Effect of Solution pH on the Retention & Flux of Aqueous Solutions of G_3-NH_2 PAMAM Dendrimer by Regenerated Cellulose Ultrafiltration Membranes

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Abstract:

A PAMAM dendrimer (from Greek dendra for tree) is an artificially manufactured or synthesized molecule built up from branched units called monomers and can be used to remove ions from water systems. It is removed through polymer enhanced ultrafiltration (PEUF), which uses partially permeable membranes to separate fluids or ions. Experiments with dendrimer to remove metal ions have been performed; however, this paper will discuss how an aqueous solution, with dendrimer alone, filters through an ultrafiltration membrane.

The focus of the project is to filter the dendrimer solution through regenerated cellulose (RC) membranes, so that we can; (a) observe the concentration of dendrimer using ultra-violet visible spectrophotometer (UV-Vis), and (b) study flux with time. The pH of solution is adjusted before being filtered through the RC membrane (3k Dalton). During the ultrafiltration process, the solution filters through a RC membrane. Filtered samples are collected in ten minute increments to record the weight while combining the samples after thirty minutes to observe the concentration. The expected results of the project should be that the concentration of dendrimer and flux of the samples should decrease as time increases.

Introduction:

Polyamidoamine (PAMAM) dendrimer is a polymer made of subunits called monomers and has a configuration similar to a branched tree (Figure 1). The PAMAM dendrimer has various generations according the number of active sites. Generation three PAMAM dendrimer has 32 active sites and is also the dendrimer used for this research project. The PAMAM dendrimer can be used to remove toxic ions from waste water systems.

This project focuses on the preliminary work before experimenting to observe how PAMAM dendrimer removes toxic ions from water systems. The research focuses on how pH levels effect an aqueous solution with dendrimer alone while filtering through a regenerated rellulose (RC) membrane by; (a) determining the retention of dendrimer using UV-Vis, and (b) measuring the dendrimer flux across the membrane with time. The retention is the percentage of dendrimer retained by the RC membrane while the permeate flux is the amount of dendrimer that pass through the RC membrane.

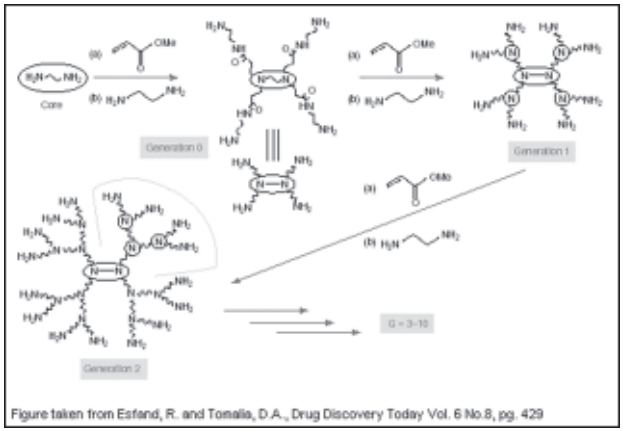

Figure 1: Dendrimer synthesis.

Procedure:

To prepare the aqueous dendrimer solution, 135 parts per million (ppm = 135 mg) of Generation 3 PAMAM dendrimer is added to one liter of dionized water. The pH of the aqueous solution is adjusted to the desired level using HNO_3 or NaOH while the RC membrane is soaked in dionized water for one hour. After the membrane has finished soaking, the membrane is then attached to the stirred cell (Figure 2, above). The control sample of the solution is collected before pouring the rest of the solution into the reservoir.

The stirred cell is attached to the reservoir and the nitrogen is turned on with the pressure being set to 450 pounds per square inch (psi). Once the solution had begun filtering through the RC membrane, samples are collected every 10 minutes for a total of 4 hours to determine the retention of dendrimer using UV-Visible Spectrometer and also measure the dendrimer flux across the membrane with time.

Results and Conclusions:

Retention is the percent of dendrimer retained by the RC membrane where as the permeate flux is the amount of dendrimer that was able to pass through the membrane. In Figure 3a, we see that the percentage of dendrimer retained by the RC membrane is higher for pH 7 than the percent retained for pH 9. We also see that the permeate flux of dendrimer is lower for pH 7 than the permeate flux for pH 9 according to Figure 3b. The two figures show that there is a relationship between the retention and permeate flux. When the percent of dendrimer retained by the membrane is high, it is clogging the pores of the membrane and therefore not allowing dendrimer to pass through the membrane. As a result, the permeate flux will be relatively low. On the other hand, when the percent of dendrimer retained by the membrane is low, the permeate flux will be high meaning that more dendrimer will pass through the RC membrane.

There is a theory, not proven, that when the pH level is adjusted to 7, the dendrimer becomes protonated. That can result in the dendrimer molecule becoming larger and therefore making the dendrimer molecules too large to pass through the pores of the membrane so more dendrimer is retained by the membrane. However, when the pH level of the aqueous dendrimer solution is adjusted to pH 9, the dendrimer molecules are not as protoned and more dendrimer molecules are able to pass through the RC membrane.

Future Work:

For future work, repeating of the experimental procedure with pH levels 7 and 9 will be necessary to check for consistency. Once there is consistency with pH levels 7 and 9, experimental procedures using different dendrimer generations (ex. Generations 4 and 5) will be performed.

The experimental procedures should also be observed at various pH levels including 4 and 11. Once the preliminary work has been finished, the experiment will be performed with metal ions (such as Copper) to study ultrafiltration of water systems.

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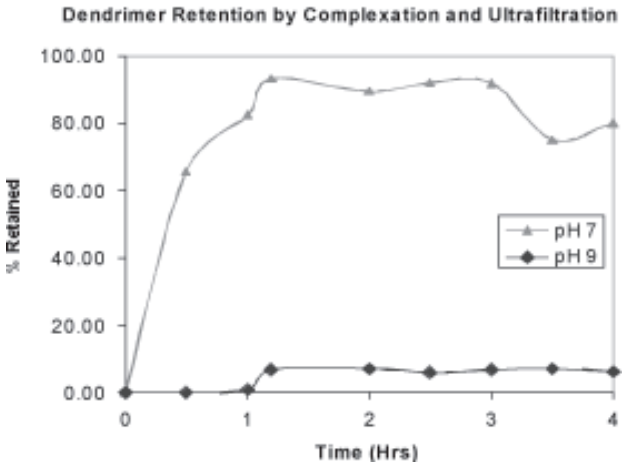

Figure 3a, above: Dendrimer retention.

Figure 3b, below: Permeate flux of dendrimer.