Desalination xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Desalination

journal homepage: www.elsevier.com/locate/desal

# State of the art review on membrane surface characterisation: Visualisation, verification and quantification of membrane properties

Daniel J. Johnson, Nidal Hilal *

*Centre for Water and Environmental Research (CWATER), College of Engineering, Swansea University, Swansea SA28PP, United Kingdom*

## HIGHLIGHTS

- An overview of techniques to characterize membrane surface properties
- Discussion of techniques commonly used in membrane development and characterisation
- It is an ongoing field, with techniques being constantly improved and refined

## ARTICLE INFO

*Article history:*
Received 15 December 2016
Received in revised form 24 February 2017
Accepted 15 March 2017
Available online xxxx

*Keywords:*
Surface characterisation
Membrane fouling
Membrane development
Fouling
Spectroscopy
Microscopy
Wetting
Electrokinetics

## ABSTRACT

Many of the properties exhibited by separation membranes are due to interactions at the interface with their environment, including flux, rejection of solutes and surface fouling. As such when trying to understand how such interactions affect their function and when developing novel membranes with improved properties, a thorough understanding of their surface properties is essential. In this review paper we describe and discuss a number of instrumental techniques commonly used to characterize membrane surface, along with illustrative examples from the literature on membrane development and characterisation. The techniques described include spectroscopic techniques, microscopic techniques and methods to measure the surface wettability and electrokinetic behaviour.

© 2017 Elsevier B.V. All rights reserved.

**Contents**



* Corresponding author.
*E-mail address:* N.Hilal@swansea.ac.uk (N. Hilal).

http://dx.doi.org/10.1016/j.desal.2017.03.023
0011-9164/© 2017 Elsevier B.V. All rights reserved.

Please cite this article as: D.J. Johnson, N. Hilal, State of the art review on membrane surface characterisation: Visualisation, verification and quantification of membrane propertie..., Desalination (2017), http://dx.doi.org/10.1016/j.desal.2017.03.023

ARTICLE IN PRESS





## 1. Introduction

As all interactions between filtration membranes and the surrounding medium, containing a potentially diverse mixture of water, ions, organics and macromolecules, occur at the surface, it follows that the physical and chemical properties play a fundamental role in their operation, affecting membrane flux, rejection and fouling. As such, when trying to understand the interactions underpinning these processes, or when developing new improved membranes, characterisation of the pertinent membrane surface properties is very important. This review will attempt to summarise the major techniques used for investigation of membrane surface properties. In the first section we will examine spectroscopic techniques, those which use electromagnetic radiation. Fourier transform infra-red spectroscopy (FTIR), particularly with the attenuated total reflectance module (ATR), is one of the most important techniques available to the membrane developer to understand chemical modifications made to membrane surfaces. The several modes of Raman spectroscopy can not only complement the chemical information of FTIR, but can add structural information and is often combined with imaging techniques to allow surface mapping of these properties. X-ray photoelectron spectroscopy (XPS) is an extremely powerful technique to examine the elemental composition of surfaces. Other techniques, including nuclear magnetic resonance (NMR), small angle X-ray/neutron scattering (SAXS/SANS) and electron spin resonance (ESR), whilst not strictly surface techniques, are included due to their great utility in obtaining information on the effects of surface treatment and modification into the structures in the upper active layer of membranes. The next section deals with three high resolution microscopy techniques, atomic force microscopy (AFM), scanning electron microscopy (SEM) and transmission electron microscopy (TEM). AFM allows quantitative examination of three-dimensional structures of surfaces in fluid environments and can generate a wide range of quantitative information on surface morphology, surface nano-mechanical properties and interaction forces between the surface and other materials. Electron microscopy techniques, SEM and TEM, are almost ubiquitous as a technique to gain high quality, high resolution images of membrane surfaces and cross-section, and when combined with energy dispersive X-ray detection (EDX) can simultaneously obtain elemental information. We examine several techniques for determination of surface wetting properties through measurement of contact angle at the air-water-solid interface. Finally, we look at membrane surface electrokinetic properties and techniques to determine surface electrical potential.

## 2. Spectroscopic techniques for characterisation of membrane surfaces

### *2.1. Fourier transform infra-red spectroscopy (FTIR)*

#### *2.1.1. Introduction and basic principles*

Much research and development on the development of separation membranes is on the creation of new surface chemical functionalities in the search for membranes with increasing resistance to fouling. One of the most mature and widely used technologies to investigate chemical functionality of surfaces is the group of related spectroscopic techniques termed Fourier Transform Infra-Red spectroscopy (FTIR).

As with all infra-red spectroscopy techniques, FTIR probes the vibrations of molecular bonds. This is because infra-red (IR) frequencies

Please cite this article as: D.J. Johnson, N. Hilal, State of the art review on membrane surface characterisation: Visualisation, verification and quantification of membrane propertie..., Desalination (2017), http://dx.doi.org/10.1016/j.desal.2017.03.023

Download English Version:

https://daneshyari.com/en/article/7007949

Download Persian Version:

https://daneshyari.com/article/7007949

Daneshyari.com