Hawai‘i Natural Energy Institute Research Highlights

Advanced Materials

Regenerative Air Filtration Materials

OBJECTIVE AND SIGNIFICANCE: This project's objective is the development of air filtration materials that are capable of regeneration through UV light exposure. These materials would have application to purify air for stationary and vehicle fuel cell power plants. Since these materials only require UV light for regeneration, ambient sunlight could serve to regenerate the materials, reducing energy or toxic material demand and use in Hawai‘i.

BACKGROUND: A novel method for regenerating air filtration material through photocatalysis is reported herein. In this study, titanium dioxide (TiO_2) and graphene oxide is covalently bonded to the surface of granular activated carbon to form a uniform nano-scale coating using nitric acid pretreatment and a hydrothermal reaction. Coupling with graphene oxide has also been shown to activate TiO_2 under longer wavelengths of visible light. Graphene oxide was utilized in this study to enhance the efficiency of TiO_2 and the allow the free radicals produced under UV radiation to scavenge surface bonded air contaminants, SO_2 molecules in this case. A custom air filtration test bed was used to expose air contaminated with SO_2 to the novel air filtration materials. The test bed allowed the characterization of the adsorption capacity of the novel air filtration materials. After adsorption capacity was determined, the material was submerged in an aqueous solution and exposed to UV radiation. During that time, the UV light is theorized to produce free radicals from interaction with the TiO_2, those free radicals are then absorbed by the electron sink of the graphene oxide, at which point the free radicals scavenge and attack the nearest SO_2 surface bond, thus releasing SO_2 from the surface and regenerating the surface so that the material can be reused as an air filtration material.

PROJECT STATUS/RESULTS: Hydrothermal synthesis of TiO_2/graphene oxide coated activated carbon was shown effective in producing a nanoscale, uniform coating of TiO_2 onto the surface of oxidized activated carbon. Nitric acid (HNO_3) pretreatment was necessary to ensuring complete surface coverage by increasing the surface carboxyl groups on activated carbon. Presence of TiO_2 decreased the adsorption capacity of pure activated carbon from 0.139 to 0.075 g SO_2/g TiO_2/graphene oxide coated activated carbon, corresponding to a 46% drop. Photocatalytic oxidation and water regeneration contributed to the overall regeneration of TiO_2/graphene oxide coated activated carbon. Water regeneration provided a significant effect where a 67% regeneration efficiency was able to be obtained without any UV exposure. When exposed to UV light, an even higher regeneration efficiency of 87% was achieved and the respective photocatalytic mechanisms were speculated. The results from this study (Figure 1) demonstrate the technical feasibility of photocatalytic enhanced regeneration.

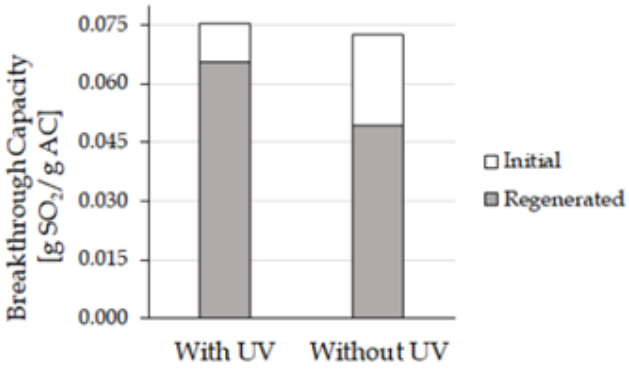

Figure 1. Initial and regenerated breakthrough capacity of TGAC with and without UV exposure.

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