# CHAPTER V

# CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

The main objectives of the present work were to develop a new carrier using $Al_2O_3$ doped alginate (AEC) as immobilized cell matrix for *S.cerevisiae* M30 in ethanol fermentation. The effects of the carrier composition, characteristic size and shape on the ethanol fermentation were investigated and compared to conventional Ca-alginate bead (EC). The AEC carrier was proven to be superior to the typical EC carrier resulting in higher cell activity and stability. The binding of cell and $Al_2O_3$ particle in the carrier constructed a network of $Al_2O_3$ – cell inside the gel matrix. This developed structure increased the porosity and mechanical strength of the AEC carrier. The improved mass transfer through the gel matrix was then achieved. In term of the AEC carrier preparation, the maximum ethanol concentration was obtained when 2.5% (w/v) of Na-alginate and 5.0% (w/v of alginate) of $Al_2O_3$ were used. In the batch fermentation for 60-72 hours, the final ethanol concentration was obtained at almost constant level of 88-92 g/L using the AEC carrier in the range of 2 – 6 mm bead diameter. Furthermore, the modified AEC carrier in a form of square shape (20 x 20 x 4 $mm^3$) was promising. The preparation of the square shape carrier was easier and more convenient for the large scale production and its ethanol concentration was proved to be comparable to that of the system of spherical shape (Ø 6 mm). Continuous ethanol fermentation was successfully carried out in a 1 liter-pack bed reactor (PBR) using the optimal applied condition from the batch experiment. The maximum ethanol production (86.58 g/l) was obtained at the dilution rate of 0.09 $h^{-1}$, while the maximum ethanol productivity (12.34 g/l · h) was obtained at the dilution rate of 0.28 $h^{-1}$. The ethanol yield in the PBR system was relatively comparable to that of the batch system. However, approximately 6 times higher ethanol

productivity than batch system was achieved. Moreover, the operation system in PBR worked efficiently and was stable for at least 30 days

In this regard, AEC carrier was promising for yeast cell immobilization in the continuous fermentation process. With the structure alterations, the porous structure with the improved mechanical strength was achieved. The AEC carriers have many advantages for long-term use including good mechanical strength, chemical stability, high immobilization yield, cell regeneration ability, and high ethanol production.

## 5.2 Recommendation

In an effort to develop a high performance cell carrier for industrial ethanol production, scaling up a reactor size for a pilot scale study is considered necessary. Moreover, the potential use of AEC carrier in other biosystem should be evaluated for more application.