

Novel and robust functional composite biomaterial for membrane biofouling control in anaerobic membrane bioreactor

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Abstract:

Quorum quenching (QQ), which degrades microbial signal molecules or downregulates their inducers or receptors, has proven effective for biofouling anaerobic membrane bioreactors (AnMBRs). However, only hydrogel-based QQ bacteria encapsulation media are used, lacking mechanical strength and durability. This study evaluates the fabrication, biocatalytic activities, morphological characteristics, and application of a functional composite biomaterial (FCBM) as a novel and robust QQ bacteria encapsulation material for effective biofouling mitigation in AnMBR. The morphologies of FCBM fabricated from Polysulfone and QQ-embedded mesoporous silica in an organic-solvent rich environment reveal trapped rod-shaped BH4 and exhibit biocatalytic activity (QQ activity) before and after its application to AnMBR, demonstrating its biocompatibility and long-term durability. Further, QQ-FCBM indicates superior tensile strength (388% of previous media) and significantly reduces biopolymers levels (~10-61%), as well as quorum sensing secretions (~15-61%), compared to phases without QQ-FCBM. Furthermore, the QQ-FCBM demonstrates significant anti-biofouling efficacy in anaerobic membrane bioreactors, extending membrane filtration times by 168-305% compared to Phases without it. The findings of this work demonstrate the potential effectiveness and practicality of FCBM in membrane fouling control and open pathways to the synthesis of flexible and robust functional composite biomaterials for separation, mechanical, and biomedical applications.

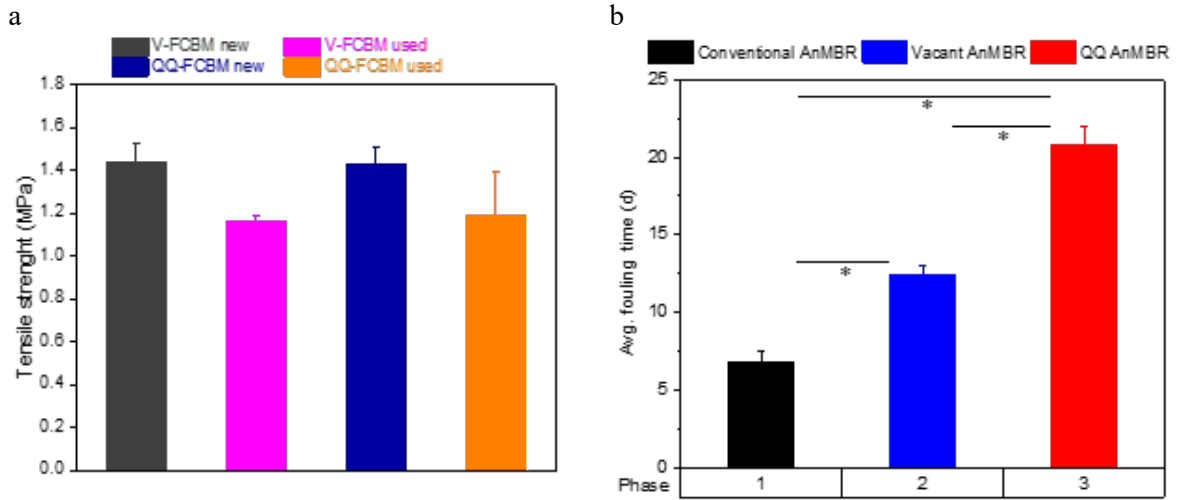


Figure. Tensile strength and average fouling time. **a** Average membrane fouling time with two-way t-test probability; **b** Tensile strength values of novel biomaterial before and after use in AnMBR. Error bars indicate 1 SD.

Keywords: Membrane biofouling, quorum sensing; quorum quenching; anaerobic membrane bioreactors; functional biomaterials