Desalination 354 (2014) 189–199

Contents lists available at ScienceDirect

Desalination

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

The effect of UV irradiation on PSf/TiO_2 mixed matrix membrane for chromium rejection

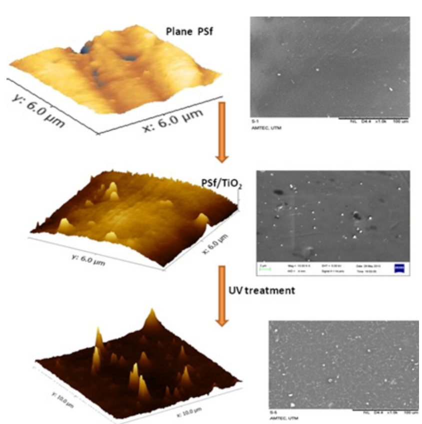
M.S. Jyothi [a], Vignesh Nayak [a], Mahesh Padaki [a,*], R. Geetha Balakrishna [a,*], A.F. Ismail [b]

[a] Center for Nano and Material Sciences, Jain University, Ramanagaram, Bangalore 562112, India
[b] Advanced Membrane Research Centre (AMTEC), Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia

HIGHLIGHTS

- The surface modification of PSf/TiO_2 composite membranes by UV treatment
- The roughness of membranes was increased with respect to TiO_2 dosage
- 100 % rejection of Cr was achieved at acidic pH condition
- Dissociation of Cr, surface roughness and surface charge influenced on performance

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 12 June 2014
Received in revised form 4 October 2014
Accepted 6 October 2014
Available online 22 October 2014

Keywords:
Composite membranes
Surface modification
Chromium rejection
Hydrophilicity
UV treatment

ABSTRACT

The study investigated a novel approach for surface modification of membranes and sustainable water recovery from chromium contaminated water by employing a lab scale dead-end cell filtration unit. Various PSf/TiO_2 composite membranes prepared with different concentrations of TiO_2 nanoparticles were exposed to UV radiations for surface modification. On exposure to UV light, TiO_2 nanoparticles emit electrons and create a surface roughness with a charge on the membranes which resulted in enhanced chromium rejection as well as flux. The surface modification has been analyzed by AFM and SEM (surface and cross sectional) images. The structural modification was investigated by ATR-IR and UV–Visible spectroscopy. The expected enhancement in hydrophilicity was studied by water uptake and contact angle measurements. The analysis of water flux and chromium rejection performed in a dead end filtration unit revealed a high water flux and 100% chromium rejection with 2 wt.% of TiO_2 composite membrane in acidic pH. The pH of feed plays an important role in chromium rejection. The rejection of chromium decreases with an increase in feed concentration due to the variation in ion distribution. The effect of interference of other metals in chromium rejection is investigated. The overall work not only demonstrates the positive effects of surface modification, but also effective removal of hazardous chromium.

* Corresponding authors. Tel.: +91 80 27506270.
E-mail addresses: maheshpadaki@gmail.com (M. Padaki), geethabalakrishna@yahoo.co.in (R. Geetha Balakrishna).

http://dx.doi.org/10.1016/j.desal.2014.10.007

Table 1
Nomenclature of prepared PSf composites, before and after treatment.

Membrane code		Weight percent of	
Before UV treatment	After UV treatment	PSf	TiO_2 NPs
M1	M1U	18.5	1.5
M2	M2U	18.0	2.0
M3	M3U	17.5	2.5

1. Introduction

Recently, membranes cumulated with inorganic nanoparticles (NPs) have gained interest as hydrophilic fillers, as they enhance the hydrophilicity and flux. These hybrids will have a synergic effect of both organic material and inorganic filler. Titanium dioxide (TiO_2) is gaining more interest as nanofiller because of its cost effective synthesis, multiple potential applications, resistance towards bacteria and super hydrophilicity [1,2]. TiO_2 is an excellent photoactive and non-toxic nanofiller of which the optical and electronic properties can be tuned by various methods such as doping, thermal treatment and immobilization [3]. Several reports have pointed that, the penetration of TiO_2 NPs into polymer matrix amplifies solvent diffusion velocity from membrane to water. Y. H. Teow et al. claimed the changes in roughness, hydrophilicity, permeability and flux of polyvinylidiene fluoride on incorporation of TiO_2 into mixed matrix membrane [4]. Although TiO_2 nanofillers enhance the hydrophilicity of the membrane, further improvement can be done by surface modification via UV-irradiation. UV-irradiation causes many chemical and physical changes to the membrane surface [5–7]. The absorption of UV radiation on exposure initiates the bond dissociation which results in chain scission and cross linking. N. N. Rupiasih et al. [8] have reported the changes in properties and performance of the (Polysulfone) PSf membrane with respect to UV-irradiation for a short range of time. They have concluded that the pure water flux of the membrane increases after UV treatment. The background studies pronounce that, the incorporation of TiO_2 into the membrane matrix and irradiation of UV on the membrane significantly affect the membrane properties as well as performance.

Hexavalent chromium (Cr (VI)) existing in the industrial effluents is a major concern, causes serious environmental pollution and is highly toxic when compared to Cr (III). It mainly causes health hazards related to skin, kidneys, respiratory tract and genetic deformation via DNA damage [9,10]. Hence, removal/recovery/reduction of chromium (VI) is mandatory to a great extent before the discharge of effluent. The common methods employed for the removal of chromium are either reduction or precipitation methods because of their simple nature of treatment. But somehow these methods end up in unsafe sludge which has to be stored or disposed in a secured way. Currently, membrane separation systems are gaining more importance in this direction. They give access for removal or recovery of contaminant as well as solvent too [11]. Studies have shown that, the separation of Cr (VI) through membranes is dependent on concentration of chromium, pH of the feed and also on operating pressure [12]. In the present study, PSf/TiO_2 composite membranes were prepared by the DIPS method and irradiated with UV light for surface modification. The changes in molecular and physical properties observed on modification were

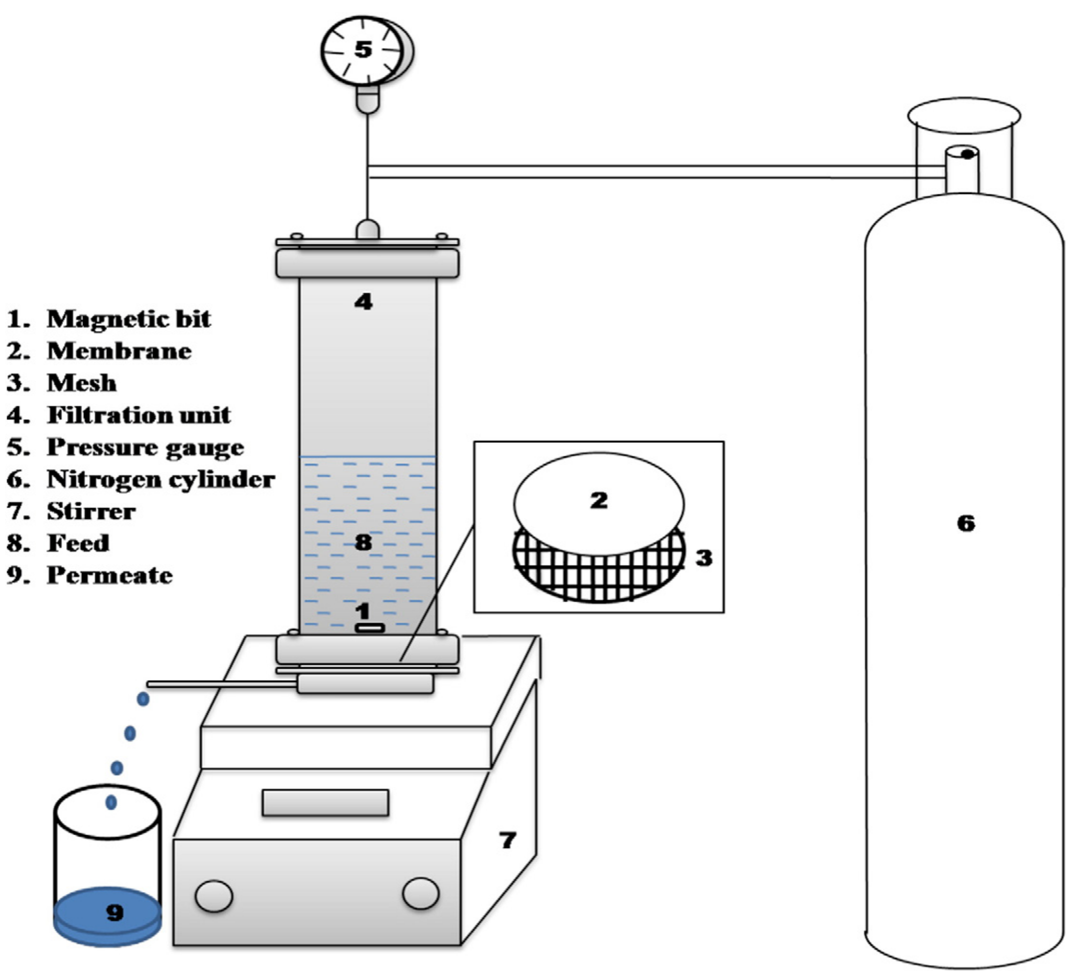


Fig. 1. Diagrammatic representation of dead cell filtration unit used for flux and rejection studies.