Downcycling Opportunities For Reverse Osmosis Membranes

ENCE489J: Green Global Challenge - Mekhi Boulware, Duncan Kihiuria, Graham Simon, Ege Yagci

Background

Reverse Osmosis (R.O.) Water Treatment

- Use of membranes to filter water as membranes possess selective permeability.
- Subject to fouling and breakage over time.
  - Membranes are thrown out when they reach end-of-life.
  - Potential recycling opportunities, but there has not been much implementation.

Figure 1: *Fouled R.O. Membrane*

Objective

- **Power-to-X (P2X)** is an initiative to produce hydrogen from green energy.
- Hydrogen production requires reverse osmosis to clean the water.(Matjaž Matošec)

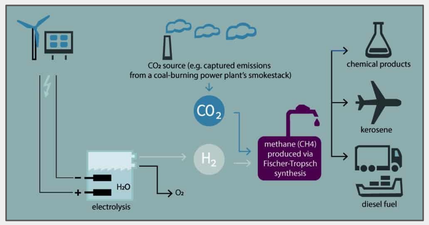

Figure 2: *Power-to-X liquids conceptual system (Bonfinger)*

- Aim to increase the sustainability of the P2X project though circular economy implementation of water filtration for hydrolysis.

Feasibility

Significance:

- Reverse osmosis membranes currently disposed of via landfill or incineration.
  - Long lifespan, but 2,000,000 units approaching end-of-life by 2025 (Tian et al.).

Figure 3: *Landfills and incineration disposal methods*

Downcycling Process:

- Unraveling of fouled membranes along with a condition evaluation.
  - No breakage = oxidation to downcycle to usable nano- or microfiltration membrane.
- Finished membranes will be tested via **molecular weight cutoff test** (MWCO)
  - Describes pore size and retention capabilities of membranes.

(Tian et al).

Costs:

- Sodium Hypochlorite (NaOCl) (for chemical oxidation)→ $118.65/L
- Labor required for disassembly, oxidation, and testing
- Transportation requirements
- €2,703,820.00 worth of energy for €360,607.24 worth of costs

Demand:

- Multiple industry uses for micro- and nanofiltration membranes:
  - Water treatment, chemicals, pharmaceuticals

Implementation

Water Treatment Facility:

- Regular testing and cleaning of existing RO membranes leads to accumulation of end-of-life membranes (Tian et al).

Unraveling and Oxidation

- Non-ruptured membranes get unraveled and oxidized based on their pore sizing.

(Tian et al).

Distribution of Membranes

- Membranes tested via MWCO and distributed to the corresponding industries needs based on porosity.

Conclusion

- Feasible potential for downcycling of R.O. membranes in other filtration systems.
- Increased sustainability in water filtration industry via prolonged life cycle.

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