Sample Outline for Preparing PowerPoint® Presentation #1
"Measurement of Membrane Fouling in Spiral-Wound Modules"

1. Title slide

1.1 Content

1.1.1 Co-Authors
1.1.2 Affiliations
1.1.3 Venue
1.1.4 Date
1.1.5 Logos

1.2 Provocative opening statement

2. Overview

2.1 Slides numbered on header
2.2 Outline of talk

2.2.1 Importance of membrane fouling
2.2.2 Technological barriers to mitigating fouling
2.2.3 Objectives of this research
2.2.4 Overview of UTDR technology
2.2.5 Experiment design and conditions
2.2.6 Corroboration of UTDR with flux and SEM data
2.2.7 Conclusions

3. Definition of fouling

4. Importance of fouling

4.1 Belfort quote
4.2 Impact of fouling on efficiency

4.2.1 RO desalination
4.2.2 Sewage treatment
4.2.3 Protein extraction
4.2.4 Whey and milk filtration
4.2.5 Biological separations
4.2.6 Wastewater treatment in pulp & paper, food, petrochemical, and pharmaceutical industries

5. Impact on RO desalination

5.1 Facts and figures

5.1.1 Water production in 2000 ~20 billion l/yr
5.1.2 11% of world membrane sales
5.1.3 25% of RO operating cost
5.1.4 Cost ~$500 million (US) per year

5.2 Need ways to monitor fouling to lower cost
5.3 Clip-art

5.3.1 Animation of cartoon showing sack of money

6. Measurement of fouling

6.1 Indirect measurement
- 6.1.1 Flux decline
- 6.1.2 Pressure increase
- 6.1.3 Permeate quality decline
- 6.1.4 Light scattering
- 6.1.5 Holographic interferometry
- 6.1.6 Silt-density index
- 6.1.7 Modified fouling index

6.2 Direct measurement
- 6.2.1 Optical microscopy
- 6.2.2 NMR micro-imaging
- 6.2.3 SEM
- 6.2.4 EDX

6.3 Define acronyms
- 6.3.1 NMR
- 6.3.2 EDX

7. Technological barriers

7.1 Direct measurement not practical for commercial applications

7.2 Flux decline and pressure increase can result from other factors
- 7.2.1 Concentration polarization
- 7.2.2 Membrane compaction

7.3 Need real-time noninvasive technique sensitive to fouling

7.4 Clip-art
- 7.4.1 Cartoon of people facing barrier wall
- 7.4.2 Cartoon of unhappy face

8. Objectives

8.1 Adapt UTDR for measuring fouling noninvasively in real-time

8.2 Develop data-deconvolution software to facilitate instrumentation

8.3 Corroborate UTDR with flux decline and SEM analyses

8.4 Clip-art
- 8.4.1 Cartoon of man running to target

9. UTDR chronology

9.1 1929 – Sokolov uses UTDR for flow detection

9.2 1960 to date – extensive use in NDT applications

9.3 1995 – Bond et al. adapt UTDR to study fouling

9.4 2007 – Chai et al. adapt UTDR to spiral-wound module

9.5 References

9.5.1 Bond et al.
9.5.2 Chai et al.
9.6 Acronyms
9.6.1 NDT
9.7 Clip-art
9.7.1 Cartoon of wise owl

10. Principle of ultrasound measurement

10.1 Animation of UTDR analysis of membrane fouling
10.1.1 Wave reflections shown by successive clicks
10.2 Plot of UTDR reflected wave amplitude versus arrival time
10.2.1 Appearance of peaks coincides with animation

11. Spiral-wound membrane module

11.1 Schematic of spiral-wound module
11.2 Point out problem with reflections from multiple surfaces

12. Methodology

12.1 Plot of amplitude vs. time for unfouled and fouled module
12.2 Point out problem with reflections from multiple surfaces

13. Analysis of UTDR signal

13.1 Equation for amplitude metric
13.2 Equation for arrival time metric
13.2 Define symbols

14. Experiment conditions

14.1 Koch 2521 spiral-wound module
14.2 0−1.6 g/l aqueous $CaSO_4$ feed solutions
14.3 0−2.8 MPa pressure
14.4 0.1−2.0 l/m feed flow rate
14.5 176 hour maximum run time
14.6 Panasonics 0.5−3.5 MHz transducers

15. Results – spiral-wound module

15.1 Plot of normalized amplitude and arrival time metrics vs. time
15.2 Plot of permeation flux vs. time
15.3 Explain water equilibration, fouling, and cleaning
15.4 Indicate measure of experiment error
15.5 Explain why metrics do not return to those for unfouled membrane
15.6 Define abbreviation WE

16. Corroboration with SEM analysis

- 16.1 Micrographs from different points along and within module
  - 16.1.1 Indicate length scale
- 16.2 Higher magnification showing calcium sulfate crystals
  - 16.2.1 Indicate length scale

17. Conclusions

- 17.1 UTDR can provide real-time noninvasive measurement of membrane fouling
- 17.2 Amplitude and arrival-time metrics provide useful means for deconvoluting complex UTDR signal
- 17.3 UTDR corroborates well with permeate flux and SEM analyses
- 17.4 Fouling deposition in spiral-wound module is spatially non-uniform
- 17.5 UTDR can be used to optimize the design of spiral-wound modules

18. Acknowledgments

- 18.1 NSF
- 18.2 Industry/University Cooperative Research Center for Membrane Science and Technology
- 18.3 Logos
  - 18.3.1 NSF
  - 18.3.2 MAST Center
- 18.4 Website for MAST Center

19. Thank You slide

- 18.1 Cartoon caricature of speaker
- 18.2 Email address of speaker