# Salinity Effect on Adsorption of Phenol by Activated Carbon from Sugarcane Bagasse

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Activated carbon was obtained from sugarcane bagasse was studied and comparing with commercial activated carbon from coconut shell. Porosity parameters of the samples were calculated by low temperature nitrogen adsorption by using some theories. Adsorption of phenol on sample was studied in comparing with commercial activated carbon. Effect of salinity on phenol adsorption was studied by assessment effectivity of phenol removal from aqueous solution. It has been shown that the presence of sodium chloride in solution can increase adsorption of phenol by activated carbon.

**Keywords: Activated Carbon, Nitrogen adsorption, Sugarcane bagasse, Phenol, Salinity effect.**

## INTRODUCTION

Sugarcane is the most important plant for sugar production and one of the world′s largest crop by quantity. Extracted sucrose from sugarcane is used mainly in food industry or fermentation to biofuel [1]. Due to high coefficient of photosynthesis sugarcane is classified as bio renewable resource. Bagasse, a waste of sugarcane, which is fiber in nature and widely used for fuel, paper material, cattle feed, adsorbents, *etc*. [2-4]. Several articles are reported using sugarcane bagasse as potential adsorbents for the removal of arsenic [5], dyes [4,6], heavy metals [7,8], nitrate ions [9], *etc*. In order to obtain activated carbon (AC) from bagasse, most of reseachers use pyrolysis at high temperature under inert atmosphere.

One of the most toxicants environmental contaminant group is phenol and its derivatives. The presence of these pollutants, even at low concentration, makes water non-potable. Toxicity of phenolic derivatives based on irritation and protein degenerating effect. Unfortunately, phenolic derivatives are found commonly in petrochemical industrial sectors, *viz*. oil refineries, coal gasification sites, petrochemical units, *etc*. Also phenols are widely used in synthesis of plastics, dyes, pesticides, insecticides, *etc*. [10]. So, the environment, particularly water resources, always exposed to huge loads from them. Several conventional methods of treating phenols from aqueous solutions

*e.g.* chemical oxidation, biological degradation (anaerobic and aerobic), ion-exchange, solvent extraction and adsorption, *etc.* are reported in the literature [11-14]. Among these methods, immobilization of phenol and its derivatives on activated carbon is most popular and efficient [15,16], but adsorption process can be affected of salinity.

In the present work, effect of salinity on phenol adsorption onto activated carbon was studied. Two adsorbent samples were chosen: commercial activated carbon (AC) from coconut shell (AC-1) and activated carbon sugarcane bagasse (SB) impregnated with KOH and pyrolyzed in absence of oxygen air at 600 °C (AC-2). Adsorption capacity of samples to phenol was calculated by using Langmuir and Dubinin-Radushkevich models.

## EXPERIMENTAL

Bagasse was collected from a local market of Hanoi city, Vietnam. Analytical reagents phenol was purchased from Sigma-Aldrich, while other analytical grade reagents and chemicals *viz*. KOH and NaCl were purchased from Xilong (China).

**Adsorbent:** Collected bagasse was washed for removing dust and residual sucrose, cut into small pieces (2-5 mm) and dried at 80 ± 5 °C for 24 h. To prepare AC-2, dried bagasse was treated with 10 % aqueous solution of KOH in 10 h, then
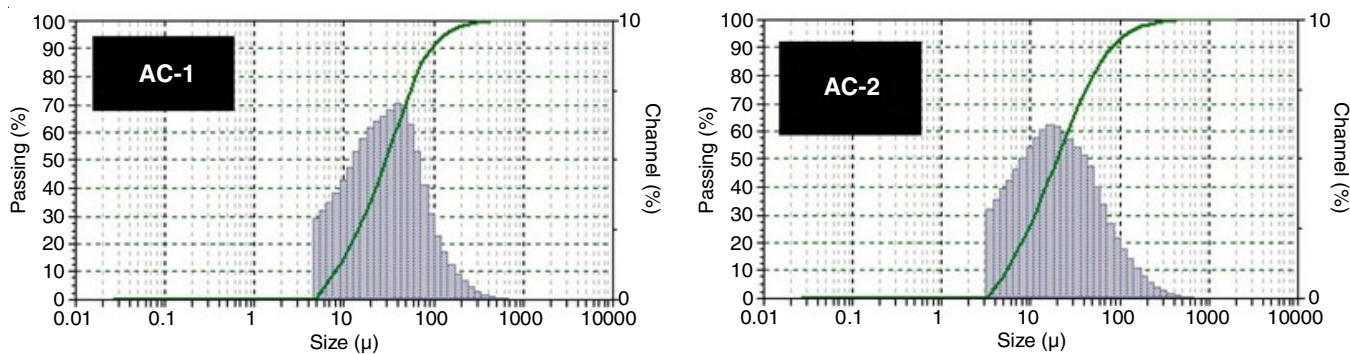
Fig. 1. Particle size distribution of materials

filtered out and dried at 80 ± 5 °C for 24 h. Treated bagasse then pyrolyzed in absence of oxygen air at 600 °C in 1 h. Pyrolyzed product was washed by distilled water again, powdered and stored in glass jars. Determination of the particle size distribution of materials was carried out on a Microtrac S3500 (USA) laser analyzer of the dispersion composition of solid materials. Specific surface was calculated by low temperature nitrogen adsorption in Quantachrome 3200e.

**Adsorbate solutions:** Aqueous solutions of 100 mmol/L of phenol were prepared by dissolving required mass of reagent in distilled water. Solutions for adsorption experiment with different concentrations were obtained by diluting stock solution. The pH of solutions was not adjusted. Concentration of phenol solution measured on UV-VIS spectrophotometer Hitachi UH5300 at wavelength 270 nm.

## RESULTS AND DISCUSSION

An important indicator of powder material is the particle size distribution. The distribution of experimental samples by size is shown in Fig. 1. The integral curves show the dependence of the fraction of particle size fraction in mass percent. It has been established that in sample AC-1, the fraction of particles smaller than 100 μm is 92.05 % and in sample AC-2, their share is 93.43 %.

As seen, the maximum area of histogram AC-1 is in the region of 50-70 μm while in case of AC-2, maximum area of histogram AC-2 is shifted to the smaller fraction 30-50 μm. This indicates a more uniform distribution of particles in the size of sample AC-2.

The results of low temperature nitrogen adsorption analysis are showed in Table-1. By using several theories, the porosity parameters of samples were determined.

The adsorption isotherms of phenol are illustrated in Fig. 2. Adsorption parameters of samples were calculated by using Langmuir and Dubinin-Radushkevich isotherm models (Table-2).
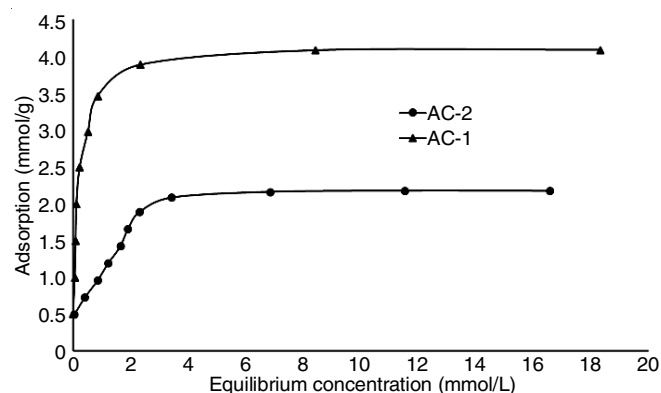


Fig. 2. Adsorption isotherms of phenol on activated carbon samples

### TABLE-2
### ADSORPTION CONSTANTS CALCULATED BY OTHER METHODS

| Method | Parameter | AC-1 | AC-2 |
|---|---|---|---|
| Langmuir isotherm | $Q_0$ (mmol/g) | 4.124 | 2.296 |
| | $K_L$ (L/mmol) | 6.644 | 1.351 |
| | $R^2$ | 0.999 | 0.996 |
| Dubinin-Radushkevich isotherm | $q_s$ (mmol/g) | 4.613 | 1.646 |
| | $K_{RD}$ | $2 \times 10^{-8}$ | $3 \times 10^{-8}$ |
| | E (KJ/mol) | 5.00 | 4.08 |
| | $R^2$ | 0.562 | 0.622 |

Sample AC-1 demonstrated its higher effective of phenol adsorption than AC-2 on all the concentration range (Fig. 2). In Langmuir model, the monolayer adsorption capacity of AC-1 is higher than AC-2 by 1.8 times while in Dubinin-Radushkevich model, the theoretical isotherm saturation capacity of AC-1 higher than AC-2 by 2.8 times. Adsorption of phenol is well in agreement with the data shown in Table-1, where porosity parameters of AC-1 is higher than AC-2. The Langmuir model is fitted much better than that of Dubinin-Radushkevich. The value of free energy less than 8 kJ/mol is indicating that the adsorption is a physical process.

In order to study the effect of salinity on phenol adsorption in activated carbon samples, a series of phenol solution have been prepared in presence of sodium chloride, which concentrations were 10, 20 and 30 g/L. Due to unknown solubility of

### TABLE-1
### POROSITY OF EXPERIMENTAL SAMPLES

| Theory | Parameter | AC-1 | AC-2 |
|---|---|---|---|
| BET | | | |
| -Multi point | Surface area (m²/g) | 951.4 | 489.3 |
| -One point | | 954.4 | 492.2 |
| DFT | Surface area (m²/g) | 915.4 | 848.8 |
| | Pore volume (mL/g) | 0.608 | 0.317 |
| HK | Micropore volume (mL/g) | 0.498 | 0.254 |
| DA | Micropore volume (mL/g) | 0.581 | 0.303 |
| α-s | Micropore volume (mL/g) | 0.404 | 0.209 |
| BJH | Mesopore and macropore volume (mL/g) | 0.157 | 0.03 |

phenol in saline water, batch adsorption experiment could not be done. So, only the efficiency of adsorption from diluted solution with low concentration of phenol will be calculated. The salinity dependence on adsorption effectivity illustrated in Figs. 3 and 4.
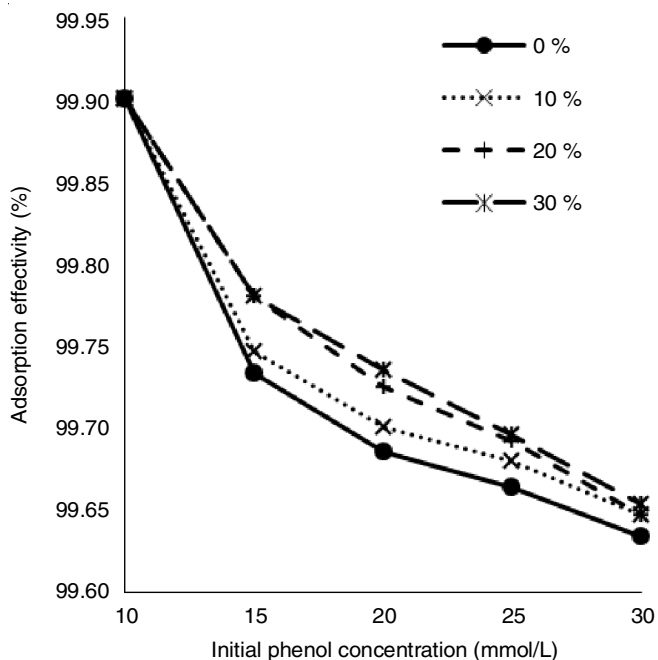


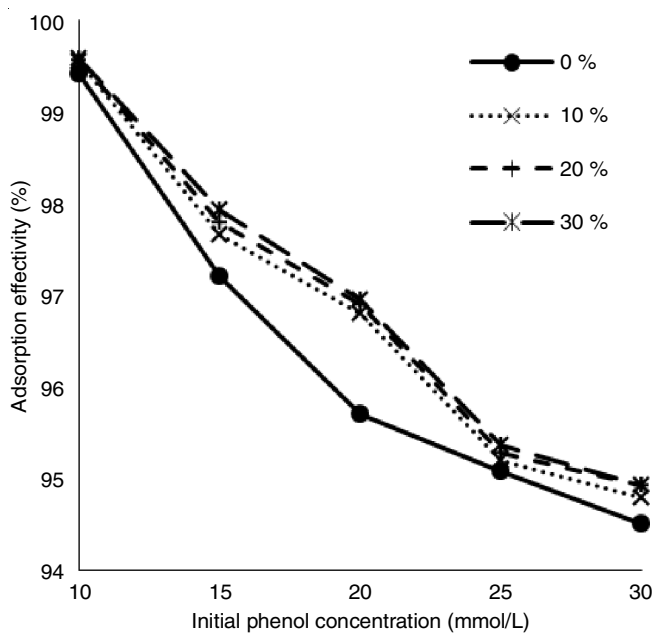Fig. 3. Salinity effect on adsorption effectivity sample AC-1



Fig. 4. Salinity effect on adsorption effectivity sample AC-2

From Figs. 3 and 4, it is found that commercial activated carbon AC-1 is more effective than AC-2 in all the concentration range of salinity. Moreover, adsorbents work in solutions

with lower concentration with higher effectivity and at the same initial concentration of phenol, presence of sodium chloride increase adsorption effectivity.

## Conclusion

Salinity effect on adsorption of phenol on two different activated carbons was studied. The adsorption capacity of activated carbon obtained from sugarcane bagasse is lower than commercial activated carbon as confirmed by both Langmuir and Dubinin-Radushkevich models. Presence of sodium chloride in solution increases removal efficiency of phenol more effectively. In saline solution, efficiency of removal phenol by using activated carbon from bagasse is slightly lower in comparison to commercial activated carbon obtained from coconut shell.

### CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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