Photoelectrochemical Water Treatment

Kihyun Cho[a]

[a]Department of Energy Engineering, Dankook University, Cheonan 31116, South Korea

Abstract

Environmental pollution, water scarcity, resource shortage, and fossil fuel reliance have all represented threats to a sustainable future. Separation processes play a pivotal role in improving sustainability in fields such as industrial processes, resource recycling, wastewater treatment, and water desalination, among others. Electrochemical systems have gained increased attention as effective separation platforms, not only in performance but also as a potentially energy-efficient approach. However, the reliance on non-renewable energy sources, such as fossil fuels, for electricity generation limits the advancement toward a fully sustainable separation process. Integration of separation processes with eco-friendly renewable energy sources can increase overall sustainability and decrease carbon footprint. To advance the sustainability of electrochemical separations and extend its renewable-energy integration, here, we propose redox-mediated photoelectrochemical separation processes using redox-polymer-functionalized semiconductor photoelectrodes, which integrates direct solar energy as a driver for wastewater purification and critical resource recycling. The semiconductor photoelectrodes successfully enable redox-reactions of the redox-polymer without electrical energy under light irradiation. An energy analysis shows that our PEC cells not only can generate energy for spontaneous separation reactions, but also can reduce electrical energy consumption by up to 68.8% compared to EC cells for separation processes when coupled with an external electrical energy. Our results pave the way for new hybrid PEC processes using redox-electrodes for future sustainable separations by decreasing the reliance on non-renewable energy sources.