Nanotechnology-Enabled Water Treatment: A Vision to Enable Decentralized Water Treatment

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Through control over material size, morphology and chemical structure, nanotechnology offers novel materials that are nearly "all surface" and that can be more reactive per atom than bulk materials. Such engineered nanomaterials (ENMs) can offer superior catalytic, adsorptive, optical, electrical and/or antimicrobial properties that enable new technology platforms for next-generation water treatment. This presentation will address emerging opportunities for nanotechnology to meet a growing need for safer and more efficient decentralized water treatment and reuse. Because water is by far the largest waste stream of the energy industry, emphasis will be placed on technological innovation to enable produced water reuse in remote (off-grid) oil and gas fields or offshore platforms, to minimize freshwater withdrawals and disposal challenges. Examples of applicable nano-enabled technologies include fouling-resistant membranes with embedded ENMs that allow for self-cleaning and repair; capacitive deionization with highly conductive and selective electrodes to remove multivalent ions that precipitate or cause scaling; rapid magnetic separation using superparamagnetic nanoparticles; solar-thermal processes enabled by nanophotonics to desalinate with membrane distillation; disinfection and advanced oxidation using nanocatalysts; and nanostructured surfaces that discourage microbial adhesion and protect infrastructure against biofouling and corrosion. These enabling technologies can be used to develop compact modular water treatment systems that are easy to deploy and that can treat challenging waters to protect human lives and support sustainable economic development.