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Review paper

Development of an asymmetric ultrafiltration membrane based on phosphates industry sub-products

Mouna Khemakhem[a,*], Sabeur Khemakhem[a], Salwa Ayedi[a], Marc Cretin[b], Raja Ben Amar[a]

[a]*Laboratoire Sciences des Matériaux et Environnement, Université de Sfax, Faculté des sciences de Sfax, Rte. de Soukra Km 4, 3018 Sfax, Tunisia*
[b]*IEM (Institut Europeen des Membranes), UMR 5635 (CNRS, ENSCM, UM 2), Université de Monpellier, Place E. Btaillon, F-34095 Montpellier, France*

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Abstract

New ultrafiltration membrane from phosphates industry sub-products material was prepared. The choice of this material is mostly due to its abundance in the Tunisian ores. However, it is considered as harmful subproduct for environment. Plastic paste was prepared using 250 μm calibrated powder of mud of hydrocyclone laundries phosphates mixed with organic additives and water and then was shaped into a tube by extrusion molding. After drying and sintering at 900 °C, the obtained support exhibits an average pore diameter and porosity of about 1.07 μm and 39%, respectively. It shows also a very interesting properties in terms of mechanical and corrosion resistances.

The coated layer resulting in the ultrafiltration (UF) membrane was performed by a slip-casting method using a suspension made of a mixture of the mud powder, water and polyvinyl alcohol solution (PVA), then heated at 650 °C. The UF membrane average pore diameter measured by nitrogen adsorption/desorption method was of 11 nm. The determination of the membrane water permeability shows a value of 90 l/h m^2 bar which is suitable for membrane operating in UF domain.

The application for the treatment of industrial textile wastewater shows an important decrease in turbidity (inferior to 1 NTU), chemical oxygen demand (COD) (retention rate of about 90%) and almost a total color removal.

Keywords: A. Extrusion; Phosphates hydro cyclone laundries mud; Ceramic support; Ultrafiltration membrane

Contents

1. Introduction

Membrane separation is considered to be a suitable technology for the separation of various mixtures within the textile, chemical, food and pharmaceutical industries due to

*Corresponding author.

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advantages offered by their relatively high stability, efficiency, low energy requirement and ease of operation [1–3]. Nowadays, the interest is derived toward inorganic membranes due to their superior permeability–selectivity combination, high life duration and suitable performance for high temperature or corrosive environment compared to polymeric membranes [4,5].

For economic consideration, a great deal of research has been devoted to the development of new type of inorganic membranes made from low cost natural material. Rapid development and innovation have already been realized in this area [6–8]. From the literature, Saffaj and Loukili used the natural Moroccan clay to produce supports for microfiltration (MF) and ultrafiltration (UF) application [9,10]. On the other hand, clays and granitic sand were used by Rakib and Bouzerara [11,12] to prepare porous supports for tangential microfiltration and ultrafiltration membranes. Also, graphite [13] and phosphates [14] as well as abundant sub-products resulting from some industrial transformation such as fly-ash obtained from coal fired power station [15] were used to make microfiltration and ultrafiltration membranes.

The mud of the hydro cyclone laundries of phosphate could be also a good material to make low cost membranes which allows a good management of these sub-products representing a major environmental problem in phosphates transformation industry. In addition, the crushing step, usually used to prepare calibrated powder, is not needed for this kind of material due to its very small particles sizes. The phosphoric subproduct can give also ceramic pastes of a good plasticity and an easy shaping. Thus, an adapted configuration for ceramic microfiltration or ultrafiltration membrane can be performed. In the literature there is almost no previous works which treat the upgrade of the phosphates industry subproduct. It can be noticed particularly works done by Khiari and Chaari [16] who had used the mud of the hydrocyclone laundries of phosphates to prepare porous material based on light weight aggregates used as adsorbent to retain lead from heavy metal solutions.

The present work describes the preparation of both macroporous support and active layer based on mud of the hydro cyclone laundries of phosphates to elaborate a new asymmetric ceramic ultrafiltration membrane. The efficiency of this membrane was evaluated through the application to the treatment of industrial textile wastewater.

2. Support elaboration and characterization

In this study, the support was prepared with mud of the hydro cyclone laundries of phosphates coming from Gafsa ores located in the south of Tunisia. Fig. 1 presents the XRD patterns of raw mud of the hydro cyclone laundries of phosphate. It can be shown that quartz (Q) and Calcium Hydroxide (C) are the main crystalline mineral present in this powder. This result was checked by the chemical analysis achieved in our previous works [17] which exhibits that the major components were silica (SiO_2: 38.89%) and calcium oxide (CaO: 19.98%).

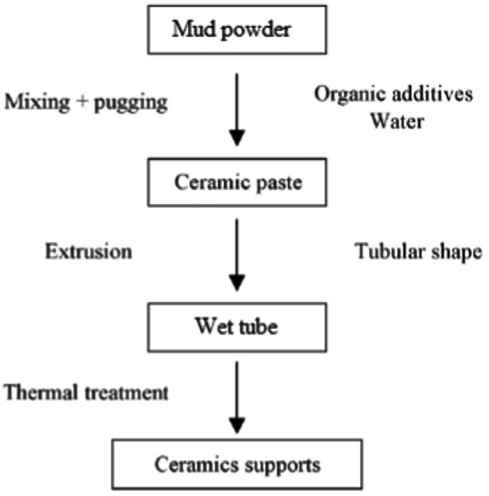

Fig. 2. Various steps of macroporous ceramic tube preparation.

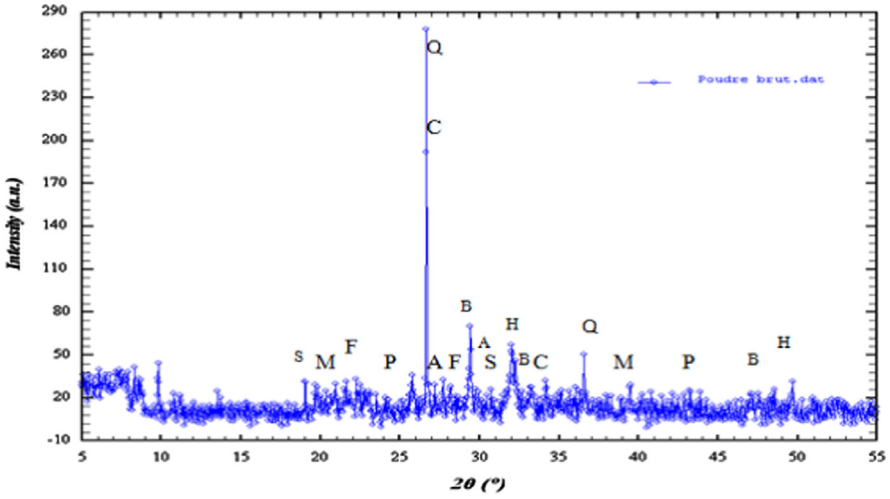

Fig. 1. X-ray diffractogram of the mud of hydrocyclone laundries of phosphates powder.