Hydrogen Sulfide and Ammonia Removal from Biogas using Water Hyacinth-derived Activated Carbon

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Introduction
Despite the increased utilization of biogas both in industries and domestics there are some impurities associated with biogas which are harmful and toxic. Hydrogen sulfide (H₂S) is one of these toxic components which on low level exposure causes eye and respiratory system irritation. It also causes loss of consciousness and death when the exposure reaches 750-1000 ppm (Milby and Baselt, 1999). Its acidity nature leads to acidic rains when present in the atmosphere and corrosion of metallic materials and concrete metallic materials (MA, Cheng et al. 2000). On the other hand, ammonia (NH₃) when released to the atmosphere interferes with cloud formation and distribution as well as the increase of albedo by formation of NO₂, a greenhouse gas (Kirkby, Curtius et al. 2011). Additionally, ammonia leads to emission of NOₓ from turbine engines. Removing these components using water hyacinth –derived activated carbon has multiple advantages as it reduces detrimental effect in aquatic life.

Aims and Solutions
- Preparation of activated carbon from water hyacinth (WHAC)
- Adsorption of H₂S and NH₃ using WHAC from biogas

Significance of the Study
- Provision of clean biogas for industrial and domestic use
- Minimizing the effects caused by H₂S and NH₃
- Provision of alternative way of solving water hyacinth effects to aquatic nature

Methodology

- Collection, drying and grinding of the water hyacinth from Lake Victoria
- Carbonization at 450, 550, and 650°C to get water hyacinth porous carbon (WHC)
- Activation with KOH at 700°C in 1:0.25, 1:0.5, and 1:1 WHC:KOH for increasing porosity to get water hyacinth activated carbon (WHAC)
- Adsorption of H₂S and NH₃ from biogas using the WHAC at Banana Investment Ltd

Results
i. Characterization

Figure 1: SEM images of 650°C activated carbon where (a) is WHC, (b) is 1:0.25 WHAC, (c) is 1:0.5 WHAC, and (d) is 1:1 WHAC

The surface morphology of WHC shows smooth surfaces with nearly spherical shape. The activation process of WHC at 650°C with ratios 1:0.25, 1:0.5, and 1:1 deforms the smooth surfaces and decrease of the particle size which are good for adsorption.

ii. Adsorption
- WHC carbonized at 650°C (WHC-650) had a H₂S adsorption of 5% followed by WHC-550 30% and WHC-450 22%. That of NH₃ was 72, 50, and 42% respectively. The activated samples followed the same trend.
- WHC had best performance on adsorption of both H₂S and NH₃ compared to WHC. The performance increased with the increase of activation ratio. The adsorption capacity of H₂S by WHAC-650-1, WHAC-650-0.5, WHAC-650-0.25 and WHAC-650 were 32, 26, 23, and 8g/100g respectively at their breakthrough time.
- NH₃ adsorption by WHAC-650-1, WHAC-650-0.5, WHAC-650-0.25 and WHAC-650 were 100% of NH₃ in 2 h.
- The adsorption of the two gases also increased with the decrease of gas flow rate and increase of adsorbent mass

Figure 2: Effect of carbonization temperature on (a) H₂S adsorption (b) NH₃ adsorption

Figure 3: Effect of impregnating ratio WHC:KOH (a) H₂S adsorption (b) NH₃ adsorption

Figure 4: Sulfur sorption capacity of activated carbon

Conclusion
- The synthesized WHAC has high efficiency of removing H₂S and NH₃ from biogas through adsorption.
- The use of water hyacinth for AC production adds to the ways of minimizing problems posed by these plants in aquatic environments.

References