

Characterization of Membrane for Water Treatment: Zeta Potential Measurement by Electromobility Method

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1. Introduction

Membrane process is one of promising advanced water treatments in the aspects of removing disinfection by-products (DBPs) precursor (natural organic matter (NOM)) and pathogenic microorganisms.

There are two membranes that can be used for membrane filtration processes; polymeric membranes exhibit relatively high permeability, while, ceramic (inorganic) membranes can exhibit very high resistance to severe chemical environments. However, the performance of both membranes may substantially be reduced.

There are two major mechanisms in membrane application for solute rejection: size exclusion and charge repulsion. The pH and ionic strength of a solution can influence these solute-rejection mechanisms by changing pore size and surface charge of a membrane. Moreover, the interactions between foulants and membranes may alter the membrane performance in terms of solute rejection, thus, it should be investigated rigorously collectively.

In this study, we focused on the charge effects on membrane characteristics through iso-electric point (i.e.p.) and acidity measurements at different pH and ionic strength conditions.

For example, a membrane contains iso-electric point below pH 6, NOM in a natural water (pH=6-7) can effectively be removed by the charge repulsion between NOM acids and the negative-charged membrane surface. Different ionic strength conditions can alter the pore size and surface charge of the membrane, resulting in substantial changes in solute rejection.

2. Methods and Materials

2.1 Zeta Potential Measurement

Both the membrane surface and colloids (or particles) contain charge related properties. However, the surface charge can not be measured directly, thus, zeta potential (mV) can be used as an indicator of the surface charge. Zeta potential is the potential on the Stern layer which is located between fixed layer and diffusion layer. A commercialized electrophoretic apparatus (ELS-8000, Otsuka Electronics, Japan) was used to measure zeta potential. As a standard particle, poly styrene latex (size: 520nm) was used, and the standard particles were coated by hydroxy propyl cellulose (HPC) to prevent interactions with measurement quartz cell. The particles were dispersed in 10mM NaCl solution.

2.2 Functionality Measurement by Acidic Titration

Charge density was measured by a micro titrator (Metrohm, CH-9101). Consumed NaOH amount of 0.05N was used for the calculation of acidity in the unit of meq/g-dried membrane. The effects of ionic strength and divalent cation presence were also evaluated with additions of NaCl and Ca^{2+} .

3. Results and Discussion

3.1 Iso-Electric Point (i.e.p.) of Organic/Inorganic Membranes

The Iso-electric point was measured by plotting the measured zeta potentials as a function of pH.

Fig.1 shows that the i.e.p. of ESNA (NF, MWCO=250 mass units, Hydronautics, U.S) is somewhat smaller than that of Titania 1000 (ceramic UF,

MWCO=1000 mass units, TAMI industries, France). The ESNA membrane exhibits negative charge in the range of pH above 3.65, suggesting that negative-charge solutes (i.e., NOM acids and haloacetic

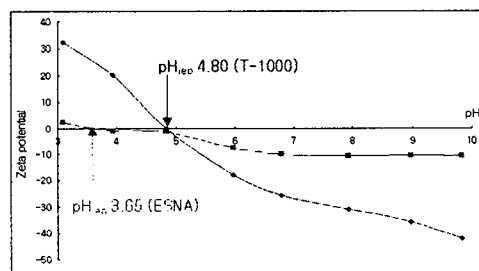


Fig 1. Zeta potential of Ceramic(T-1000) & ESNA membrane for i.e.p (I = 10mM).

acids (one of DBPs)) can easily be rejected by the charged membrane surface.

3.2 Functionality Analyses of Organic/Inorganic Membranes.

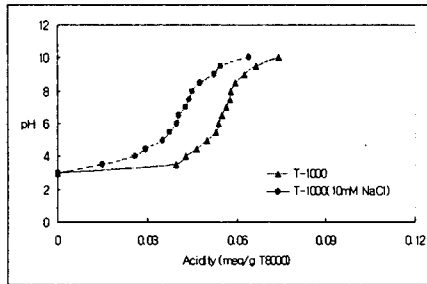


Fig 2. Ionic Strength Effect on Titania with an addition of 10mM NaCl

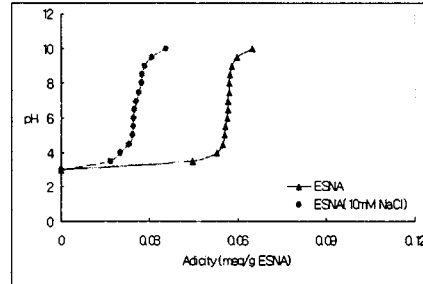


Fig 3. Ionic Strength Effect on ESNA with an addition of 10mM NaCl

Figs 2 and 3 shows the acidities (meq/g membrane) of the NF membrane under different ionic strength conditions. When there is no ionic strength adjustment, the acidity values and its trends for both NF and UF membranes are similar (ESNA: 0.057 vs. Titania: 0.058), however, at higher ionic strength (adjusted by NaCl), the acidities of the ESNA decreased more compared to the ceramic membrane (ESNA:0.028 vs. Titania:0.045). Thus, the pores size of the ESNA membrane seem to be reduced by double layer compaction that was induced by increasing ionic strength.

4. Conclusions

Through zeta potential and acidity measurements of membranes, charge interactions between negative-charged membranes and solutes were demonstrated. More rigorous characterizations of membrane surface are to be evaluated in terms of zeta potential, functional groups (by FTIR for carboxylic and phenolic groups), and pore size distribution (by solute rejection and AFM methods)

5. Acknowledgements

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6. References

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