A Study on a Buoy-Type Kurutoga TENG Power Generation System for Eutrophication Remediation

Lee, Geolmook (School: Busan Science High School)

Severe eutrophication causes hypoxic “dead zones” (e.g., the Gulf of Mexico). The mass death of marine life accelerates oxygen depletion, creating a vicious cycle. Conventional restoring methods, like pump-based aeration or chemical treatments, suffer from high energy consumption or potential ecological toxicity. Thus, I propose a self-powered, eco-friendly system to restore eutrophic waters by supplying micro-oxygen bubbles via seawater electrolysis. The electrical energy is generated by a triboelectric nanogenerator (TENG). To maximize TENG efficiency, continuous friction is essential. A Kurutoga mechanism was adopted to convert irregular vertical wave motion into continuous rotational motion. This leads to continuous sliding friction, maximizing power generation. To resolve conventional gear wear limits, a new gear with circular arcs was designed. Using probabilistic modeling and the work–energy theorem, it was mathematically proved this gear achieves higher efficiency and better durability at an angle between 20° and 34.2°. The design was modeled in Fusion 360 and 3D-printed. For the TENG electrodes, PTFE and Kapton were compared. PTFE exhibited higher voltage spikes (~10 V), exceeding the threshold for seawater electrolysis, and was thus selected. Using Faraday’s law, the oxygen generation rate was theoretically estimated at 0.3–0.6 mL per 10 minutes. As a result, we calculated it requires 33 days to restore 1 cubic meter of eutrophic water. Furthermore, the system shows strong potential for large-scale application through buoy network deployment.

Awards Won: