Low-frequency blue energy harvesting for sustainable and active anticorrosion

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Abstract The ocean is a complex and bulk system featuring diverse organisms from the cellular scale to large mammal scale, changeable conditions from the atmosphere to a depth of nearly 4,000 meters, and dynamically crossing the temperate zone to the tropical site. The complexity and variability of the marine conditions pose a plethora of technical challenges to exploiting and utilizing marine resources. One extraordinary challenge is the inevitable material corrosion caused by the interaction of metal products with seawater and a wet atmosphere.[1] The undesired phenomena seriously threaten the service life of the applied engineering materials, generating material failure, economic loss, environmental damage, and even human death[2]. Engineering materials serving in marine surroundings are inevitably corroded. The corrosive marine conditions can also be utilized to harvest kinetic ocean wave energy to solve this problem. Leveraging water–solid triboelectrification to harvest low-frequency wave energy for active anticorrosion is promising. Existing techniques are efficient in harnessing environmental energy with frequencies higher than 3 Hz, whereas the dominated ocean waves with optimal wave spectral density fluctuate from 0.45 to 1.5 Hz. Herein, we proposed a highly efficient and sustainable blue energy-powered cathodic protection (BECP) strategy by fusing water-solid triboelectric nanogenerators and cathodic protection technology. Leveraging the highly efficient triboelectrification between the moving water and hydrophobic fluorinated ethylene propylene tube, we developed the built-in power module, enabling the harvest of ocean wave energy lower than 1.5 Hz. The generated volumetric current density is 28.9 $mA \cdot m^{-3}$, 5-20 times higher than the values of the reported devices. Moreover, the proposed BECP performs comparably to conventional cathodic protection in corrosion inhibition. Significantly, the proposed approach can be easily applied to ships, buoys, and other offshore platforms to simultaneously realize blue energy harvesting and engineering material protection, providing an alternative to traditional active protection technology.

Keywords: corrosion inhibition, ocean wave energy harvesting, triboelectric nanogenerator, cathodic protection

Reference

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