Adherence and Removal of Powdered Activated Carbon Coatings on Ultrafiltration Membranes

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Introduction

❖Trace contaminants are adsorbed from drinking water by powdered activated carbon (PAC) that is coated on an ultrafiltration (UF) membrane.

❖Having a carbon coating is advantageous over a PAC/UF set up because it eliminates the need for an adsorption tank and can more effectively inhibit fouling of the membrane by organic matter.

❖Experiments are being performed to determine how well PAC adheres to UF membranes during backwashing, a process used to remove foulants from the membrane.

Objectives

❖To measure how well PAC adheres to UF membranes by using a polymer or ionic compound.

❖By attaching Polydimethyldiallylammonium chloride (polyDADMAC) and/or ferric chloride to the membrane, it is hypothesized that the PAC will adhere to the membrane more efficiently.

❖Ultimately, this work investigates a new method for removing contaminants from drinking water.

Experimental Methods

- 0.2 µm cellulose nitrate membranes were soaked in a 2% solution of polyDADMAC or a 2% solution of ferric chloride for six hours.
- Between 0.2 and 16 g/m^2 of PAC were deposited on the membranes using a syringe filter.
- F-400 PAC has a particle size ≤ 50 µm, while the super-powdered activated carbon (S-PAC) is 0.3 µm.
- Once the PAC is deposited, the membrane is backwashed with deionized (DI) water by turning the membrane over and repeating the filtration in reverse.
- The mass of carbon remaining adhered after backwashing is measured using image analysis. This program determines how much mass is still adhered using digital images of the scanned backwashed membranes.

Results and Discussion

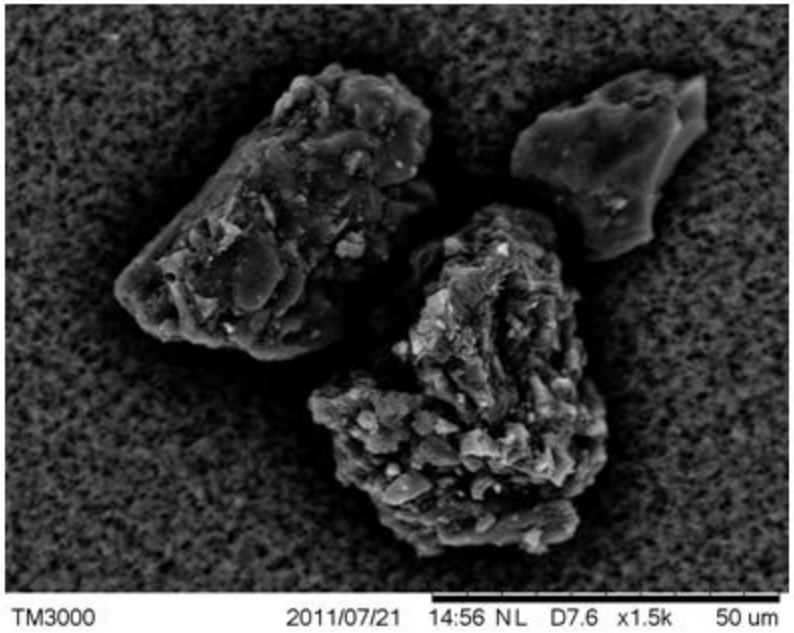


Figure 8. SEM image of F-400 PAC at 1,500x magnification.

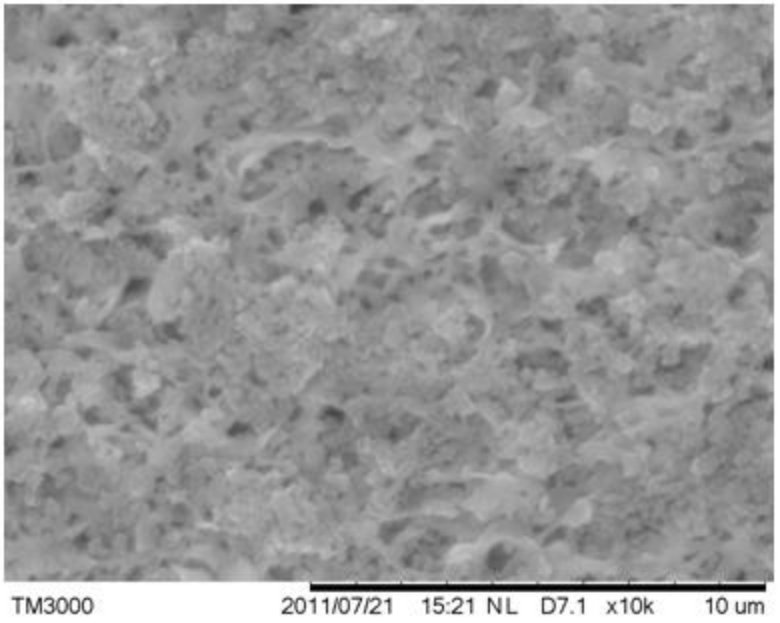


Figure 9. SEM image of S-PAC at 10,000x magnification.

Scanned Membranes

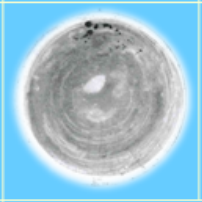
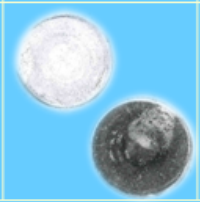
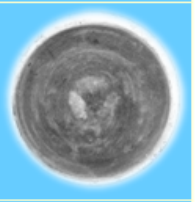
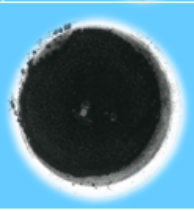
Monolayer of PAC Deposited			
	No Coagulant	With PolyDADMAC	With $FeCl_3$
Backwashed			
Not Backwashed			

Table 1. Scanned membranes of F-400 PAC adhered with polyDADMAC and ferric chloride.

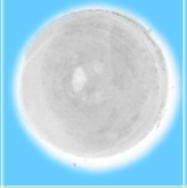
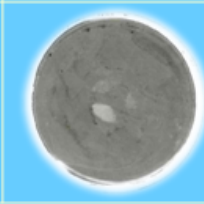
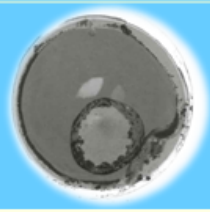
Monolayer of PAC Deposited			
	No Coagulant	With PolyDADMAC	With $FeCl_3$
Backwashed			
Not Backwashed			

Table 2. Scanned membranes of S-PAC adhered with polyDADMAC and ferric chloride.

Calibration Curves

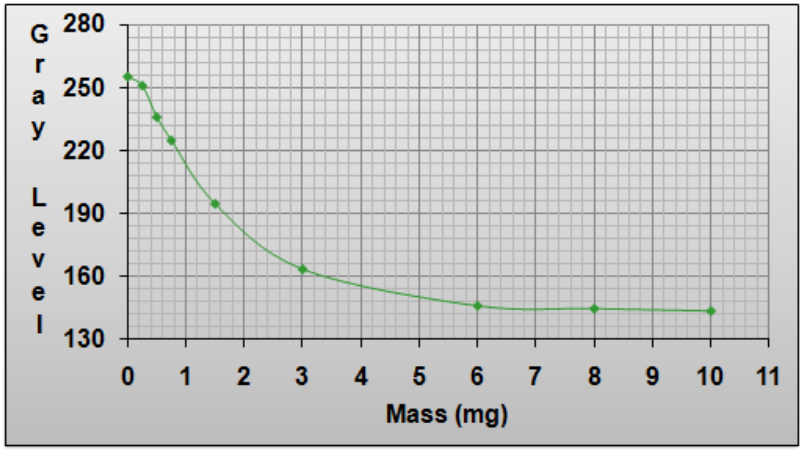


Figure 4. Calibration curve for Image analysis program to determine the mass of F-400 PAC adhered.

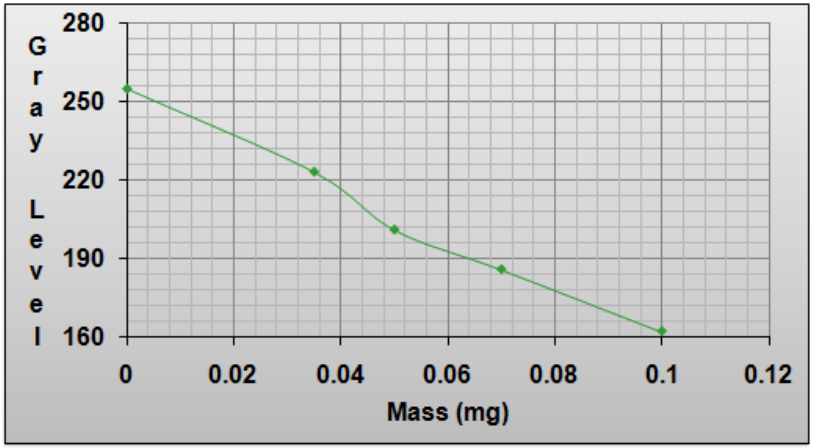


Figure 5. Calibration curve for Image analysis program to determine the mass of S-PAC adhered.

Mass and Percent Adherence of PAC

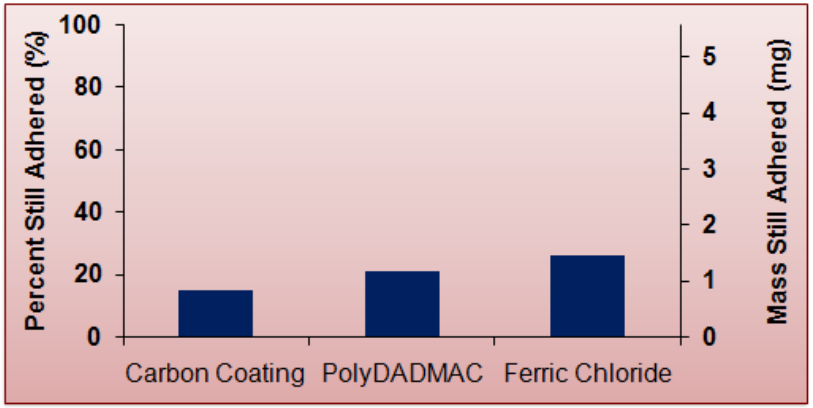


Figure 2. Mass and percent adherence of F-400 PAC to the membrane after backwashing.

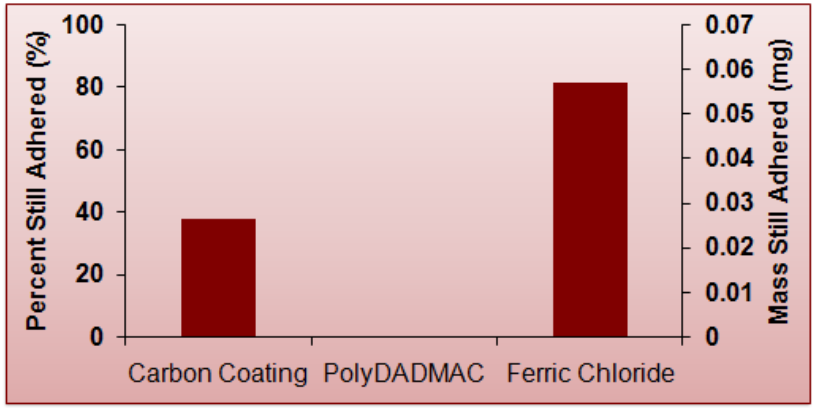


Figure 3. Mass and percent adherence of S-PAC to the membrane after backwashing.

- After backwash, 40% or less of each type of carbon coating remains adhered when neither polymer nor ferric chloride are used.
- PolyDADMAC enhanced the adherence of F-400 PAC but prevented adherence of S-PAC.
- Ferric chloride adhered the most mass for both F-400 PAC and S-PAC

Ultrafiltration Set-up

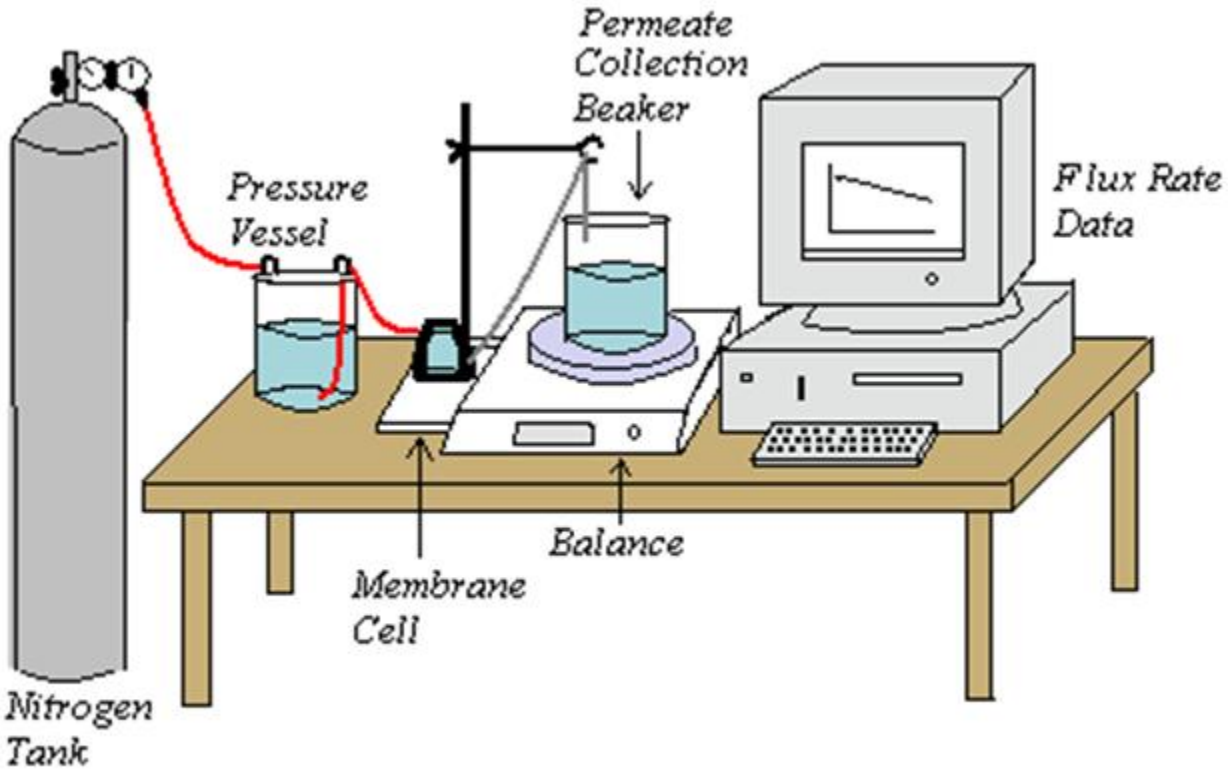


Figure 1. Ultrafiltration set up used for flux rates.

Flux Rates and FTIR-ATR Spectra

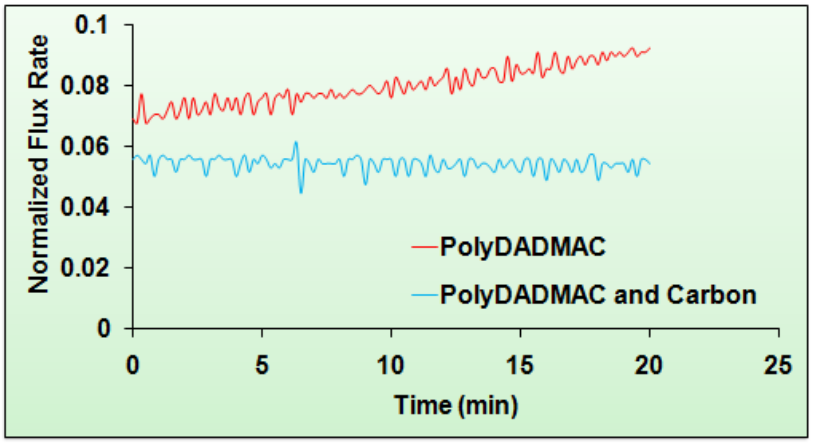


Figure 6. Flux rate of polyDADMAC and F-400 carbon. The flux rate is normalized to a blank membrane.

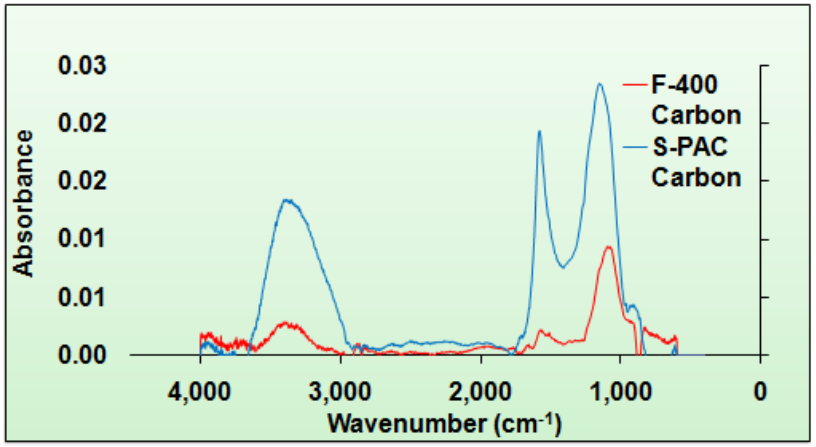


Figure 7. F-400 PAC and S-PAC Infrared Spectra. Peaks worth mentioning include a hydroxyl group at 3400, a conjugated diene at 1600, and a C-O bond at 1100 cm^{-1}.

- The polymer's flux rate was only 7% to 9% of that of the blank membrane flux. Addition of a PAC layer with the polyDADMAC decreased the flux rate to ≤ 5%. This decreased flux rate may explain such varied results in PAC adhesion.
- FTIR-ATR peaks revealed oxygenated carbon particles which may form hydrogen bonds with water and in turn can affect the adherence of polyDADMAC and ferric chloride to the carbon.

Conclusions

- Along with lowering the flux rate, PolyDADMAC inhibits S-PAC adherence and gives fluctuating results for F-400 PAC.
- Ferric chloride increases the adherence of PAC to the cellulose nitrate membrane while maintaining approximately 90% of its initial flux rate.
- Image Analysis may be a successful method to obtain the mass of PAC adhered to the membrane.
- This work may contribute to reducing the cost of removing trace contaminants in drinking water.

Future Work

- Establish a constant flux rate and even coating when filtering the powdered activated carbon onto the membrane
- Change the way polyDADMAC is used to obtain a higher flux rate which may improve PAC adhesion
- Remove the carbon from the membrane when contaminant permeate concentrations exceed a certain level
- Repeat experiments for more accurate results