Energy Quarterly

News and analysis on materials solutions to energy challenges

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Energy Sector title image page 404: Silicon wafer with an array of water sensor chips. Credit: University of Wisconsin–Milwaukee Media Office.

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MRS Bulletin

Water, energy, and materials science

A large part of the world's population echoes this feeling, even though we live on a planet that is covered by water on two-thirds of its surface. With an ever-increasing population, the demand for water for drinking and for many industrial processes is increasing steeply. There is a symbiotic relationship among water, energy, and materials. For instance, water is needed for producing hydroelectric power, cooling in power plants, fracking, and other energy-related industries. Energy is needed to treat water and pump it. Materials are critical for both.

Ancient civilizations attempted water purification using limited resources. Aristotle described a process to evaporate water using sunlight and condensation. The efficiency was low because of heat lost to the environment. In a modern version, a paper coated with carbon in the form of an inverted V is used to absorb solar radiation and convert it to heat. The bottom of the paper is soaked in water, which gets heated. The sloped region is not affected by the sun directly, remains cool, and attracts heat from the surroundings. Hence, efficiency is greater than what can be obtained from natural sunlight falling on an uncoated flat surface. This is a low-cost solution and can serve remote areas. Better coatings such as carbon-based nanomaterials can be used, but at a higher cost.

The sources of water are many, and the potentially harmful contaminants of water have to be measured carefully. For example, measurement of lead in drinking water needs sensors that work for measurements below 15 parts per billion. Commercial sensors for heavy metals, bacteria, and nutrients have yet to be developed. The role of water in each reaction is different, and water, therefore, must be specially treated before use in a reaction. There are opportunities for development of catalysts for wastewater treatment. All of these necessitate fundamental research in interfacial materials science.

Research on membranes for reverse osmosis is yielding exciting results. Some of it draws inspiration from unexpected sources. In the last paper he wrote, Alan Turing proposed a chemical basis for spontaneous formation of patterns in living systems. His model considered a mixture of two interacting molecules, one diffusing faster than the other. If one molecule inhibits the reaction while the other activates it, the mixture separates into regions of different composition. Since the diffusion rates are different, these regions are regularly spaced and form spots as on a cheetah or stripes as on a zebra fish. Polyamide membranes with three-dimensional Turing structures on the nanoscale have been produced in the laboratory. They contain sites where water permeability is high. There is usually a tradeoff between water permeability and water-salt selectivity. Membranes with a Turing structure improve both and hence surpass the traditional desalination membranes in performance.

Materials scientists must build on innovative ideas and contribute to large-scale production of appropriate functional materials so that water for various applications and clean energy for development are made widely available.

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