CHAPTER V
CONCLUSIONS

5.1 Material Characterization

The chemical treatment improved the surface acidity of activated carbon by either physical or chemical properties, as shown by the atomic percentage result (EDX). The high surface area was obtained when the activated carbon was treated by nitric acid and sodium hydroxide, whereas low surface area was obtained when sample was treated by 3-aminopropyltriethoxysilane (APTES). The pH results indicated that refluxing affected the carbon pH higher than chemical treatment (shaking).

The refluxed activated carbon obtained the carbon pH higher than chemical treatment because the refluxing operated with a severe condition. As a result, the particle size from refluxing got a smaller than chemical treatment (1.70-2.36 mm and 125-180 μm, respectively). Thus, the fine particle had the surface area more than a coarse particle indicating that the fine particle can adsorb these chemical molecules more than other. However, the sodium hydroxide treatment occurred a physical adsorption (Physisorption) which these molecules were easier to remove after washing with deionized water. Whereas, the APTES treatment referred the chemical adsorption (Chemisorption) which provided the highest pH broth. However, APTES treatment had the lowest surface area because the APTES was a bigger molecule than both nitric acid and sodium hydroxide. The mechanism adsorption of APTES is shown in Figure 4.2(b) (modified from Shanmugharaj *et al.*,2007). The FTIR results showed that the highest intensity of amine function groups, which is the bending and stretching vibration of N-H, was clearly seen with the AS-AC(R). This can be concluded that APTES treatment clearly reduced the acidity at activated carbon surface.

5.2 Fermentation

As a result, the immobilization provided the butanol concentration higher than free cell system. Among the materials used in the present work, NASH-AC was the appropriate immobilized material treated by acid-base treatment it provided a butanol concentration of 7.54 g/l. Whereas, the best immobilized material treated by amine-base treatment was AS-AC(R) which provided a butanol concentration 10.66 g/l. From the characterization results, the surface area of the materials does not have a significant effect on the solvent productivity as the carbon pH. The pH of fermentation system by immobilized NASH-AC was higher than that of AS-AC(R) system at stationary phase, which have pH 5.50 and 4.34, respectively. It indicated that the APTES treatment can reduce the activated carbon surface acidity better than other treatments. Moreover, the immobilized AS-AC(R) had a higher butanol factor than the immobilized zeolite13X (from previous work), as shown Figure 5.1. Butanol factor was used to compare the efficiency of fermentation batch which was calculated from the butanol concentration of each immobilized material divided by free cell system. Furthermore, the immobilized materials had an insignificant effect form butanol adsorption which all immobilized materials had a same trend adsorption.

Table 5.1 pH broth of every ABE fermentation systems at stationary phase.

System	pH broth	Butanol (g/l)
Free cell	4.91	Depend on each batch
NASH-AC	5.47	7.54
SH-AC	4.82	7.22
AS-AC(R)	4.32	10.66
SH-AC(R)	4.60	5.64

*Butanol concentration of free cell system in acid-base treatment and amine-base treatment fermentation occurred 7.50 and 4.48 g/l, respectively.

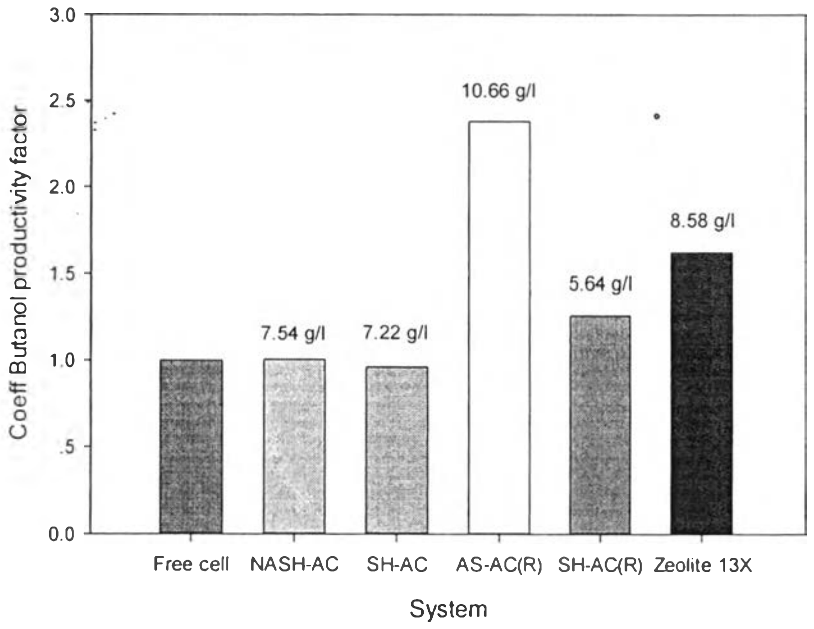

Figure 5.1 Comparison of coefficient butanol productivity factor.