Low-cost Heteronanostructure Semiconductor Uses Visible Light Energy to Efficiently Degrade Toxins Threatening Aquatic Life

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Daily human activities produce TCDD, one of 12 most concerning toxins, which enters rivers, lakes, and eventually drinking water. Research shows that TCDD accumulates for over 15 years in humans and damages the endocrine system interim. However, little research has been conducted on TCDD's impact to the aquatic ecosystem. In addition, existing remediation methods for TCDD are expensive, ineffective, and unsustainable. This research found that current environmental levels of TCDD (0.01-1ppb) severely impact medakafish embryogenesis after brief and chronic exposures (1 hour, 4 day). Phenotypic observations from light microscopy revealed high frequencies of blood clotting, hemorrhaging, and blood pooling in 7 regions of the body. Severity and relative frequency of such symptoms differed based on exposure time. Pericardial edemas swelled over 4 times larger than the control. Follow-up RT-qPCR showed TCDD-induced overexpression of the CYP1A gene. To protect the aquatic environment, a low-cost yet highly efficient heteronanostructure semiconductor was designed and synthesized to degrade TCDD using visible light energy. Efficiency was amplified through co-enhanced junctions, as well as adjusting synthesis parameters to increase surface area. The semiconductor degraded model dye methylene blue more efficiently than present benchmark semiconductors, and near completely detoxified TCDD. The semiconductor's capability to breakdown TCDD, one of the most degradation-resistant pollutants, makes it possible to degrade most other organic pollutants. Furthermore, its cheap and safe nature makes this novel semiconductor an affordable solution to water pollution in developing and developed nations.

Awards Won:

First Award of $5,000

Intel ISEF Best of Category Award of $5,000

Intel Foundation Cultural and Scientific Visit to China Award