Developing cost-effective membrane technologies to extend water resources and solve water pollution problems is critical to the sustainable development of human society. In this work, novel nanocomposite membranes with enhanced separation performance were developed for water and wastewater treatment. First, both flat-sheet and hollow fiber membrane fabrication systems were set up to provide capabilities for nanocomposite membrane preparation. Then, to improve membrane performance, nanomaterials with different components (inorganic or organic), structures (porous or nonporous), and functionalities (inert, antimicrobial activity, or photocatalytic activity) were incorporated into polymeric membranes based on proposed applications.

The results showed that hydrophilic nanofillers could improve membrane surface hydrophilicity, leading to a membrane with enhanced water permeability and antifouling properties. Meanwhile, nanofillers containing internal pore structure could further improve water permeability by providing additional flow paths for facile water transport. A chemical bonding method was successfully developed to attach silver nanoparticles (AgNPs) onto membrane surfaces for anti-biofouling. The resultant membranes showed good stability and excellent antibacterial capability. The pioneering development of nanocomposite membranes possessing visible light activity demonstrated an improved water permeability and superior antifouling properties due to the photodegradation of foulants and photoinduced hydrophilicity enhancement.

Overall, nanocomposite provides polymeric membrane design a new dimension, which could lead to the next generation of high performance membranes.