HIGHER TECHNICAL INSTITUTE

MECHANICAL ENGINEERING DEPARTMENT

DIPLOMA PROJECT

INVESTIGATION ON THE SEAWATER DESALINATION TECHNIQUES AND OPERATING PRINCIPLES

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Dedication

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Nicos Kyprianou

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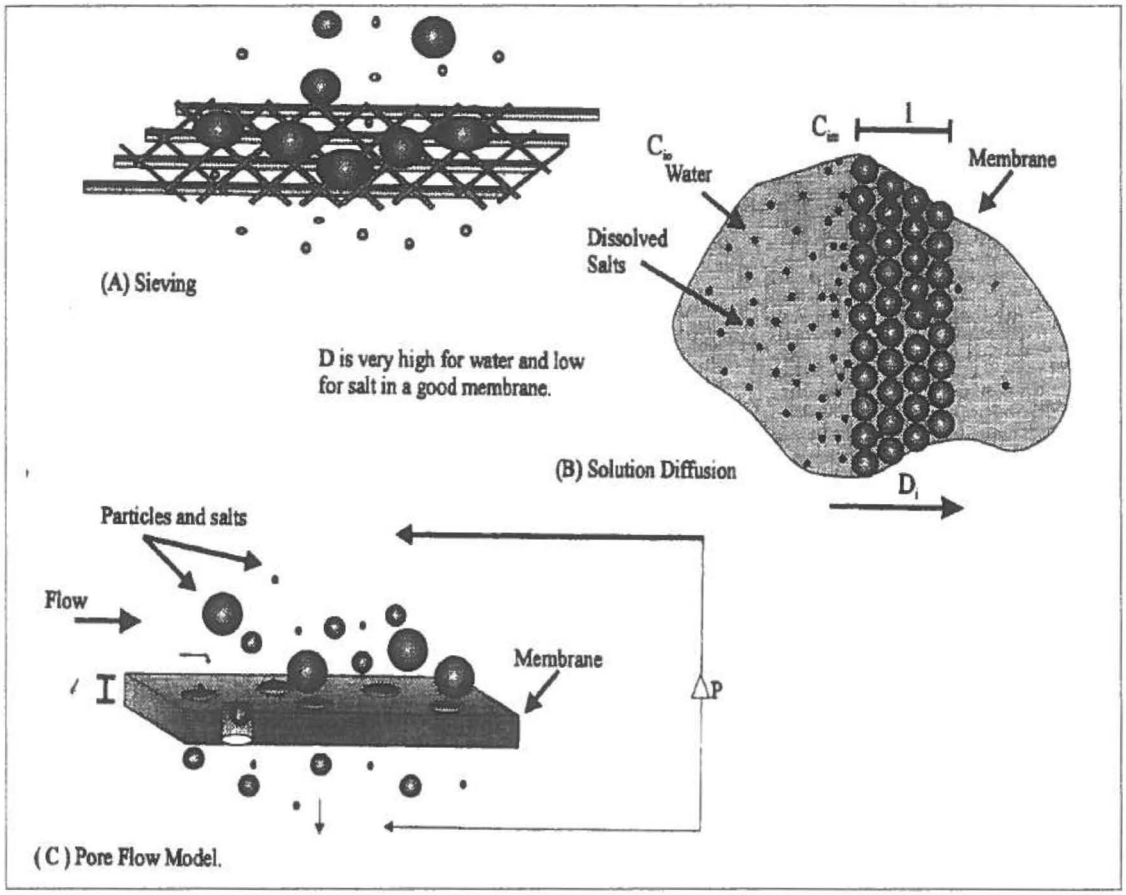

Abstract

Membrane separation processes have been used for years, but they have not come to play an important role in producing potable water supplies until the past 10 years. RO (reverse osmosis) and ED (electrodialysis) are replacing phase change desalting technologies for supplying water to coastal and island communities all over the world. **Nanofiltration** is becoming an economical alternative to the traditional water softening processes. As membrane separations become more widely understood, more applications will be found for them. This project will shed some light on these processes: how membranes are made; what makes them different; what types of membranes are available today; what is the cost of membrane processes and ***finally it will propose a unique process to fabricate membranes from nanostructured composites***. This initiative has remarkable implications especially if you consider that the cost of the membranes is a third of the cost of the desalination units and must be replaced at least every 3 to 5 years under normal operation.

The initiation of this project falls within the activities of the Nanomaterials Research Center (NRC), a newly established center at HTI, which serves as a bridge for technology transfer between HTI and the technology users (industry at large). The primary mission of NRC is to develop new methods for the economical production of nanostructured metals, ceramics, and their composites.

Under this center, two operating divisions have been established, each with its own application goal(s) and commercialization strategy:

1. nanopowders synthesis, which is commercializing high rate production of non-agglomerated nanoparticles and
2. **large area deposition of coatings and consolidation of net-shaped parts.** Both of the divisions focus on the commercialization of advanced materials processes for enhanced mechanical and thermal properties.

Current programs are focused on methods for the production of nanostructured powders, nanophase coatings (wear resistant surfaces, thermal barriers, selective surfaces for solar thermal and photovoltaic fabrications, **semi-permeable membranes**) and nanophase composites (gas turbine engines, bulletproof vests and **porous membranes**).

Overview

A membrane is a film. A semi-permeable membrane is a very thin film that allows some types of matter to pass through while leaving others behind. Some membranes are porous and separate materials based on size of the pores. Others are dense films with no apparent pores that separate matter based on differences in diffusion rates through the membrane. Ceramic and metallic membranes are used mostly for microfiltration and ultrafiltration. They tend to be highly inert, withstanding high temperatures and pH from 0 to 14.

The proposed initiative will establish a multidisciplinary program on the thermochemical processing (powder synthesis and conversion), deposition and/or consolidation of nanophase desalination membranes.

The program will focus on three aims:

1. producing metal-metal and metal-ceramic amorphous and nanostructured powders,
2. development of nanostructured coating and consolidation application parameters for superior mechanical, thermal and filtration performance and
3. producing custom materials to specification in partnership with our industrial partners.

Objective

The primary objective of this project is to fabricate membranes in the form of nano (structured) coatings or net-shaped parts from amorphous powders to enhance properties and prolong membrane life at reduced cost.

Nanomembranes will enable increased filtration characteristics compared with conventionally manufactured membranes.

Advances in high performance materials for structural, thermal and filtration applications and the associated deposition and consolidation methodologies will increasingly depend on our ability to control the size, distribution and morphology of their constituent phases at the sub-micrometer or nanometer level. Since capabilities for synthesizing such nanostructured materials in bulk are becoming available, it is now possible to produce quantities of materials needed for prototype development and testing.

Nanostructured materials are a new class of synthetic materials with ultrafine microstructures, somewhat arbitrarily defined as structures smaller than 100 nm. These materials may be composed of metals, ceramics, polymers, and their composites. The materials can be in the form of **powders, thin films, porous media,** or **dense structures**.

The primary aim of the proposed project is to exemplify the scientific and technical foundation for the bulk synthesis and deposition of amorphous and nanophase powders in the context of desalination membranes. A key feature of this approach will be to couple research on materials synthesis, processing characterization and end-product performance evaluation at all collaborating academic institutions, with work on process scale-up, coating and net-shape prototype development and testing at our industrial affiliates. Such concurrent development should expedite the implementation of nanophase composite technology.

Description

The main steps of the work are:

1. selection of materials/compounds to be deposited as nanostructured coatings or consolidated net-shaped parts, preparation and mixing of an appropriate starting solution, spray drying of the starting solution to form a chemically homogeneous precursor powder; thermochemical conversion of precursor powders;
2. determination of size, structure and composition of powder, powder stability, physical/mechanical properties of powder;

3. analysis of current powder deposition and consolidation methods, influence of the deposition and consolidation method on the final characteristics of the coatings, selection of the most suitable method and definition of all critical parameters of the process;
4. production of membrane prototypes, either in the form of nanocoatings or net-shaped parts;
5. determination of mechanical properties and thermal properties, long-term behaviour, testing and evaluation of final product.

Milestones Expected

The ultimate goal will be the synthesis of clean amorphous nanocrystalline powders and the manufacture of nanophase membranes. The membranes fabricated out of these amorphous elements/alloys are anticipated to exhibit extraordinary combination of hardness, toughness, abrasion resistance, adherence, and filtration properties at reduced cost.

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Introduction

Good quality water today becomes more and more precious, especially in large civic centers, where the blowdown wastewaters are augmenting in volumes, polluting the environment. The last few years organizations and industries try hardly to purify all their effluents before the drainage of these effluents, in the sea or in any other water system. Nevertheless the large amount of polluted effluents remains an acute problem for many places around the world. Meanwhile the good quality water resources and/or reserves are decreasing rapidly, as the rivers, the water streams, the lakes, the wells and even the seawaters are continuously polluted. Sea and/or brackish waters are available in large amounts but not for immediate use. On the other hand desalination of sea or brackish waters eliminates their high salt content, turning these waters into fresh water suitable for any use. Desalination is applied today, as industrial method, in very large capacity plants, in places deplete of water, depending almost totally from the desalinated water for their existence.

Desalination is probably the most attractive future application for places where good quality water is slowly exhausted, as well for the purification of various effluents for water re-uses. The aim of this project is to show the ways that have been developed in this very interesting and very important scientific progress of our times.

It is obvious that this project, which is an introduction for all people, scientists, engineers but also non scientists who are interested in the subject from an encyclopaedic point of view, can be helpful to understand the basic physicochemical and physical properties related to seawater, and their use to the practical application of all desalination methods. Furthermore, a rather detailed description of the various desalination methods that have found commercial application is tried, with their principles of operation. Finally, it could be a guide to membranes for municipal water treatment.

It depends upon the readers to judge whether or not I succeed in giving a clear overall picture of these extremely important, almost new technological achievements of our times.