UNIVERSITY OF SOUTH FLORIDA

Clean Drinking Water using Advanced Solar Energy Technologies

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Description: The availability of fresh water is a big problem facing Florida. In many locations, Florida's water is contaminated from leaky underground tanks and agricultural pesticides. Although salt-water desalination is possible, conventional systems are too energy intensive. Solar energy can supply the power, and innovative vacuum and humidification/dehumidification desalination systems can provide adequate fresh water for the state's needs. This team will develop water desalination for small community needs and also in bulk. Another goal is to develop photocatalytic disinfection to remove contaminants and integrate these technologies with solar PV for complete water supply systems. Projects include: Natural Vacuum Solar Flash Desalination: Creating vacuum conditions above liquids increase their evaporation rates. This phenomenon can be integrated into a practical continuous desalination process by repeatedly flashing seawater in vacuumed chambers to produce water vapor that will be condensed producing fresh water. Solar PV Assisted Photocatalysis for Air/Water Disinfection: Improving titanium dioxide photocatalysts for purification and disinfection of water and air contaminated with organic, heavy metal and microbiological species, using solar energy. This can be integrated into a practical continuous desalination process by flashing seawater in vacuum chambers to produce water vapor that will be condensed, producing fresh water.

Budget: $326,756
Universities: USF
External Collaborators: NA

Project Summary

Natural Vacuum Solar Flash Desalination: A flash desalination process sustainable by the natural forces of solar radiation and gravity has been proposed. Experimental and theoretical simulations of the proposed desalination process have been carried out. The process includes a start–up procedure and a continuous operation consisting of pumping seawater through a solar heater before flashing it under vacuum in an elevated chamber. The vacuum is passively created and subsequently maintained by the hydrostatic balance between the pressure inside the elevated flash chamber and the outdoor atmospheric pressure. Theoretical simulations were performed using a computer code comprising the fundamental physical and thermodynamic laws plus numerous correlations and parameters. Experimental and theoretical simulations were run at varying operating conditions but at analogous circumstances and their results were compared and analyzed to validate the developed model. The feasibility of the proposed system rapidly increased with flash temperature due to increased fresh water production and improved heat recovery.

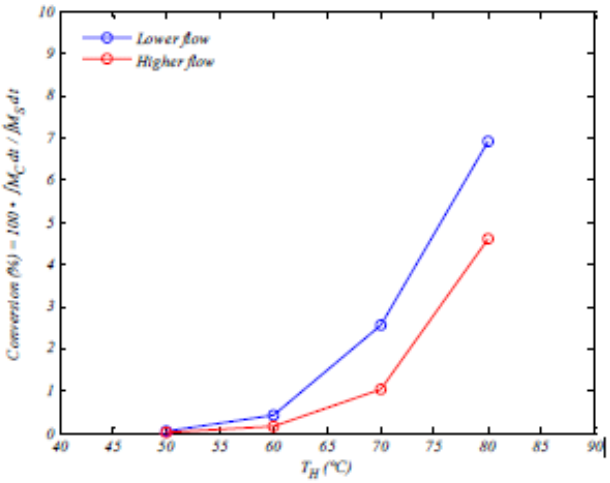

Figure 1. Seawater conversion dependence on flash temperature

The results suggest that the proposed process becomes more feasible if operated at higher temperatures and more moderate flow rates. It was found that that most fresh water production occurs in the beginning of the operation, where vacuum pressure is lowest.

Solar PV Assisted Photocatalysis for Air/Water Disinfection: The construction of an effective photocatalytic disinfection system for water purification is currently limited by the lack of reliable models to aid in the design and testing of these systems. Simplified models have been proposed, but most are inadequate because they rely on traditional disinfection theories that are not applicable to photocatalysis. Therefore, the major goal of this research focus is to develop a model for photocatalytic disinfection based on fundamental processes, which may then be used to design water treatment systems in the state of Florida. The progress achieved in the current reporting period is as follows:

Model Development

- We have developed a theoretical model for disinfection of microorganisms for slurry and immobilized catalyst systems.
- The theoretical model and a thorough review have been accepted for publication in a high-impact-factor journal, the Journal of Applied Catalysis B: Environmental.

Bench-scale Experiments

- A series of bench-scale experiments have been conducted to test the following which feeds directly into the model:
  - The influence and physiological significance of cell membrane fatty acids in the disinfection process
  - The influence of light intensity of disinfection
  - The influence of catalyst concentration on disinfection
  - The difference in disinfection kinetics for slurry and immobilized catalyst systems