The inroduction to membrane fouling biology essay

Science, Biology

Chapter 1

1. 1Introduction

Due to the increasing awareness of the shortage of consumable water, the scientist had been working their socks off in order to increase the supply of the consumable water. As a result, the membrane industry has experienced an exponential growth over the last 5 years due to their ability to deliver fresh water and in addition treatment of waste water. However, the focus of studies recently had been focus on the membrane fouling as membrane fouling is one of the major reasons hindering the development of membrane technology.

1. 2 Theory

What is membrane fouling? The International Union of Pure and Applied Chemistry defines membrane fouling as " The process that results in a decrease in performance of a membrane, caused by the deposition of suspended or dissolved solids on the external membrane surface, on the membrane pores, or within the membrane pores. (Koros 1996)" (Koros, et al., 1996). On a simpler term, membrane fouling is the accumulation of undesirable materials near the surface of the membrane surface which results in flux decline. Flux decline, as what its name suggests, is the decline of permeation rate of the membrane as a function of time. The flux decline is generally caused by a decreasing drive force or an increased resistance near the membrane surface. The volumetric flux of a membrane can be illustrated by the equation below: From the equation, it is clear to see that with viscosity being constant, the decline of flux is caused by either a decrease of

driving force or an increase of resistance. There are four types of resistances that generates from the filtration process. The first type of resistances is pore-blocking which the pores of the membrane is blocked by the solute. This resistance depends on the particle size and the membrane structure as it usually occurs in asymmetric membrane. During the RO process where dense membranes are used, pore blocking does not occur. The second type of the resistance is the adsorption of solute on the wall of membrane pores or on the surface of the membrane. This resistance depends on the interaction between the membrane surface and the solute. Adsorption of proteins on the membrane is one of the famous types of fouling results from adsorption. Thirdly, concentration polarization is also one of the resistances causing flux decline. During the filtration process where the solvent passing through the membrane while the solute is being retained at the feed side of membrane, the feed side of the membrane will have an increasing concentration as oppose to the permeate side of the membrane which have lower concentration due to the accumulation of solute at the feed side of the membrane. The fourth resistance is gel layer formation. During the filtration process, some colloidal particles tend to form a gel layer on top of the membrane surface when they are retained at the membrane surface. A gel layer is a form of fouling layer that possesses a cross linked three dimensional networks of the deposited particles. Formation of gel layer on top of membrane surface can be a difficult task for membrane cleaning as it is more resistant to removal by shear due to its cross-linked nature. Moreover, although the gel layer has relatively large pores, it usually has specific resistance due to the lack of connectivity between pores. However,

recent studies has showed that the gel layer can act as a second barrier on top of the membrane surfaces and thus significantly improves the quality of the effluent although a decrease in permeation flux is likely expected accompanied by the gel layer.

1. 3Type of Fouling

According to the different type of fouling materials, we can characterized the membrane fouling into four categories which are colloidal fouling, organic fouling, inorganic fouling (scaling), and biofouling. These fouling can also be further divided into two group, which are reversible fouling and irreversible fouling which based on the strength of the particles attach to the membrane surface. Reversible fouling can be removed by physical cleaning such as backwashing. However, irreversible fouling is impossible to be removed by physical cleaning and its cleaning is usually done by disinfection or chemical cleaning. The type of fouling is illustrated in Figure 1. 1https://fbcdn-sphotos-g-a. akamaihd. net/hphotos-ak-snc6/10110_10151393394334503_955520082_n. jpgFigure 1. 1 Type of Fouling

1. 3. 1Colloidal Fouling

The size of colloids particles ranged from a few nanometers to a few micro meters. During membrane fouling, colloids will accumulate on top of the membrane surface or within the membrane pores which will then affect the quality of effluent and the permeation rate of the membrane. In most cases, colloidal fouling is usually reversible as the colloids accumulate on top of the membrane surface is normally can be removed by hydraulic cleaning

measures easily such as backwashing and air scrubbing. Only in a rare case where the colloidal fouling will cause irreversible fouling. This happens only when the colloids have smaller size relative to the membrane pore size. Consequently, those colloids will enter and trapped within the membrane structure and it is not easily clean by hydraulic cleaning and it will also affect the quality of the effluent.

1. 3. 2Organic Fouling

Organic fouling is usually caused by the organic substances that dissolved within the feed solution. One example of organic fouling is the filtration with surface water such as lake or river. Surface water usually contains relatively higher natural organic matters (NOM) than ground water. These dissolved organic matters tend to attach to the surface of the membrane and causing flux decline of the membrane.

1. 3. 3Inorganic Fouling (Scaling)

Inorganic fouling is caused by the precipitation of solid salts such as metal hydroxides. Precipitation are formed when temperature change or when the concentration of the chemical species exceed their saturation concentrations such as water removal. Inorganic fouling is a major concern in RO and NF membranes as these membranes usually rejects inorganic matters. Those inorganic matters accumulates and for a concentrated layer at the feed side of the membrane. This is the phenomenon of concentration polarization as discussed in the previous section.

1. 3. 4Biofouling

Biofouling is the result of formation of biofilms on top of the membrane surface. First of all, biofilm is denied as a structured community of microorganisms encapsulated within a self-developed polymeric matrix and adherent to a living or inert surface. The formation of biofilm is initiated when the bacteria attach to the membrane, they will start to multiple and produce extracellular polymeric substances (EPS) to form a viscous, slimy, and hydrated gel. EPS usually contains heteropolysacchirides and have high negative charge density. This gel structure protects the bacteria cells from hydraulic cleaning and from chemical attacks of biocides such as chlorine.

1. 4Summary

As a summary for this chapter, the type of fouling material is closely linked to the type of fouling. Table 1. 1 shows the relationship between these two.

Table 1. 1: Relationship between type of fouling and fouling materials

Type of Fouling	Fouling Material
Colloidal foulingColloids which size ranged from a few nanometers to a few micrometersEg: ferum (III) hydroxide, aluminium hydroxide	Organic FoulingOrganic matters dissolved in the feed solutionEg: oil, humic acid, anti-foaming agents
Inorganic FoulingInorganic precipitateEg: calcium carbonate, calcium sulphate	BiofoulingMicroorganism (bacteria)Eg: iron reducing bacteria, sulphur reducing bacteria