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Converting Waste Tire to Activated Carbon Adsorbent Materials for Landfill Gas Purification

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Since 2013, the amount of scrap tire waste generated in the U.S. has increased by over 32%, while the utilization of materials derived from tire waste has decreased by over 25%. This has led to an increase in land disposal of tire waste by 123%. This trend necessitates the development of new methods and markets for processing and recycling scrap tires. One possibility, based on the sustainability principles of industrial ecology, is to use tire waste as a source of carbon, which can be activated and used to make adsorbent materials which can be used in turn to purify landfill gas (LFG). LFG is generated when organic waste decomposes in the low-oxygen environment of a landfill. It is an unavoidable byproduct of the landfilling of municipal solid waste (MSW), and it is rich in methane (50-60 vol.%) and carbon dioxide (40-50 vol.%), with lower levels of hydrogen sulfide, water vapor, and siloxanes. Once purified, LFG can be used as renewable natural gas (RNG) to generate electricity or fuel the natural gas grid. The treatment of LFG into RNG is not only beneficial as a source of renewable energy but also benefits the environment by reducing greenhouse gas and odor emissions.
To explore the potential of using amine-modified adsorbent materials from waste tire-derived activated carbon (AC) to treat LFG, the following steps were taken. First, the waste tire was characterized to determine its composition and to identify any potential treatment or processing required before activation. Second, microwave heating was used to carbonize the tire in an oxygen-deficient environment, followed by converting the carbonized tire into AC. Third, N2 physisorption was used to explore the textural and structural properties of the AC, and multiple samples were selected for amine modification. Fourth, amine-modified activated carbon (i.e., aminocarbons) were synthesized with various amine types and loadings. Fifth, the potential of the synthesized aminocarbons for carbon dioxide adsorption was determined in the presence of dry carbon dioxide (30 vol.% in nitrogen), with multiple performant samples being chosen for further analysis. Sixth, the potential of the performant samples from the last step was further explored in the presence of humid carbon dioxide, with multiple performant samples being shortlisted for further evaluation. Seventh, the hydrogen sulfide adsorption potential of the previous performant samples was analyzed. Our preliminary results indicated that tire-derived AC materials are potential candidates to remove multiple impurities from LFG.

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