New membranes for water treatment: towards circular economy to increase water resources

Paula Arribas Fernández

The development of efficient membrane filtration technologies is especially important as water shortage has become a growing global problem. Low cost operation, high energy efficiency and high throughput enable membrane separation processes to compete successfully with conventional separation processes. Membranes are a highly utilized, environmentally-friendly method in wastewater treatment, in water purification and in clarification and concentration processes. However, the fabrication of adequately designed membranes for a specific application is challenging. The main objective of this research is the preparation, characterization and optimization of different types of membranes that could be competitive with the ones available in the industry for the treatment, clearance and disinfection of different types of contaminated waters throughout different filtration processes. The fabrication conditions of new polysulfone electrospun nanofibrous membranes (PSU ENMs) were optimized and a heat post-treatment approach was applied to modify their structural and morphological properties and improve their filtration performance, obtaining membranes suitable for wastewater treatment. These membranes showed a high performance in humic acid (HA) removal by microfiltration (MF). To reduce the organic fouling tendency of PSU ENMs and consequently to increase their lifetime while reducing the operation and maintenance costs of the filtration process, different surface modification techniques such as interfacial polymerization (IP) and TiO2 coating were conducted on the membranes. Particularly, thin-film composite (TFC) polyester-PSU based ENMs were prepared by IP of bisphenol A and trimesoyl chloride and the reaction time was optimized for best antifouling performance of the membranes. To develop the first approach to recycle disposed reverse osmosis (RO) membranes as support in forward osmosis (FO) wastewater treatment, different polyamide-IP approaches were, in a preliminary study, tested on commercial polyethersulfone membranes and their FO-filtration performance was evaluated with HA. In addition, new antibacterial membranes were developed by modifying their surface with interlaced carbon nanotubes electrodes. The electrodes effectively reduced the biofouling during the treatment of water contaminated with bacteria and viruses by electrochemical MF. Finally, new graphene oxide membranes were manufactured using different types of graphene oxides available in the market. They were evaluated for their intrinsic antifouling performance, dye absorption capacity and membrane permeability.