleaning agent and cleaning conditions were not appropriate to desorb albendazole from investigated NF/RO membranes.

ACKNOWLEDGEMENT

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