# Effect of Co-existing Components on Adsorption of Constituents in Pyroligneous Acid by Activated Carbon from Rubberwood

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## Introduction

In Southeast Asia Countries, rubber wood furniture is one of the most important products for exportation [1]. On the other hand, there are many problems concerning the discharge from rubber wood furniture manufacturing process. The main problems are large quantity of the rubber wood residues and the toxic substances used for wood preservation. The wood residues and the toxic preservatives discharged from the process impact the environment, pollute the soil and the river [2].

To improve this manufacturing process, the utilization of products from thermal treatment of rubberwood residue was proposed. Pyroligneous acid can be used as preservative, activated carbon (AC), as adsorbent to adsorb toxic substances in the pyroligneous acid (PA), and off-gas, as heat energy [3].

In this study, the effect of the co-existing components on the adsorption of pyroligneous acid using rubberwood activated carbon is discussed. The rubberwood was thermally treated to obtain activated carbon and, with this activated carbon, adsorption equilibriums of model and pyroligeous acid solutions were examined.

## 1. Experimental

### 1.1 Preparation of activated carbon from rubberwood

The biomass used in this study was rubberwood sawdust from Malaysia. The apparatus of thermal treatment is shown in Figure 1. The thermally conditions are shown in Table 1. The sawdust samples were treated in a horizontal stainless tube situated in an electrical oven. The tube was heated to final temperature and held at this temperature for 1 hour in steam atmosphere. The activated carbon, AC, was, thus, prepared.

### 1.2 Adsorption in model solution

The activated carbon prepared from rubberwood sawdust was used as an adsorbent in adsorption runs. The activated carbon was washed by boiling water, crushed, and sieved to a particle size of 149 ~ 420 × $10^{-6}$ m before conducting adsorption runs. The used adsorbates were phenol, acetone, acetic acid (typical constituents in pyroligneous acid) in model solutions. The experimental conditions of adsorption equilibrium measurement are shown in Table 2.

Adsorption runs were conducted by placing 0.1 g of adsorbent and 25 g of aqueous solution in 1.0 × $10^{-4}$ $m^3$ conical flask. The flask was put in a constant temperature (303 ± 1 K) shaker bath with a shaker speed of 5400 $h^{-1}$ for 120 h. After reaching adsorption equilibrium, the mixture was filtered and the filtrate was analyzed by gas chromatograph [4].

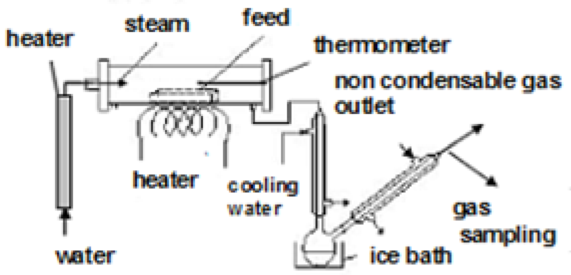


Fig.1 Apparatus of thermal treatment

Table 1 Thermally conditions

| | |
|---|---|
| Feed[g] | Rubberwood from Malaysia 25~30 |
| Thermal temperature [K] | 873 |
| Steam supply initiation temperature [K] | 473 |
| Steam flow rate [L/h] | 30 |
| Holding time [h] | 1 |

Table 2 Adsorption experimental conditions

| | |
|---|---|
| Feed solution | Aqueous solutions of a compound (phenol, acetone, acetic acid)<br>Aqueous solutions of two compounds (phenol and acetone or phenol and acetic acid) |
| Mass fraction[-] | 0.0004 - 0.3 |

## 2. Results and discussion

### 2.1 Yield of AC in thermal treatment

The yield of AC in the thermal treatment was about 0.22, which agreed with the values reported in the previous study [3].

### 2.2 Removal ratio R

The removal ratio $R$ was obtained by,

$$R = \frac{V(c_0 - c_e)}{Vc_0}$$

where $C_0$ and $C_e$ are the initial and equilibrium liquid phase concentrations. The R of phenol, acetone, acetic acid in single solutions are shown in Figure 2.

The maximum $R$ of phenol was about 80%. As a result, it was thought that the activated carbon could be used to remove the harmful components within the range of these experiment conditions.

### 2.3 Adsorption of single solute solutions

Figure 3 shows the adsorption isotherms of phenol, acetone, acetic acid in aqueous solutions on activated carbon. The activated carbon could adsorb three compounds. The adsorbed amounts of phenol obtained here were in good agreement with the previous data [4] as shown in Figure 3. Langmuir constants are also shown in Figure 3. All of the isotherms shown in these figures fit the Langmuir model well.

### 2.4 Adsorption isotherm in binary solutes solutions, multi solutes solutions and pyroligenous acid solutions

The adsorbed amounts of phenol, acetone, and acetic acid in the case with co-existing solute components in the solutions were compared with those without co-existing component [4].

Figures 4 ~ 6 show the adsorption isotherms of phenol, acetone, and acetic acid, respectively, in binary solutes solutions. The results of adsorptions in model multi solute solutions (Multi), which contained phenol, acetone, acetic acid, methanol, guaiacol, m-cresol, p-cresol, and in diluted PA are also shown in Figure 4~6. The rubberwood activated carbon could adsorb the components in all runs. In these figures, Langmuir curves obtained from the adsorbed amounts in single solute solutions are presented as well. The adsorption amounts of phenol in binary solutes solutions, multi and in the diluted PA were lower than those in the single solute solutions. The effect on the acetone adsorption was not clear. There was not obvious difference of the adsorption amounts of acetic acid between single and binary solutes solutions. The adsorbed amounts of acetic acid might hardly be affected by co-existing solutes, especially at the high concentrations. It is thought that Langmuir constants and equilibrium concentrations of solutions influenced the adsorptions.

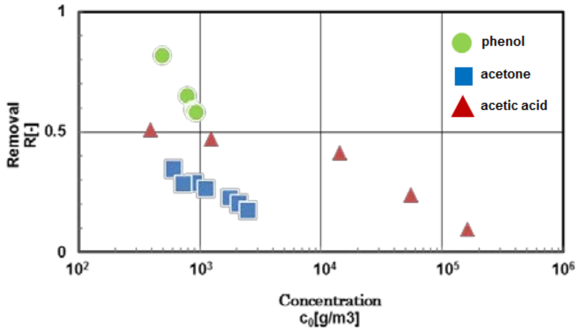


Fig.2 R of phenol, acetone, acetic acid in single solutions

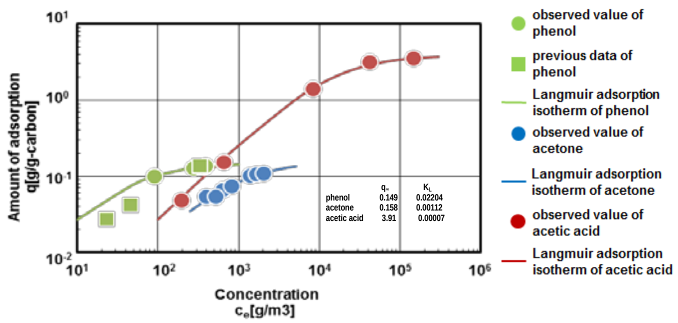


Fig.3 Adsorption isotherm of phenol, acetone, accetic acid

## 3. Conclusion

The rubberwood activated carbon could adsorb harmful constituents in PA favorably. According to the difference of the characters of the adsorbates and conditions of adsorptions, the adsorbed amount was lowered by co-existing of
other solutes components.

## Literature Cited

[1] Konishi Shunsuke, Bachelor Thesis, Tokyo Institute of Technology, 2004

[2] Shi Nan, Bachelor Thesis, Tokyo Institute of Technology, 2004

[3] Mitani Saori, Bachelor Thesis, Tokyo Institute of Technology, 2009

[4] Rizafizah Othaman, Doctor Thesis, Tokyo Institute of Technology, 2009

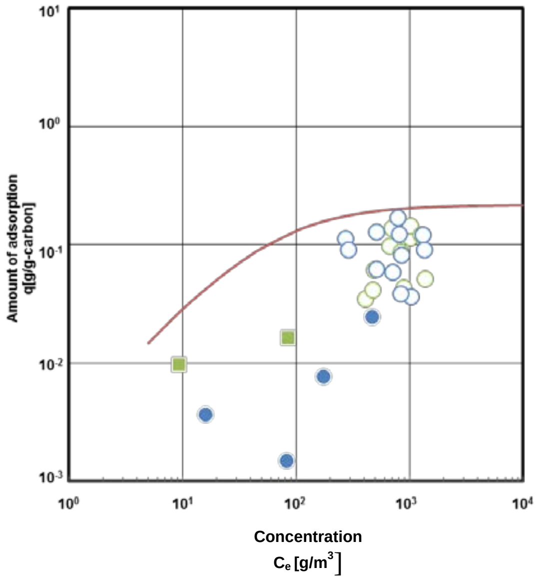


Fig.4 Adsorption isotherm of phenol in binary solutes solutions

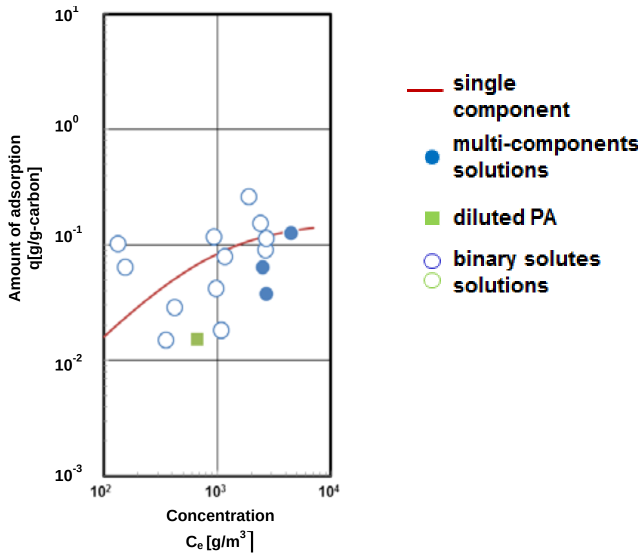


Fig.5 Adsorption isotherm of acetone in binary solutes solutions

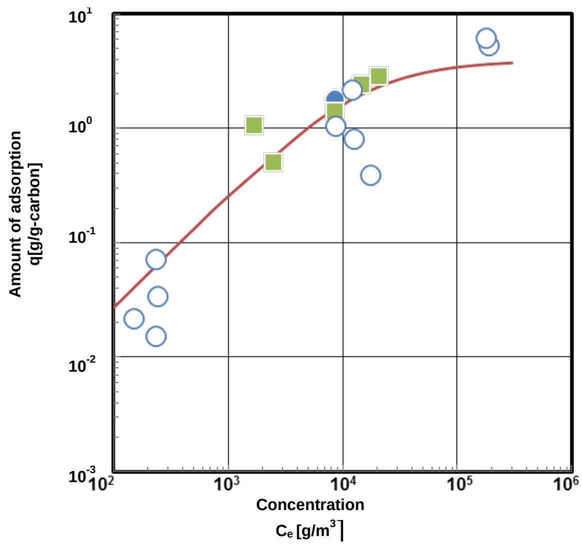


Fig.6 Adsorption isotherm of acetic acid in binary solutes solutions