Council for Mineral Technology

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Nanotechnology-based membranes for the removal of organics and heavy metals from Industrial Waste Waters (IWW)

Presented by

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Introduction

Examples of Industrial activities in RSA

Industry	**Typical pollutants**
Mining	Acidity, metals
Chemical, Pharmaceuticals, Petrochemicals	Organics, heavy metals
Pulp and paper	Bleaching agents, organic dyes
Mineral processing	Organics, heavy metals
Food	Organics, heavy metals k1
Textiles	Organics dyes k2

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Slide 2

k1 polyphenols from production of table oilve oil.

Chelating character of compounds produces introduces toxic heavy M in soln

keneiloes, 28/05/2009

k2 Dyes aresuspected to be carcinogenic, also capable of absorbing/reflecting sunlight which can have detrimental effect on bacterial growth

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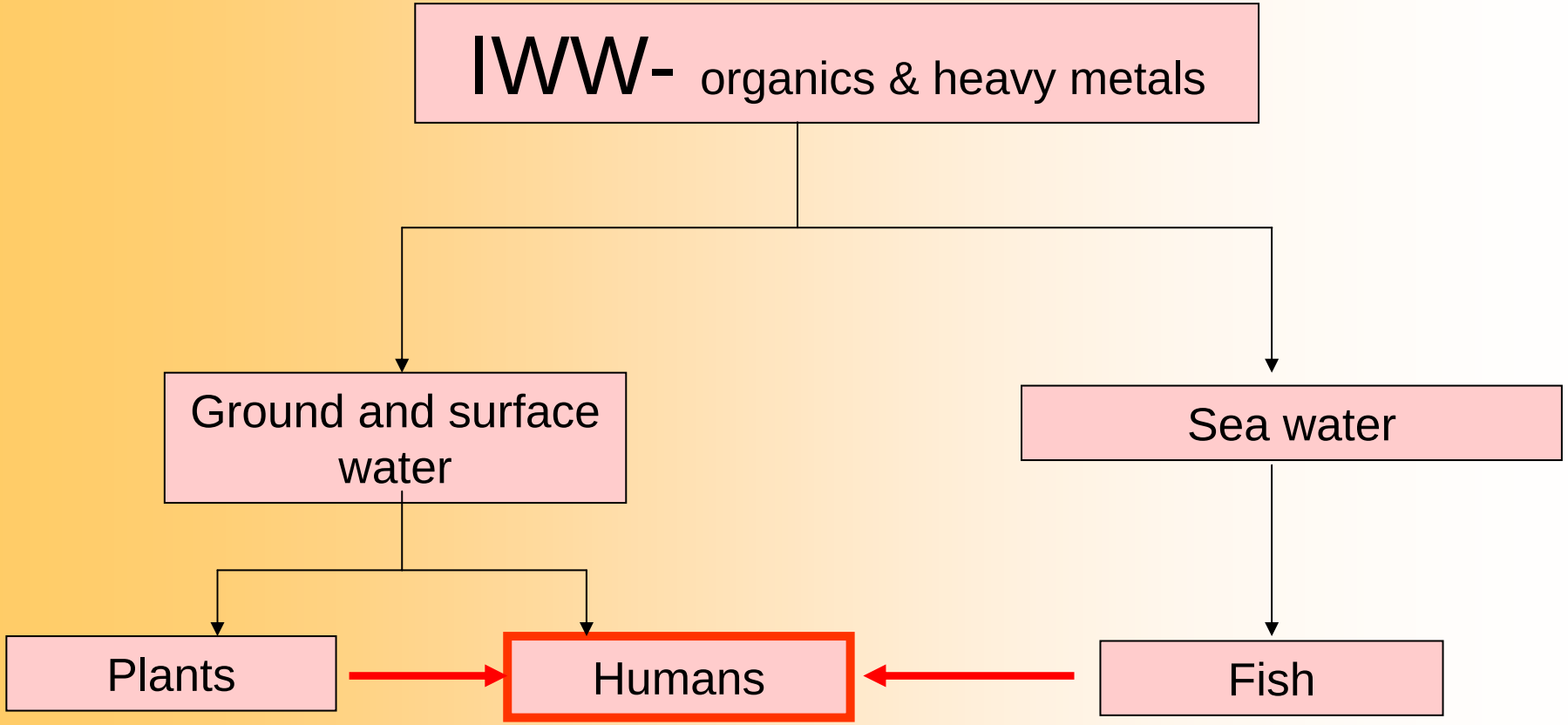
Effects of pollution by IWW



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Effects on human

- Carcinogenic
- Developmental defects
- Reproductive defects
- Tumour growth
- Organ failures

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Typical treatment methods

- activated carbon adsorption
- coagulation–flocculation
- biological degradation (activated sludge)
- electrochemical treatment
- ozonation
- chemical oxidation

Set-back: Inefficient, large amount of waste for disposal

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Membrane Technology

- A selective barrier
  - ➢ RO – Monovalent ions
  - ➢ NF – Multivalent ions
  - ➢ UF – Macromolecules
  - ➢ MF- Suspended solids

- Set-back- High pressures required for operation

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Nanotechnology in water treatment

- f-CNTs – adsorbents for pathogens, organics, heavy metals
- Fe(0) NPs – dechlorination and heavy metal reduction (e.g. As^{4+}, Ni^{2+})
- Ag NP- disinfection
- Nanoclays
- Nanocrystalline zeolites
- Set-back:

➢ Metal NPs agglomerate in solution

➢ NP total recovery is impossible

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Aims

Develop nanotechnology-based active MF membranes for industrial waste water treatment:

- For the removal of organic compounds and heavy metals
- With **catalytic** properties to reduce organic pollutants into non-toxic compounds and to reduce heavy metal ions to be precipitated out of solution
- Treated water can be recycled for industrial use
- Treated water can be used for recreational purposes
- Treated water can be discharged back to the sea

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Approach

	Polysulfone (PSf)	Polyvinylidene Flouride (PVDF)
Temperature limit	75 ^{o}C	40 ^{o}C
Working pH	1 - 13	2 – 10.5
Tolerance to oxidants, e.g. chlorine	Good	Excellent
Resistance to Organics	Aliphatic HCs, fully hydrogenated HCs, alcohols and acids	Resistant to common solvents
Loves or hates H_2O	Hydrophilic	Hydrophobic

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Approach cont…

Nanomaterials to be used:

- Functionalized CNTs – Adsorption of organics and metals
- Fe^0 NPs- particle reducer (organics and metals)
- Bimetallic NPs systems; e.g. Ni-Fe, Pd-Fe, Pt-Fe NPs
- Photocatalytic oxidation of organics by nanostructured TiO_2 and ZnO

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Methods

Two methods:

- *In situ* synthesis of NPs on pore structure of existing membrane
  - Simple, improved reproducibility of nanocomposite, possibility to reuse membrane matrix, better accessibility of NPs to reactants in pearmeate
  - Feasible with metal NPs
- Incorporation of NPs during membrane formation
  - allows design of nanocomposite structures with improved mechanical and separation processes
  - The structure of the resulting membranes is generally a function of the physical and chemical properties of polymer matrix and Nps as well as the method of NPs incorporation
  - Feasible with CNTs, TiO_2 and Metal NPs

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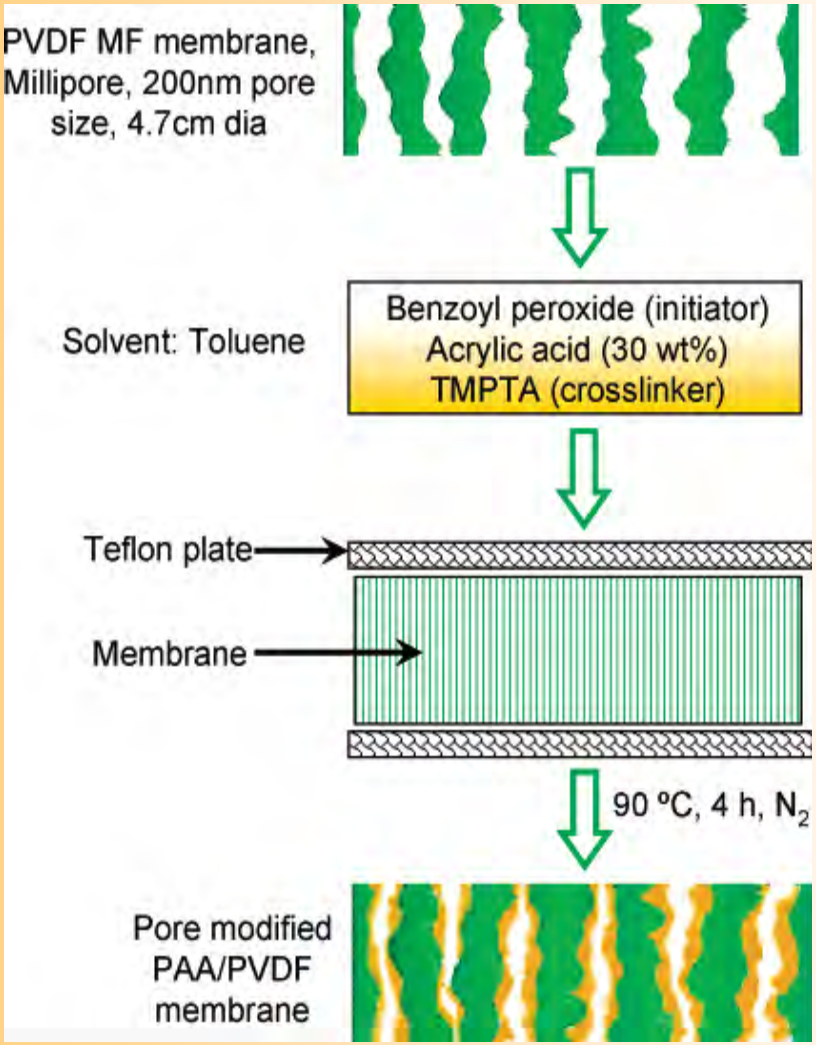
In situ free radical polymerization



J. Xu, D. Bhattacharrya, *Ind. Eng. Chem. Res.* **2007,** *46,* 2348-2359

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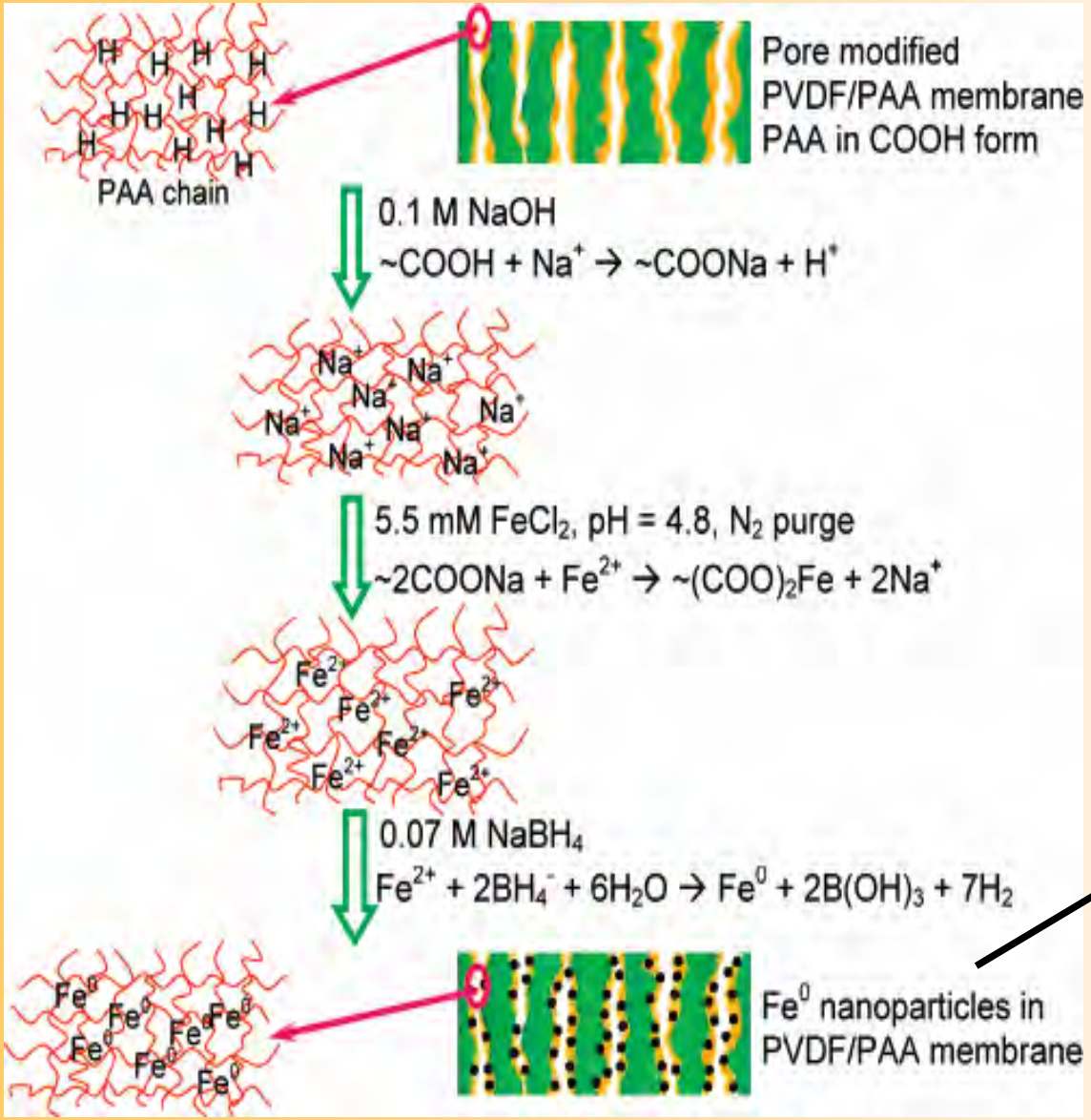
In situ radical polymerisation cont…



Then soaked in K_2PdCl_4 soln and deposited Pd NPs through redox reaction:

$$Pd^{2+} + Fe^{0} \rightarrow Fe^{2+} + Pd^{0}$$

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Incorporation of NPs in membrane synthesis

- Phase inversion method
- Cast films of PSf or PVDF dissolved in solvent and mixed with solution containing dissolved or dispersed NPs
- Shaped using casting knife
- Then solvent evaporated

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Characterisation

- Morphology- Electron Microscopes- SEM, TEM, AFM
- Thermal stability- Thermal Analysis
- Porosity and pore size distribition- N_2 Physisorption
- Functional Groups- FTIR
- Hydrophilicity/hydrophobicity- contact angle
- Crystallinity- Wide angle X-ray

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Application

Removal of organics and heavy metals in

- Simulated industrial waste water
- Sampled industrial waste water

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THANKS FOR YOUR ATTENTION!!

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