Chapter 5
Nanomembrane Applications in Environmental Engineering

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ABSTRACT

This chapter delivers an outline of the strategies and techniques that are used and developed for the fabrication of membrane techniques/methods for application in environmental engineering. Human activities are the cause of increased hazardous gases in atmosphere mainly in soil and water. Nanotechnology deals the ability to control matter at the nano-scale level. Materials prepared are in nano level and thus they will possess some special properties to deal with specific functions. One of the major aspects of nanotechnology is nanomembrane fabrication which is mainly employed for water purification plants. The chapter is specifically offers a full understanding of the technologies and laws used to synthesize membranes. The chapter also provides an introduction to techniques to characterize nanomembranes.

INTRODUCTION TO MEMBRANE TECHNOLOGY

In eighteenth century many scientists started studies on membrane science and technology and how they work. In start these membranes were only used in laboratories for experimental studies and they did not possess any commercial or daily life importance. For example, the behavior of solutions by using membranes was carried out by Traube and Pfeffer. Their experiments and work done was used by van't Hoff in 1887 which lead to limit law explaining behavior of ideal dilute solutions that contributed to the development of famous "Van't Hoff Equation". The work is further proceeded by other scientists who worked on different types of membranes including semipermeable membranes which resulted in development of another theory known as "Kinetic Theory of Gases" by Maxwell was introduced to the world. Early membrane investigators experimented with every type of diaphragm which was available to them including animal bladders. In 1907, Bechhold, a well know scientist, prepared nitrocellulose membranes having very small pore size to determine a bubble test (Bechhold, 1907). Thus, nowadays membranes importance have increased so much that many technologies are in use to synthesize nanomembranes. The major problems in membrane development are its pore size and its sustainability as

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the real challenge is to allow specific materials to pass through the membrane and blocking the others depending upon the type of application (Baker, 2004) hence fabricating membranes targeted to specific application and vice versa. Thereby, for environmental issues, food and chemicals or wastewater treatment, the diverse types of membranes having different parameters will be employed. To permit separation process, specially designed synthetic membranes are widely used which separate particles on the basis of their molecular size and shape. Since early 1970s, membranes were not considered very important in separation industries but their importance rose suddenly in mid 1970s in that area resulting in dramatic increase in their successful use in industries. The area of synthetic membranes further flourished in middle of the twentieth century impacting positively both small and large scale industrial processes. Now an extensive variety of synthetic membranes is known to the world (Toyomoto et al., 1992) that include polymers, liquids or even inorganic materials. Among these the successful and commercially viable membranes are made up of polymeric materials mainly.

Loeb and Sourirajan are two well-known scientists who investigated the process of osmosis to prepare a synthetic membrane (Loeb & Sourirajan, 1962). Their experiments led to the successful completion of desalination plant which was later installed in some arid regions to purify sea water. Thus it is an influential discovery that transformed membrane separation from a laboratory to an industrial process and called as Loeb–Sourirajan process for making defect-free, high-flux, anisotropic reverse osmosis membranes. The characteristics of these membranes are that they are ultrathin, selective in nature and possess permeable microporous support for increased mechanical strength. The studies showed that membranes prepared by Loeb and coworker had increased mechanical strength and very good efficiency (10 times higher than that of any membrane then available).

Membranes can be classified based on their surface chemistry, bulk structure, and morphology and production method. Common types of membranes include porous membranes, asymmetric and dense membranes which are followed by separation industries (Freeman & Pinnau, 1999).

Types of Membranes

A membrane is nothing but a discrete, thin interface that moderates the permeation of chemical species in contact with it. This interface may be molecularly homogeneous (completely uniform in composition and structure) or it may be chemically or physically heterogeneous. For example, it may have holes and pores of restricted dimensions or it may have layering structures inside the membrane unit. Commonly it is called that membranes are just like filters; no doubt a normal filter meets the definition of a membrane, but in actual the filters are only those structures which act as separation unit. It means filters work on the rule that they will separate smaller and larger particle in the range of 1-10μm in a heterogeneous system. A large variety of membranes is available and Figure 1 schematically presents the principal types of membrane which are described briefly below.

Isotropic Membranes

Isotropic membranes are further categorized according to the specification of membranes. Some are discussed below:

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