Removal of Humic Acid and Chloroform from Drinking Water Using Commercial NF and RO Membranes

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Introduction

Removal of disinfection byproducts (DBPs) or their precursors (e.g. humic acids) becomes a mandatory issue during water treatment process due to their negative health effects [1-2]. Membrane filtration is increasingly used to remove natural organic matter (NOM) and, in particular, dissolved organic materials (expressed as dissolved organic carbon (DOC)). This technique can be applied to continuous processes, at room temperature without phase changes and, in general, without addition of chemical products. There are extensive studies on the removal of DOC using ultrafiltration (UF) membranes and some of these studies have obtained reductions in organic materials of up to 85% depending on the organic material studied and the membranes used [3-4]. Other authors obtained removal yields between 30 and 60% [5]. Thus, the efficiency of nanofiltration (NF) and reverse osmosis (RO) for the removal of chloroform (as the major component of DBPs) and humic acid (as a DBPs precursor) from water were assessed . Six different commercial membranes have been used for that purpose including NF90 and NF270 for NF and TM820, SW, BW30 and XLE for RO. The used membranes were characterized by FTIR, SEM, contact angle and zeta-potential measurements in addition to flux and permeability analysis for each membrane.

Methods

- The commercial NF and RO membranes were characterized using different techniques such as SEM, FTIR, contact angle, and Zeta potential measurements.

- Flux experiments are carried out in Dead-end mode of UF cell under certain conditions (15 bar as applied pressure, 100ml as feeding solution and 300 rpm as constant stirring speed.

- Rejection of each solute is calculated from the following equation $R = (1 - C_p/C_f)\ \%$ where Cp is the concentration of this solute in the permeate solution while the Cf is the concentration of the feed solution.

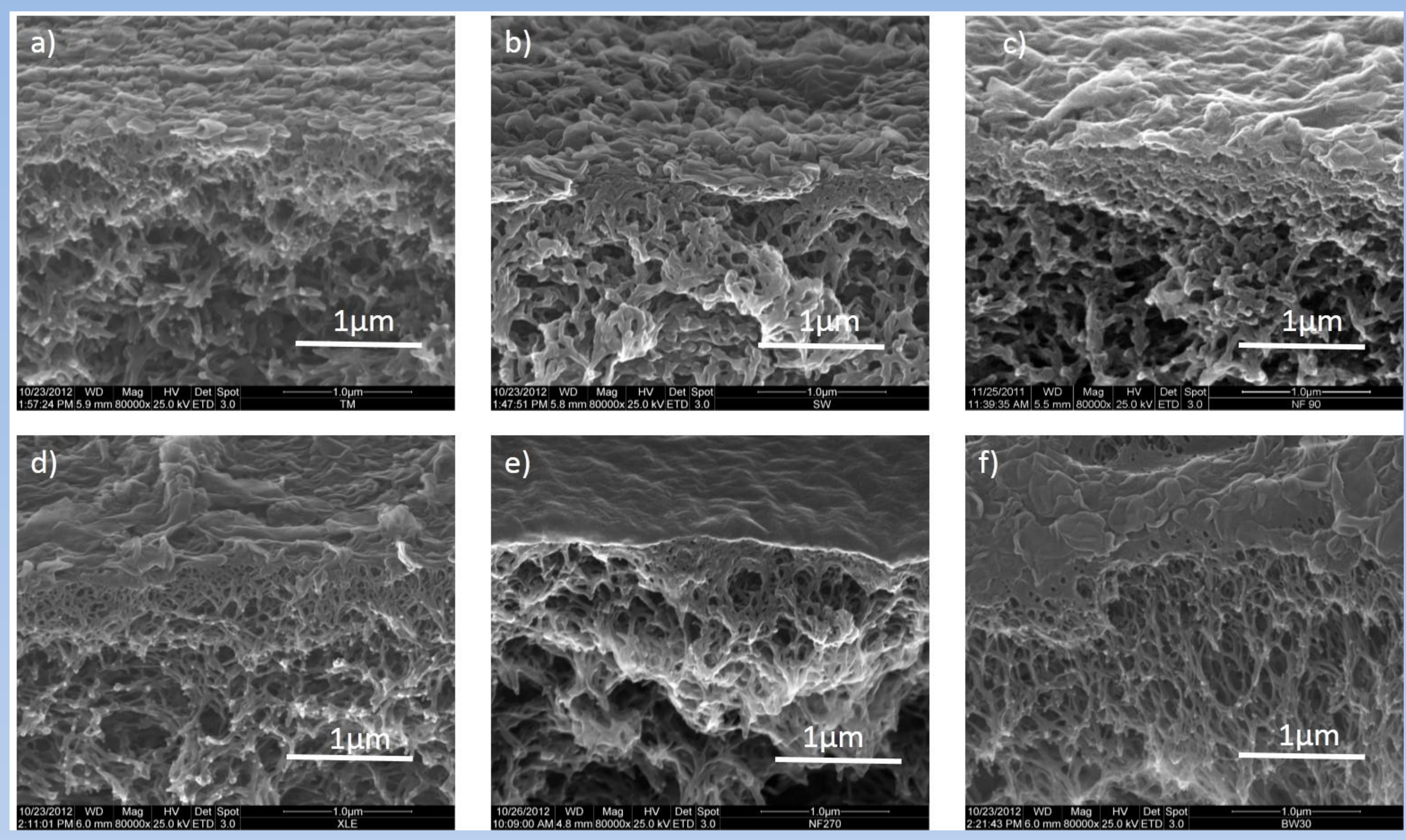

Fig.1 SEM images of as-received commercial membranes: (a) TM820 , (b) SW30 , (c) NF90, (d) XLE , (e) NF270 , (f) BW30

It is clear from Fig. 1 that the surface topography is different for the six membranes which will affect on the rejection and flux behavior for each membrane.

Results and Discussion

1- Salt rejection

NF membranes can reject more than 98% of the salts while the RO membranes the rejection exceeds 99.5% as shown in table (1). The flux decreases as the time is increasing due to the concentration polarization phenomenon at the membrane surface.

2- Humic acid rejection

NF90 removes humic acid by 98.5% while for NF270 it is about 98%. These high rejection values are due to the large M.Wt. of humic acid and the lower M.Wt cut-off for NF270. For RO membranes, it depends mainly on the membrane surface charge at different pH values so the main mechanism for the rejection is Donnan- exclusion mechanism. With time the flux of each membrane decreases and this is due to the fouling by humic acid molecules. The decreasing in the flux for the six membranes is in different due to the difference in the physico-chemical properties of each membrane. Higher roughness of the surface leads to more decreasing in the flux so that NF90 and XLE showed the largest drop in the flux for humic acid solution for 120 minutes.

3- Chloroform rejection

Chloroform is classified as non ionic hydrophobic substance which has log Kow 1.97, so the rejection mechanism is mainly governed by hydrophobic-hydrophobic interaction.
NF90 removes Chloroform by 92.1% while for NF270 it is about 76.1%. This large difference in the rejection is due Lower MWCO of NF90 compared to NF270. The RO membranes reject chloroform more than 94% due to the smaller MWCO .
TM820 shows the highest rejection of chloroform may be due to it has the lowest MWCO but the effect of Hydrophobic-Hydrophobic interactions appears by increasing the time of operation of the experiments so decreasing the rejection of chloroform by time.

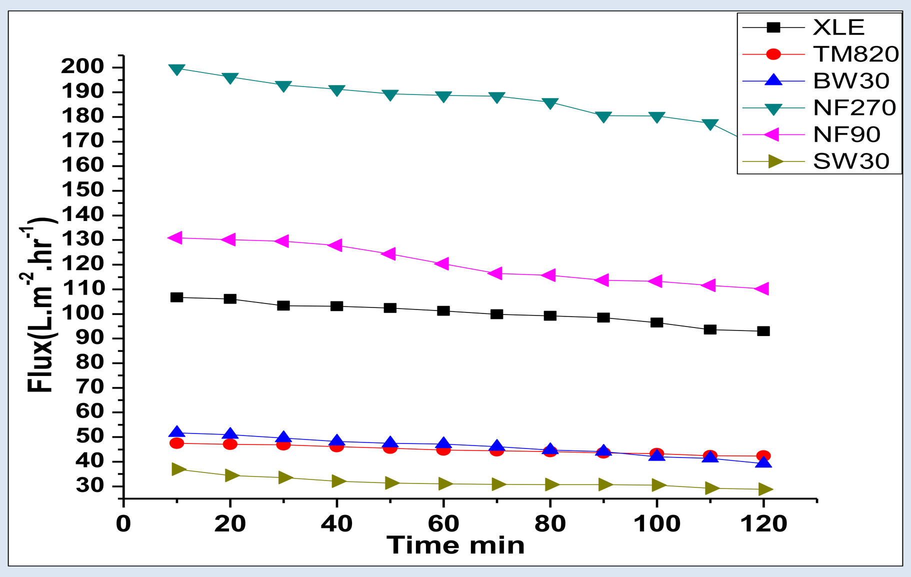

Fig. 2 Flux of the six membranes for 200ppm MgSO4

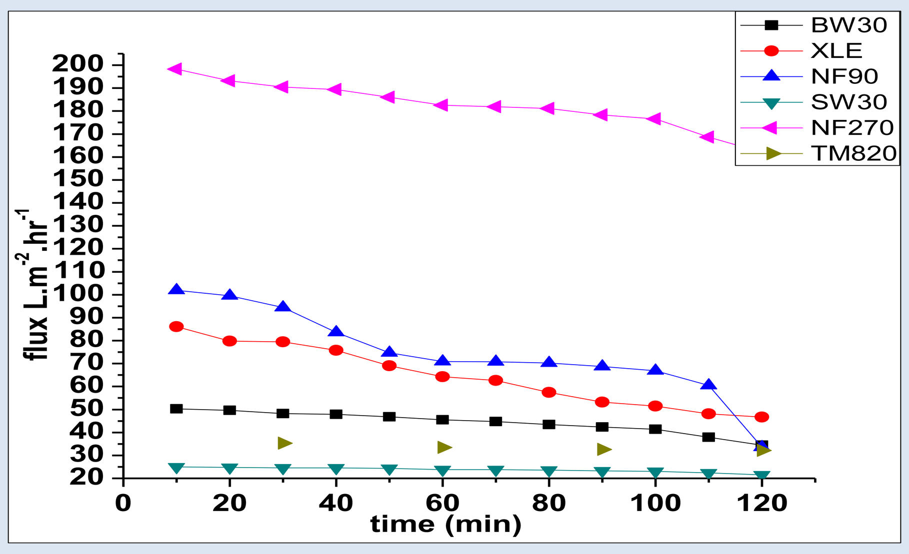

Fig. 3 Flux of six commercial membranes for 10ppm Humic acid

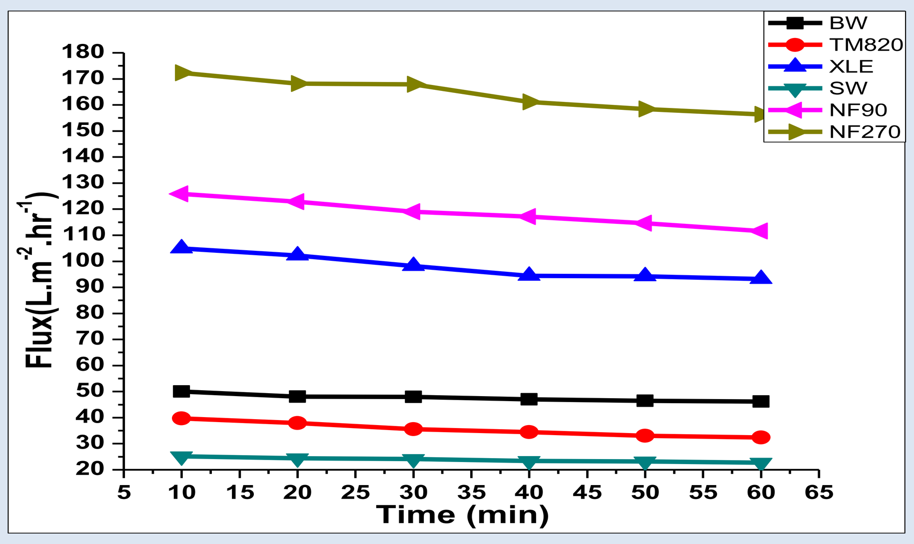

Fig. 4 Flux of the six commercial membranes for Chloroform

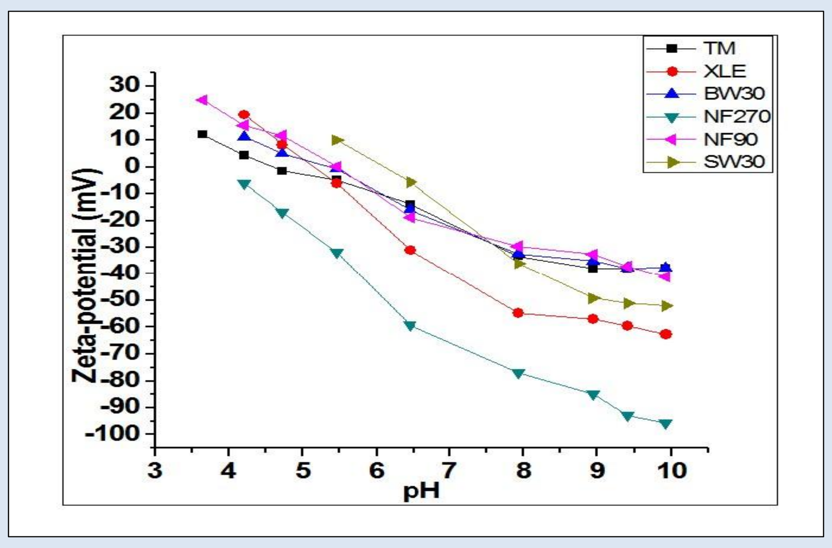

Fig. 5 Zeta-potentials values for the six membranes

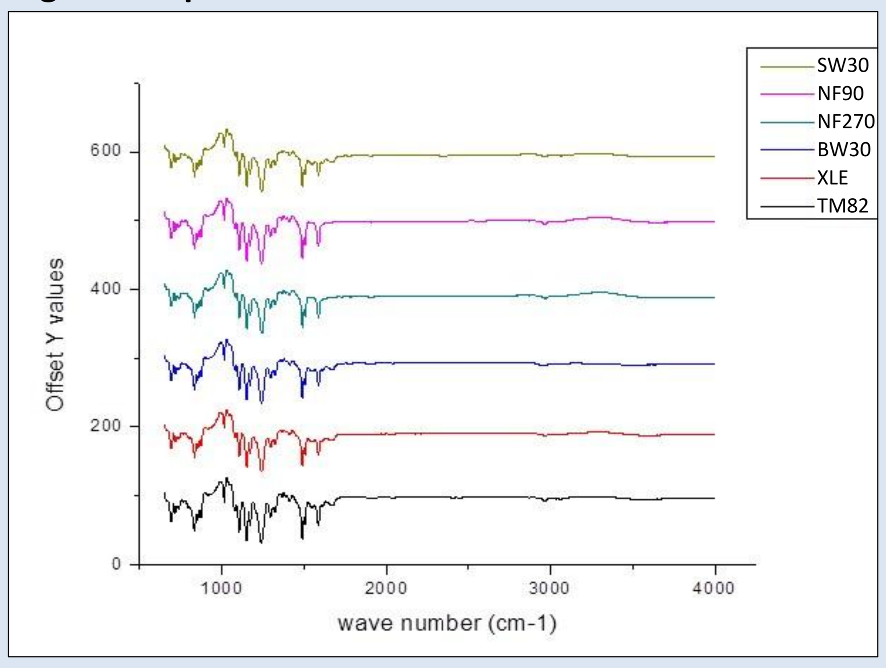

Fig. 6 ATR-FTIR Spectra of the six membranes

Membrane	200ppm MgSO4	10ppm Humic acid	100µg/L Chloroform
NF90	≥98.5%	≥98.5%	92.1%
NF270	≥98%	≥98%	76.1%
XLE	≥99.5	≥99.75	94.5%
SW30	≥99.5	≥99.75	97.3%
TM820	≥99.75	100	98.5%
BW30	≥99	≥99.5	97%

Table. 1 Rejection of the commercial six membranes

Conclusions

The performance of the RO membranes for the rejection of chloroform follows the order TM820>SW30 > BW30 > XLE. For NF membranes, NF90 rejects chloroform at higher percentage than NF270. The rejection of the NF and RO membranes depends mainly on the membrane physico-chemical characters (e.g. membrane roughness and hydrophobicity) in addition to the solute properties (e.g. log Kow and Diffusion coefficient). The overall results proved that both NF90 and TM820 can be used efficiently to control DBPs level in the produced drinking water.

Outlook

Studying the factors affecting the rejection of chloroform like the operating pressure , the effect of time and the effect of the concentration of chloroform. Rejection of other micro-organic pollutants like monochloroacetic acid and dichloroacetic acid will be performed.

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