Universidad de Cantabria - Doctoral Programme

Membrane Science and Technology

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Lectures (4 x 2h)

These 4 lectures are structured in order to provide firstly information about membrane materials and their impact on the design of membrane processes. From this point, and the review of fundamental concepts as “polarisation of concentration” and “fouling”, three other lectures are organised in such a way that common membrane processes (Donnan dialysis, micro / ultrafiltration and nanofiltration, facilitated transport, vapour permeation and pervaporation) are naturally discussed through a case-study approach.

Lecture 1 – Membrane Materials and Processes

Type of membranes: structural and morphological characteristics; membrane materials; functionality;

Type of processes and their relation with the materials used; mechanisms of solute rejection / transport;

Polarisation of concentration; solute accumulation and solute depletion – examples;

Fouling: mechanisms and tools for minimization; concept of critical and sustainable flux – examples;

Perspectives on new materials / processing.

Lecture 2 – New tools for Monitoring of Membrane Processes

Identification of new needs: in real-time, non-invasively, *in-situ / in-vivo*, at a molecular scale, using pattern-recognition approaches;

Discussion of selected case-studies:

- Real-time mass spectrometry applied to gas / vapour permeation and pervaporation;
- Spectrometric confocal techniques (including Raman confocal spectrometry for studying concentration polarization profiles and solute distribution inside membranes);
- 2D fluorometry for monitoring of biological reactors (including integration of chemometric tools – ANN);
- 2D fluorometry for monitoring of fouling (proteins and humic /fulvic acids);
- Fluorescence anisotropy and time-decay fluorescence applied to protein fractionation by ultrafiltration.

Lecture 3 – Membrane Processing Using Neoteric Solvents

Principles of sustainable Chemistry (Green Chemistry);

Integration of Green Chemistry principles and membrane processing; Green metrics criteria and their use;

Concept of “Neoteric Solvents”;

Discussion of selected case-studies:

- Integration of membrane processes and supercritical fluids
    - Recovery and reuse of the supercritical fluids
    - Integrated supercritical fluid extraction / nanofiltration
    - Supercritical fluid assisted-ultrafiltration
    - Membrane contactors and/or reactors using supercritical fluids
    - Membrane preparation using supercritical fluids
- Integration of membrane processes and Room Temperature Ionic Liquids
    - Membrane processes for the recovery of target solutes from Ionic Liquids (typically “post-reaction” recovery of target solutes by nanofiltration and pervaporation)
    - Design of “new” membranes by immobilisation/incorporation of Ionic Liquids (dense membranes - e.g., proton conducting membranes) and Supported Liquid Membranes / Membrane Contactors

Lecture 4 – Recent Developments on Membrane Bioreactors

Why Membrane Bioreactors?

Concept of integration of selective transport and catalytic compartments;

New challenges: sustainable flux
selectivity for target solutes

New developments, their impact and perspectives:

- Biphasic reactors
- Submerged membrane bioreactors
- Extractive membrane bioreactors
- Ion-exchange membrane bioreactors

Selected applications in:

- Fine chemistry
- Industrial effluents / Domestic effluents
- Water reuse
- Drinking water production (problems associated with production of safe drinking water)

Seminar (1h plus debate)

"De-fragmentation of Membrane Research in Europe"

Research development from an individual group approach (our own case at Universidade Nova de Lisboa) towards an European perspective;

NanoMemPro and the development of a "Strategic Business Research Agenda" for membrane science and engineering in Europe;

The future development of a "European Institute" and its funding sustainability;

Impact on the 7th Framework Programme and beyond.

Individual Research Projects

Proposed structure:

- State-of-the-art / Motivation (max. 1 page)
- Objectives and Innovative aspects (max. 1 page)
- Tasks description and timetable (max. 2 pages)
- Expected impact (scientific and technological) and outputs (max. 0.5 page)
- Budget (max. 0.5 page)

Individual oral presentation and discussion
(alternatively a poster could be prepared and a poster session organised?)