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Cleaning up water

The provision of clean water for a growing global population offers many challenges and opportunities for materials research.

Around 1.2 billion[1] of the world's estimated 6.5 billion people[2] lack access to clean water. The UN has predicted[2] that population levels will rise by around 2.7 billion, close to a 40% increase, by 2050. If this happens, extreme pressure will be placed on our precious and already hard-pressed freshwater resources. Greatest population growth is expected in the developing regions of Earth where already clean water is often incredibly hard to come by. Many growing economies desire Western standards of living where high-protein diets demand water-intensive agriculture, and greater energy consumption also consumes huge volumes of water in the generation of electricity[3]. The problems associated with water supply are not just about quantity. A growing number of contaminants such as heavy metals, distillates and micropollutants[1] are entering our water supplies, making purification even more challenging.

Conventional methods for water treatment can and do address many problems. But treatments can be chemically, energetically and operationally intensive. And some of these technologies can introduce new and potentially harmful contaminants into water supplies. For example, in the USA, free chlorine has been used to control waterborne pathogens in ageing water-distribution systems. However, the treatment process results in the formation of toxic by-products; disinfection regulations now require the minimization of such by-products, which could force a re-think of how to deal with the problem[1].

Recent developments in materials science offer hope for new approaches to the challenges of water disinfection, decontamination and desalination to cope with man's increasing demands for clean water. Many physical scientists are now focusing on developing new membrane materials and investigating fundamental behaviour at the aqueous interface in the hope of advancing technologies for water purification so that they are efficient, robust and sustainable. Clean-water technologies are becoming regular symposia topics at conferences of the Materials Research Society and American Chemical Society and full special issues on the topic have recently appeared[4,5].

Fresh water is already hard to come by in many parts of the world.

Scientists envisage new membranes for disinfection, which can sequester viruses using biomimetic surface chemistries or deactivate pathogens with nanostructured photocatalysts[1]. Nanofibrous membranes offer improved efficiency in the decontamination of water supplies. Although such materials have been used for years in air-filtration devices, their application in water filtration is still in its infancy[6]. Membranes from block copolymers offer even greater control of pore-size distributions and thus water flux, along with pore surface chemistries that could resist fouling — perhaps the most challenging problem in water-treatment technologies more generally[1].

Futuristic devices for desalination include the carbon-nanotube-based membranes that have already been shown to have high water fluxes and salt-rejection co-efficients[1]. Perhaps even more intriguing is the concept of robust bioinspired membranes — with channels based on aquaporins and ion channels found in biological cell membranes — that have high ion selectivity and high water flux, offering energy efficiency[1,7].

But such devices will take years to get to a point where they might be affordable even for use in developed countries. And the provision of clean water in some parts of the world is already a substantial problem. Some extremely economical devices have already been conceived for developing-world situations, which can be manufactured immediately using sustainable resources, many of which are available at the point of use. Good examples are the terracotta filtration devices developed by Potters for Peace, which can be made by local workers[8], and the Kanchan arsenic filters made from very basic materials: iron nails, brick, sand and gravel[9]. But more could be done to apply science in the development of low-tech filters; even more pressing is the need for cheap and easy-to-operate devices to identify contaminated waters and quantify levels of pollution, to ascertain the degree of danger from its consumption.

The materials community has now recognized that their skills and expertise, particularly in the development of nanostructured materials, could have a huge impact. The global significance of a clean water supply for future generations and the numerous associated scientific challenges should provide much inspiration to continue to work towards this important goal.

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