

The Challenge of Water

- Panel
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Current State of Technology

- Water purification
 - Purify source waters for food production, human use, energy, and industry.
 - coagulation, filtration, chlorine-based disinfection, desalination of seawater and brackish water
- Water treatment
 - Treat waste streams from food production, human use, energy, and industry.
 - Biological processes, filtration, membrane separations, oxidation, adsorption, disinfection



Current State of Technology

- Common trends
 - Increased use of membrane processes in both water purification (desalination) and treatment of waste (water recycling)
 - Increased use of advanced oxidation for low-level toxic contaminants and disinfection (O_3 , H_2O_2)



Long term vision and goals

- Increase H₂O supplies where and when they are needed through efficient purification of impaired water.
- Detect and selectively remove low-levels of toxic contaminants at low cost.
- Disinfect without producing toxic by-products.
- Develop low-cost, robust systems with minimal energy and chemical inputs that can be deployed world-wide.



Materials Research Needs

- Multi-functional materials
 - Membranes that separate and disinfect
 - Adsorption/catalytic materials that concentrate and destroy organic contaminants



Materials Research Needs

- Membranes
 - Capability to rapidly develop and deploy application-specific membranes for both centralized and point-of-use systems.
 - Chlorine tolerant membranes for reverse-osmosis, nanofiltration, and forward-osmosis.
 - Membranes resistant to bio-fouling and scaling.
 - Improved rejection of neutral small molecules (B, As-containing species).



Materials Research Needs

- Detection and destruction of low-level toxic contaminants
 - Sensor materials and systems that are sensitive, selective, and long-lived in natural water and waste streams.
 - Closed-loop sensor/purification systems.
 - Remotely powered, on-line, portable sensing.
 - Catalytic and photocatalytic materials for advanced oxidation of organic micro-pollutants.



Materials Research Needs

- Disinfection (particularly in non-industrialized regions)
 - Materials that enable sunlight-driven disinfection (or if not sunlight then high-efficiency UV LEDs powered by photovoltaics).
 - Low pressure membranes that can be easily cleaned and capable of removing viruses



Materials Research Needs

- Basic research challenges
 - Incomplete molecular-level understanding of membrane separations.
 - No one can separately measure or predict the partition coefficient and mobility of a contaminant.
 - No one can quantitatively connect molecular structure to water permeability.
 - Incomplete understanding of mechanisms of oxidation and disinfection by photocatalysts.
- Gaps in basic understanding impair our ability to design new materials for specific applications.



International Cooperation

- As with energy, water is an international problem. Energy use is growing; water use will grow too.
- Water crosses national boundaries and will increasingly become a cause of conflict between nations.



International Cooperation

- International, cooperative research on materials for water purification/treatment is very limited compared to the scope of the problem we face.
 - China with Japan (JST and JSPS funding) and Korea on water treatment technologies.
 - China with EU on basic science of pollution of surface waters.
 - US with Saudi Arabia (KAUST) on desalination



Impediments to Int. Cooperation

- At least in the US, overall funding is small and little additional funding is available for international cooperative research
- US has much to gain from other countries who have invested heavily in water research and are facing severe problems sooner-rather-than-later
 - China, Israel, Singapore, Saudi Arabia, Spain, Netherlands



International Cooperation

- Industry has to be involved. Research universities cannot deploy materials on the scale needed in water purification and treatment. Cost is an overriding issue.
 - Waste water treatment in US and China totals 10^{11} m³ per year.



Outreach

- Raise public awareness of the value of water.
 - Source protection
- Education on health and safety of water sources. Water should be recycled too.

