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Analysis of Chemical Cleaning of Reverse Osmosis Membrane Fouled by Textile Wastewater

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Abstract: Membrane cleaning is an integral part of operation for filtration systems in the industry and has significant impact on process operations as it can improve the permeability and selectivity of a membrane process. The choice of cleaningmethod depends on the nature of the foulant and membrane material and the best method for identifying the type of foulant is the extensive analysis of feed. Chemical cleaning of the textile wastewater-fouled spiral wound reverse osmosis membrane completely fouled by textile wastewater was experimentally investigated.H_2SO_4, HCl, NaOH and EDTAat five different concentrations (0.1, 0.25, 0.5, 0.75 and 1.0 percentage) were used as the cleaning agents with a cleaning time of 1 and 2 hours. The effect of surfactant (sodium dodecyl sulfate) on performance of cleaning chemicals was studied. The degree of membrane cleaning was determined in terms of percentage of foulant removal which, in turn, was determined using optical method. The percentage of foulant removal increased with increase in cleaning time, increase in chemical concentration, increase in surfactant concentration,and increase in temperature. The cleaning performance differed from one cleaning chemical to the other.
Keywords: Membrane cleaning; RO membrane; chemical cleaning; reverse osmosis.

Introduction:

Membranefiltration is one of the important technologies applied for the purification, recovery and reuse of water since it involves no phase change and no use of chemicals[1]. *Reverseosmosis* (RO) is applied in a wide range of fields, such as chemical, medical, textile, petrochemical, electrochemical, water treatment, biotechnology and environmental industries as it has high efficiency in selective mineral rejection, high permeability to the water, low cost requirements, environment friendly operations, no requirement of heat, no chemical requirement[2].Despite these advantages, reverse osmosis has several drawbacks to overcome; especially, fouling of membranes is the most important problem in reverse osmosis desalination since economy of the process is highly influenced by membrane fouling rate and effectiveness of fouling control[3]. *Membranecleaning* is an integral part of operation for filtration systems in the industry and has significant impact on process operations as it affects the permeability and selectivity of a membrane process[4]. Cleaning can be defined as "a process where material is relieved of a substance which is not an integral part of the material"[5,6]. The cleaning method depends on the module configuration, membrane resistance and nature of the foulants, which must be selected in such a way that the cleaning process must remove deposits and restore the normal capacity and separation characteristics of the system. The choice of cleaningmethod depends on the nature of the foulant and membrane material and the best method for identifying the type of foulant is the extensive analysis of feed. Chemical cleaning of the textile wastewater-fouled spiral wound reverse osmosis was experimentally investigated for this study.

Experimental:

Chemical cleaning of reverse osmosis membrane was experimentally investigated using spiral wound polysulfone RO membrane completely fouled by textile wastewater. H_2SO_4, HCl, NaOH, KOH and EDTAat 0.1, 0.25, 0.5, 0.75 and 1.0 percentage concentrations were used as the cleaning agents with a cleaning time of 1 and 2 hours. Sodium dodecyl sulfate, at 0.05 and 0.10 mM concentrations, was used as the surfactant. The polysulfone reverse osmosis membrane, completely fouled by textile wastewater, was collected from the common effluent treatment plant, SIPCOT, Perundurai, Tamilnadu. The fouled membrane samples, placed in cleaning chemicals contained in conical flasks, were cleaned using orbital shaker operated at 100 and 150 rpm. All the experiments were conducted at four different constant temperatures viz., 30, 40, 50 and 60°C. The degree of membrane cleaning was determined in terms of percentage of foulant removal which was determined using optical method.

Results and Discussion:

Cleaning time (1 and 2 h), concentration of the cleaning chemicals (0.1, 0.25, 0.5, 0.75 and 1.0 percentage), concentration of the surfactant (0.05 and 0.10 mM), temperature (30, 40, 50 and 60°C), and operating speed of orbital shaker (100 and 150 rpm) are the parameters studied for observing the percentage of foulant removal.

1. Cleaning Time:

Fig.1 shows the effect of cleaning time on percentage foulant removal at 30 °C for a concentration of 0.75 percentage of all the five chemicals used.The removal of foulant increased with increase in cleaning time and had no significant effect after reaching certain degree of membrane cleaning. However, the effective cleaning time differed from one cleaning chemical to the other and also from one concentration to the other.

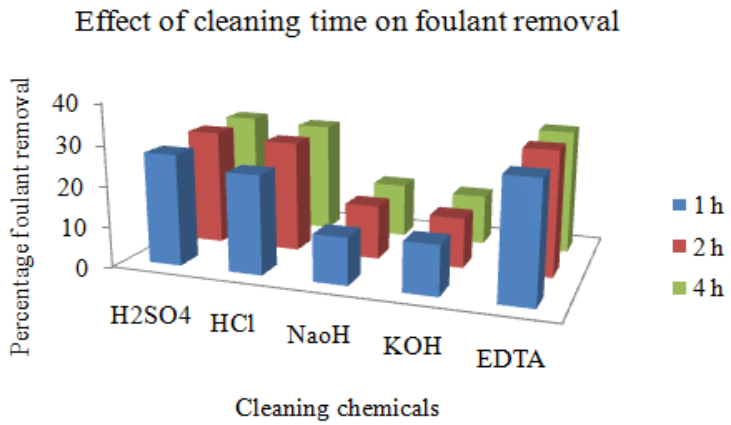

Fig. 1: Effect of cleaning time on membrane cleaning at 30 °C for a concentration of 0.75 percentage

2. Concentration of Cleaning Chemicals:

The percentage foulant removal increased with increase in concentration of the cleaning chemicals and acids showed more effective cleaning than the bases. However, the use of cleaning agents at higher concentrations may significantly affect the mechanical strength of RO membrane. The removal of foulants,for a cleaning time of 1 hour at 30 °C, was plotted against five different concentrations viz., 0.1, 0.25, 0.5, 0.75 and 1 % of all the five cleaning chemicals used in this study and the results are presented in Fig. 2. Results of this study showed that at lower concentrations EDTA showed a better cleaning but at higher concentrations sulphuric acid cleaned the membranes effectively.

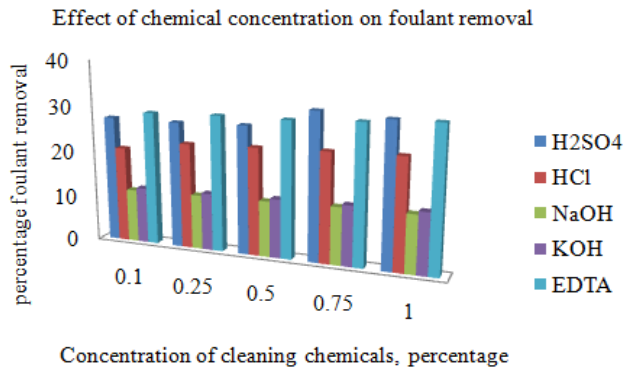

Fig. 2: Effect of concentration on membrane cleaning for a cleaning time of 1 hour at 30 °C

3. Temperature:

Increase in temperature showed a steep and continuousimprovement in membrane cleaning. However, the swelling of the gel layer at higher temperature might also contribute to weakening of the membrane's structural stability. In general, acids showed comparatively better cleaning than bases for an increase in temperature where sulphuric acid peaked in its cleaning efficiency and EDTA came next to it. Fig. 3 shows the effect of temperature on foulant removal for a cleaning time of 4 hours and cleaning chemical concentration of 1%.

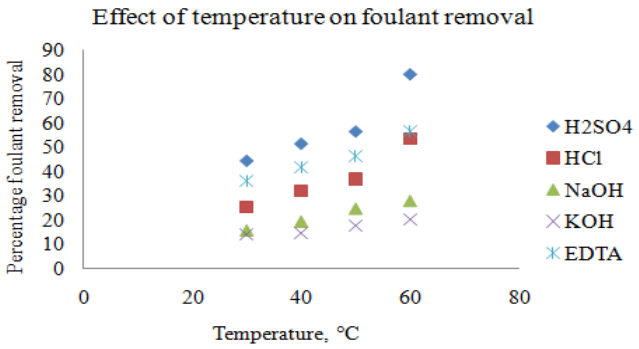

Fig. 3: Effect of temperature on membrane cleaning for a cleaning time of 4hours and concentration of 1%.

4. Surfactant:

Fig. 4 shows the effect of surfactant on foulant removal for 1% concentration of cleaning agents for acleaning time of 2 hours at a temperature of 60°C. Sodium dodecyl sulfate (SDS) was used at 0.05 and 0.1 mM concentrations and the percentage removal of foulant was found to increase with increase in surfactant concentration.

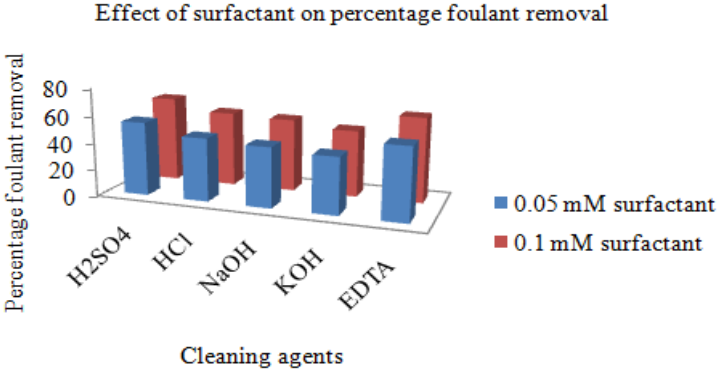

Fig. 4: Effect of surfactant on foulant removal for 1% concentration of cleaning agents for acleaning time of 2 hours at 60°C.

The results presented in this study are for the chemical cleaning of RO membrane fouled with textile wastewater. It can be stated that cleaning time, concentration of cleaning chemicals and temperature would have similar effects for other foulants of similar characteristics. However, the relative performance and suitability of cleaning chemicals may differ from one foulant to the otherand hence a set of trial experiments are needed in order to identify the suitable chemical agents for membrane cleaning and the operating conditions could be optimized for the selected cleaning agents.

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