Highly Efficient Purification of Mult-component Wastewater by Electrospinning Kidney-beans-skin-like Porous H-PPAN/rGO-g-PAO@Ag+/Ag Composite Nanofibrous Membrane

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Introduction

Polyacrylonitrile (PAN) is a common polymer matrix for membranes because of its good chemical and thermal stability, corrosion, and high mechanical strength^{1, 3-4}. Moreover, there are plenty of nitrile groups (-CN) on the backbone of PAN molecular chains, which can be easily converted to hydrolytic groups (-COOH). In addition to improve the hydrophilicity of the membrane skin, the -COOH groups can provides nucleation sites in favor of the growth of nanocrystals. Therefore, the pre-synthesized poly amidoxime-g-reduced graphene oxide (PAO-g-rGO) was used as an additive for adsorbing heavy metals, PVP as porogen to prepare PAN-based composite nanofiber membrane (CNFM) by electrospinning in this study². Then, the CNFM was further hydrolyzed and thermal reduction treatment. A part of Ag⁺ growing on the membrane skin and adsorbed by PAO were reduced to Ag elementary substance as a result. The heavy metal ions Ag⁺ adsorbed by PAO and loaded on the membrane skin are skillfully utilized, which makes it recyclable and environment friendly. The two Schottky structures of rGO/Ag and Ag⁺/Ag loaded on the PAN-based nanofiber membrane synergically endow the membrane with photocatalysis to organic dye and bacterial microorganism⁵⁻⁶.

Experiment

Characterization

Figure 1. (a) FT-IR spectra and (b) XRD patterns of CNFM1-7~CNFM4-7, (c) Ag 3d XPS spectrum of CNFM4-7.

Figure 2. (a) Photocatalytic degradation of BA on the CNFMs under UV light. (b) First-order kinetic models of BA on the CNFMs-7 membrane. (c) Recycling stability of CNFM4-7 to BA as under visible light. (d) The growth of E. Coli on CNFMs, inset: magnification of the red area. (e) Photographs of E. coli colonies culturing results of the treated bacterial culture medium on solid culture medium for 24 h at 37 ± 1°C after 6 h irradiation to the testing system containing CNFM2-7, CNFM3-7, CNFM4-7 and blank. (f) Schematic diagram of the hypothetical synergistic antibacterial mechanism of rGO-g-PAO@Ag⁺/Ag nanosystem.

Photocatalytic mechanism

Figure 3. (a) Photocatalytic degradation of RhB, on CNFM4-7 with the presence of different scavengers (b) First order kinetic models of RhB on the CNFM4-7 with the presence of different scavengers (c) pseudo first-order kinetic constants of CNFM4-7 with different scavengers under visible-light irradiation. (d) Hypothetical photocatalytic mechanism of CNFM4-7.

Conclusion

H-PPAN/rGO-g-PAO@Ag⁺/Ag composite nanofiber membrane (CNFM) was fabricated by using a simple electrospinning method combined with thermal reduction. This multifunctional membrane exhibited excellent photocatalytic and bactericidal properties rGO-g-PAO@Ag⁺/Ag could be easily excited to generate photogenerated electrons and holes (SPR), which could promote the light absorption capacity and the sterilization property of the composite membrane, as well as improve the efficiency of photocatalysis. The CNFM possessed stable microstructure and exhibited high mechanical strength of 7.21 MPa even though experiencing 5 times of cycling. It is worthy to mention, CNFM was cost-effective and can be easily scale up industrially. In addition, the multifunctional porous membranes surface loading element enabled it to remove heavy metal ions (reported in previous works).³⁵ At the same time, organic dyes and metal organic complexes could be removed by a chemical oxidation process, which would not bring secondary pollution to the environment. Therefore, CNFM is a right substitute for actual wastewater treatment.

References

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