Research Article

Comparation of Interrelation between Casting Solution and Performances for Reverese Osmosis Membranes (400-1, 400-2, 400-3)

Teuta Selimi [1], Naim Hasani [2*], Makfire Sadiku [1]

[1]Department of Chemistry, Faculty of Natural Sciences, University of Prishtina, Str. "Nëna Terezë" n.n.,10 000, Prishtinë, Kosovo.

[2]Departament of Hydrotecnics, Faculty of Engineering and Architecture, University of Prishtina, Bregu i Diellit, n.n., 10000, Prishtinë, Kosovo.

***Corresponding author's E-mail:** naim.hasani@uni-pr.edu

Received: 31-03-2017; **Revised:** 22-05-2017; **Accepted:** 08-06-2017.

ABSTRACT

The aim of this work was further improvement of performance of cellulose acetate –coal heterogeneous reverse osmosis. Three batches of heterogeneous reverse osmosis membranes (cellulose acetate – coal membranes have been investigated in this study. The concept of changes on the structure of casting solution during film formation justificate practical interest of this study. All types of membranes were tested with referent system NaCl-H_2O solution of feed concentration $6.86x10^{-3}$ mol /dm^3 and feed flow rate corresponding to a mass transfer coefficient of $45x10^{-4}$ cm/sec. The differences in the performances were attributed to the relation with casting solution and the effects of the volatility and evaporation rates of solvents. The performance data obtained with heterogeneous asymmetric membranes suggest that this membranes seen promising for treatment of waste waters.

Keywords: Reverse osmosis membrane, formamide, coal, cellulose acetate, aceton.

INTRODUCTION

Water is important for hydration and, consequently, for life. It is also essential in food preparation and cooking, sanitation and hygiene and for different uses. The safe drinking water must be free from all hazardous materials and contaminant; therefore the primary objective of drinking-water supply is to protect human health, including ensuring access to adequate quantities of safe water. Monitoring drinking water quality is an environmental issue that has big awareness these days [1].

Explosive population growth and industrial activities have been causing huge consumption of water resources and water pollution, nowadays insuring enough quality water is one of the most serious issues in the world. The extreme shortage of potable water has made countries rethink their potable water supply policies [2].

Heavy metals are elements which have atomic density more than 5. Some toxic heavy metals cause metal toxicity in living organisms. These toxic metals are major pollutants of freshwater reserves. Most of the metals are non-biodegradable, highly toxic and carcinogenic in nature. Toxic heavy metals reach through various food chains and cause toxic effects on the ecosystem as well as humans and animals. Therefore, it is necessary to treat metal-contaminated wastewater before its discharge into the environment.

Reverse osmosis (RO) technique is used mainly for the separation and fractionation of organic and inorganic substances and heavy metals in aqueous and non aqueous solutions. The RO technique can be used to treat different types of industrial effluents, viz., chemical, textile, petrochemical, electrochemical, food, paper and tannery [3].

Reverse osmosis (RO) is a separation process that uses pressure to force a solution through a membrane that retains the solute on one side and allows the pure solvent to pass to the other side. More formally, it is the process of forcing a solvent from a region of high solute concentration through a membrane to a region of low solute concentration by applying a pressure in excess of the osmotic pressure. This is the reverse of the normal osmosis process, which is the natural movement of solvent from an area of low solute concentration, through a membrane, to an area of high solute concentration when no external pressure is applied. The membrane here is semi permeable, meaning it allows the passage of solvent but not of solute. The membranes used for reverse osmosis have a dense barrier layer in the polymer matrix where most separation occurs. In most cases the membrane is designed to allow only water to pass through this dense layer while preventing the passage of solutes (such as salt ions) [4].

Membrane separation processes have been found greatly used in industrial applications as an alternative to thermal separation process. Some of the advantages of membrane process are low energy consumption, high product quality, and, flexible design and installation. Seawater desalination, waste reduction, food processing, biotechnology and medical applications are some of the processes where membranes are used [5].

Reverse osmosis can filter chemically contaminated water, brackish water, or seawater, removing minerals, chemicals, toxins, and dissolved and undissolved substances [6].

Membrane technology has become increasingly promising in removing heavy metals from wastewater and improving water recovery rate due to its high efficiency and low cost [7, 8].

Recent studies have revealed that mixed matrix membranes made by embedding porous materials in a polymeric matrix may considerably enhance membrane properties such as selectivity, surface area, permeability, stability, or catalytic activity in various membrane separation processes [9].

Heterogeneous RO membranes have been developed recently from cellulose acetate and coal. By inclusion of coal in casting solution of cellulose acetate, the product rate of membranes was improved in comparison with CA membranes. It is attributed to inclusion of coal particles into membrane, affecting active and porous layer, changing rheology of the membranes, as well as the morphology of polymer chains. The method based on cellulose acetate modified with coal created by the phase inversion process seems to be a very promising method for preparation of heterogeneous RO membranes [10].

MATERIALS AND METHODS

Materials

Cellulose acetate Eastman Kodak 398-3 with a degree of acetylating of 39.85 % and Kosovo coal namely lignite was used for preparation of heterogeneous asymmetric membranes acetate cellulose- coal.

The powdered coal was treated with water at 353 K under stirring conditions to remove all dissolved materials, i.e. inorganic part, color, etc. The residual coal after filtering was dried at 378K to constant weight, ground and sieved. The coal fraction of <0.12 match particle size was used in this study.

Membrane preparation- casting and coagulations conditions

System of two solvents (acetone and formamide), has been used for membranes preparation. The weight ratio of cellulose acetate to dispersed coal particles in the casting solution was respectively, 1:1 for (400-1), 1:1.25 for (400-2) and 1:1.5 for (400-3) membrane.

Table 1: Composition of casting solutions (membrane batches 400-1, 400-2 and 400-3)

	Concentration of components in the casting solution in % w/w				
Film. No	cellulose acetate	coal	acetone	formamide	
I	17	17	46	20	(400 -1)
II	10	12.5	48.5	29	(400 -2)
III	10	15	47	28	(400-3)

The temperature of casting solution and casting atmosphere was 297 K, and the casting was done in ambient with air relative humidity, 60%. The films were cast on a clean glass plate (22 x 38 cm) using a metal cylinder with uplifted edges to obtain the required film thickness (0.12 mm). The glass plate was kept at the same temperature as the casting solution. The casting was done practically without any evaporation period, i.e. the cast solution was immediately dipped into a gelatin bath consisting ice cold water without any solvent evaporation period. Coagulation was performed in water bath. The duration of the film setting in ice cold water was 1h. Before the reverse osmosis experiments the membranes were preshrunk under water at 362 K. And initially each film was subjected to pure water pressure treatment for 1h at 20% higher pressure than that to be used in reverse osmosis run. All experiments were of the short run type, and performed at laboratory temperature.

The RO experimental procedure was the same as described in the previous article [11].

RESULTS AND DISUSSION

Table 2 shows the experimental results for NaCl solution as reference system, obtained with different batches of films casted under the same conditions.

In Figure 1 are shown comparative characteristics of membranes (400-1), (400-2) and (400-3), for NaCl system as a referent system.

From Table 2 and Figure 1 it can be seen that increasing of coal amount increase the product rate of NaCl solution as a reference system. Product rate and separation are greater for membranes 400-3 than 400-2, while 400-1 membranes indicate small product rate but separation reaches up to 90%. This indicates that the amount of small coal has no influence in changing the structure of the surface of these membranes and membrane are very similar to the asymmetric membranes of cellulose acetate [12].

The experimental data of heterogenous reverse osmosis membranes for aqueous solution of $CuSO_4$, are presented in Table 3 and graphically in Figure 2.

The same performance as for the reference system is also for the $CuSO_4$ system (Table 3 and Figure 2). Solution separation is greater for 400-1 however the product rate is low.

Table 2: The performance of (400-1), (400-2) and (400-3) membranes for NaCl system as a referent system

Membrane (400-1)	Temp. of processing (K)	Separation (%)	Product Rate (g/h)	Pure Water Permeation Rate (g/h)
1	362	88.94	22.25	23.84
2	362	84.22	22.59	22.45
3	362	79.51	18.593	18.49
4	362	78.41	22.61	27.90
5	362	75.64	28.91	28.57
Membrane (400-2)	**Temp. of processing (K)**	**Separation (%)**	**Product Rate (g/h)**	**Pure Water Permeation Rate (g/h)**
1	362	50.00	66.18	70.55
2	362	50.30	65.26	69.39
3	362	59.71	48.71	53.22
4	362	51.46	81.29	84.81
5	362	50.33	66.18	63.2
6	362	70.55	66.81	69.33
Membrane(400-3)	**Temp. of processing (K)**	**Separation (%)**	**Product Rate (g/h)**	**Pure Water Permeation Rate (g/h)**
1	362	70.45	41.63	44.96
2	362	63.31	50.21	61.31
3	362	61.62	84.64	103.86
4	362	58.7	84.43	94.05
5	362	52.20	111.16	120.41
6	362	55.71	132.25	127.77

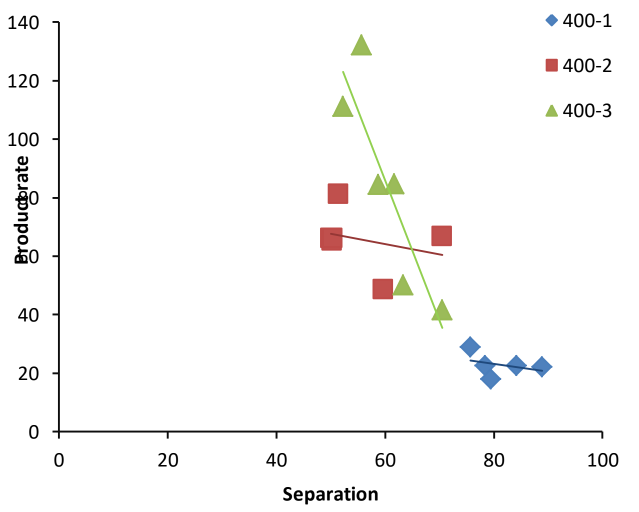

Figure 1: Comparative characteristics of membranes for NaCl system. Conditions: Feed conc.: 6.8 * 10^{-3} mol/dm^3, Film area: 11.92 cm^2, Mass transport coefficient: 45.10 * 10^{-4} cm /s, Operating pressure: 17.63 * 10^5 Pa.

Increasing the coal quantity in the membrane, affects the increase of product rate of solution but also separation is quite good.

The observed effect is attributed to the changes in morphology of membranes due to coal-polymer interaction.

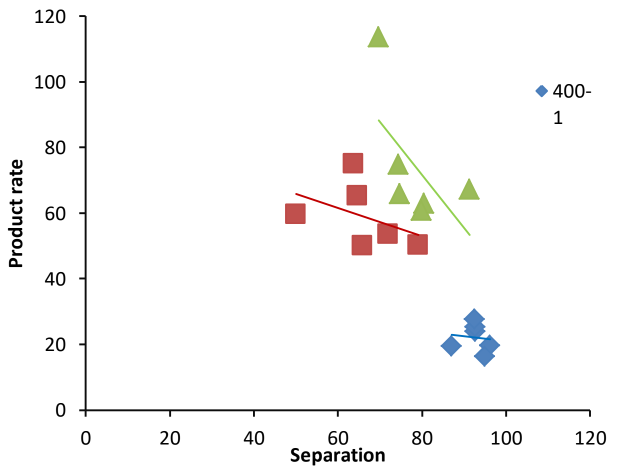

Figure 2: Comparative characteristics of membranes for $CuSO_4$ system. Conditions: Feed conc.:6.8 * 10^{-3} mol/dm^3, Film area: 11.92 cm^2, Mass transport coefficient: 45.10 * 10^{-4} cm /s, Operating pressure: 17.63 * 10^5 Pa.

Table 3: The performance for membranes (400-1), (400-2) and (400-3), for CuSO4 system.

Membrane (400-1)	**Temp. of processing (K)**	**Pure Water Permeation Rate (g/h)**	**Product Rate (g/h)**	**Separation (%)**
1	362	21.87	19.50	87.07
2	362	25.06	23.83	92.78
3	362	58.23	19.66	96.14
4	362	23.71	16.36	95.0
5	362	26.20	25.33	92.78
6	362	27.97	27.55	92.50
Membrane (400-2)	**Temp. of processing (K)**	**Pure Water Permeation Rate (g/h)**	**Product Rate (g/h)**	**Separation (%)**
1	362	66.54	65.32	64.7
2	362	60.1	59.65	50.0
3	362	49.8	50.01	65.9
4	362	74.87	75.01	63.72
5	362	52.35	53.54	72
6	362	48.99	50.22	79.11
Membrane (400-3)	**Temp. of processing (K)**	**Pure Water Permeation Rate (g/h)**	**Product Rate (g/h)**	**Separation (%)**
1	362	93.27	91.27	67.18
2	362	75.24	74.48	51.6
3	362	73.71	69.78	59.0
4	362	77.10	74.78	65.8
5	362	82.57	80.54	62.89
6	362	83.07	79.98	60.86

CONCLUSION

The improvement of productivity of membranes is result of the coal addition in casting solution. From the different proportions by weight of celulose acetat-coal, the better results had given dhe membranes 400-3 (proportion of celulose acetat-coal, 1:1.5).

REFERENCES

1. Janna H, Abbas MD and Mojid MH, Demineralized Drinking Water in Local Reverse Osmosis, Journal of Geoscience and Environment Protection, 4, 2016, 104-110.
2. Seyed ZA, Hashemian J, Ghaneian TM, Performance Study of Reverse Osmosis Plants for Water Desalinationin Bandar-Lengeh, Iran, Journal of Community Health Research, 2(1), 2013, 8-14.
3. Malik DS, Jain CK, Yadav AK, Removal of heavy metals from emerging cellulosic low-cost adsorbents: a review, Appl. Water. Sci., 2016, 1-24.
4. Bakalár T, Búgel M, Gajdošová L, Heavy metal removal using reverse osmosis, Acta Montanistica Slovaca, 14(3), 2009, 250-253.
5. Aljendeel HA, Removal of heavy metals using Reverse Osmosis, Journal of Engineering, 17(3), 2011, 647-658.
6. Wimalawansa SJ,Purification of Contaminated Water with Reverse Osmosis: Effective Solution of Providing Clean Water for Human Needs in Developing Countries, International Journal of Emerging Technology and Advanced Engineering Website: 3(12), 2013, 75-89.
7. Feini L, Guoliang ZH, Qin M, Hongzi ZH, Performance of Nanofiltration and Reverse Osmosis Membranes inMetal Effluent Treatment, *Chinese Journal of Chemical Engineering*, 16(3), 2008, 441—445.
8. Hussein J, Mukhtar DA, Mukhlis HM, Water Treatment Stations and the Potential Effect on Human Health, *Journal of Geoscience and Environment Protection*, Journal of Geoscience and Environment Protection, 4, 2016, 104-110.
9. AL-Sheetan Kh M, Shaik RM, AL-Hobaib AS, Alandis NM, Characterization and Evaluation of the Improved Performance of Modified Reverse Osmosis Membranes by Incorporation ofVarious Organic Modifiers and SnO2 Nanoparticles, Journal of Nanomaterials, 2015, 11.
10. Gashi TS, Daci MN, Selimi T, Berisha S, Preparation and properties of cellulose acetate coal heterogeneous reverse osmosis membranes, Environ. Prot. Eng., 26, 2000, 29.
11. Selimi T, Sadiku M, Berisha A, Berisha V, Separation of Heavy Metals Salts from Aqueos Solutions by Reverse Osmosis Membranes (317K-2), Int. J. Pharm. Sci. Rev. Res., 40(2), 2016, 283-287.
12. Sourirajan S, Reverse Osmosis, Logos Press, Ltd. London, 1970.

Source of Support: Nil, **Conflict of Interest:** None.