

## Regeneration of Spent Activated Carbon Using $\text{H}_2\text{SO}_4$ , $\text{HCl}$ and $\text{H}_2\text{O}_2$

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### Structured Abstract

**Background:** The regeneration of spent activated carbon (AC) offers a practical solution to environmental and economic challenges associated with its saturation and disposal. This study investigates the chemical regeneration of spent AC using three agents, sulfuric acid ( $\text{H}_2\text{SO}_4$ ), hydrochloric acid ( $\text{HCl}$ ), and hydrogen peroxide ( $\text{H}_2\text{O}_2$ ). Activated carbon, renowned for its high adsorption capacity owing to its large surface area and porous structure, is widely utilized in water purification, air filtration, and industrial applications. However, the saturation of adsorption sites compromises its efficiency, necessitating effective regeneration processes to restore its functionality and reduce waste generation.

**Methods:** The research employed a systematic process, including pre-treatment, chemical treatment with varying concentrations of regenerants, rinsing, drying, and detailed characterization of the regenerated AC. Scanning Electron Microscopy (SEM) and Fourier-Transform Infrared Spectroscopy (FTIR) were used to analyze changes in the structure and surface chemistry of the regenerated AC. The iodine value was measured to evaluate adsorption capacity. The efficiency of different concentrations and soaking durations for each regenerant was compared to identify optimal regeneration conditions.

**Results:** Regeneration with sulfuric acid, hydrochloric acid, and hydrogen peroxide demonstrated significant recovery of the adsorption capacity of spent AC. SEM analysis revealed that regeneration effectively restored the porous structure, removing blockages caused by adsorbed contaminants. FTIR data showed a reduction in chemical impurities and the restoration of functional groups critical for adsorption. Iodine value measurements showed that regenerated activated carbon treated with  $\text{H}_2\text{SO}_4$  regained the highest proportion of its original adsorption capacity, followed by  $\text{HCl}$  and then  $\text{H}_2\text{O}_2$ . Notably, hydrogen peroxide was found to be the most sustainable and environmentally friendly option, owing to its ability to minimize secondary waste generation. Cost analyses highlighted that chemical regeneration is substantially more economical compared to the production of new AC.

**Conclusion:** This study confirms that chemical regeneration effectively restores the adsorption capacity of spent activated carbon, extending its lifecycle while reducing environmental impacts and operational costs. Sulfuric acid provided the most efficient recovery in terms of adsorption capacity, while hydrogen peroxide emerged as the most sustainable option. These findings hold significant implications for industries relying on activated carbon, enabling cost-effective and environmentally responsible practices.

**Keywords:** Activated Carbon, Chemical Regeneration, Adsorption Capacity, Sustainability, Waste Management

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