Chapter 4
CONCLUSION

Activated carbons were produced from bagasse and pericarp of rubber fruit (an agricultural waste material) by using chemical activation with zinc chloride ($ZnCl_2$). Then, they were characterized some physical (especially porous texture) and chemical properties of the obtained activated carbons. The studies of the adsorption properties of cadmium, Cd^{2+} and lead, Pb^{2+} ions on the obtained activated carbons by controlling condition were performed to elucidate adsorption mechanism of both metal ions on the activated carbons. From nitrogen adsorption experiment had shown that types of raw materials affect to porous characteristics more than activation methods. The bagasse based activated carbons possess both micropores and mesopores. This contrast to pericarp of rubber fruit based activated carbons which possess large amounts of micropores. FT-IR which used in this study can distinguish the structural change from the raw materials to chars and chars to activated carbons clearly by comparison of different bands in each steps. FT-IR spectra of all activated carbons demonstrate the intense band around 3400 cm^{-1}, 1540 cm^{-1} and 1200-1100 cm^{-1} due to O-H stretching vibrations, C=C aromatic ring vibration and C–O stretching vibrations or O-H, respectively. pH_{pzc} measurement had shown all activated carbons is acidic because of the values less than 7.

For studies of the dependence of adsorption on adsorbent and adsorbate characteristics, adsorption of two metal ions Cd^{2+} and Pb^{2+} onto four obtained activated carbon had been performed. The adsorption isotherm

data showed that the higher atomic weight metal ion Pb^{2+} was preferably adsorbed by carbons with the most mesoporous character (B-70-600). The porous character was not only parameter for explaining adsorption ability of the carbons, the pH_{pzc} values could be augmented the ability of adsorption. The order of adsorption capacities over entire range of studies were the following: B-70-600 > B-325-800 ≈ Pr-70-600 > Pr-325-800 for Pb^{2+} adsorption and B-70-600 ≈ B-325-800 > Pr-70-600 > Pr-325-800 for Cd^{2+} at the same initial pH (pH =5) and temperatures.

The adsorption followed both Langmuir and Freundlich isotherm models but the latter gave a slightly better result than the former. From this reason, it is apparent that most of adsorption behavior of both metal ions on obtained activated carbons will be more heterogeneous.

In thermodynamic consideration (effect of temperature), all Langmuir, Freundlich and Clausius-Clapeyron equation were not be able to calculate the isosteric heat of adsorption of both metal ions for all activated carbons (except Pr-325-800 due to no observation).

The adsorption mechanism could be proposed from all experimental results that ion-exchange had been occurred between metal cations and H^+ ions at the activated carbon surface. These reactions induced a release of H^+ ions in solution and thus decrease the pH values. In addition, the EDA analysis was also used to confirm the presence of metal ions on activated carbon surfaces due to strong chemical bonding after washing process with water. The adsorption mechanism could be ascribe that metal ions adsorbed on activated carbon were attached by chemical bonding due to ion-exchange process whereas another which washed out by water were weaker attached by electrostatic or van de Waal interactions. It was reasonable to conclude

that both ion-exchange and such weaker interaction may involve in adsorption process.