CHAPTER V
CONCLUSIONS AND RECOMENDATIONS

5.1 Conclusions

ZnO-TiO_2 and Ag_2O-TiO_2 composite hollow fibers can be completely accomplished by coaxial electrospinning technique of Ti(Iso)/PVAc/Zn powder and Ti(Iso)/PVAc/Ag powder colloidal solutions, respectively. The obtained mats were subsequently calcined at 500 °C for 1 h. Calcination of the electrospun mats causes the removal of polymer as well as mineral oil which was behaved as core content. In addition, this process can also produce titanium oxide hollow fibers composed of zinc oxide and silver oxide particles in good morphology. The calcined ZnO-TiO_2 and Ag_2O-TiO_2 composite hollow fibers maintained uniformity throughout the length with the average outer diameter of around 0.6 μm with a wall thickness of around 0.1 μm. The apparent zinc oxide and silver oxide within the obtained fibers were efficient to be utilized as seeds so as to provide nucleation sites for facilitating crystal growth on TiO_2 surface via hydrothermal treatment. The effects of temperature and time of hydrothermal treatment on the morphology, yield, and the average diameter of both synthesized ZnO-TiO_2 and Ag_2O-TiO_2 composite hollow fibers have been observed. The calcined ZnO-TiO_2 and Ag_2O-TiO_2 composite hollow fibers were then hydrothermally treated in various conditions; at the fixed time for 1 h (110 °C, 115 °C, and 120 °C) and the fixed temperature of 115 °C (0.5 h, 0.75 h, and 1 h). In regard to the temperature effect on ZnO-TiO_2 composite hollow fibers (time fixed for 1 h), the results showed that the flower-like outgrowths are grown all over the TiO_2 surface. Moreover, the average diameter and yield inclined to enlarge along with temperature. However, yield became lower at 120 °C owing to the slightly deteriorate of crystals and the partial dissolution of ZnO at high temperature. For Ag_2O-TiO_2 composite hollow fibers, the results of surface morphology displayed dot-like outgrowths of AgO_2 covering thoroughly on the surface of TiO_2 fibers. The average diameter and yield tended to increase with increasing temperature as in that case of ZnO-TiO_2 composite ones. All above-mentioned, it can be indicated that the enlargement of the average diameter and yield came from grains growth which was increased in size of grains at higher temperature, together with a reduction in the amount of grains per volume and the total area of grain boundary. Considering the effect of hydrothermally treated time on the surface morphology of ZnO-TiO_2 and Ag_2O-TiO_2 composite hollow fibers, both types exhibited the same results as compared to the effect of temperature. Similarly, the average diameter and yield obtained of both types increased as a function of time. These results can be implied that the increasing in diameter and yield were allowed to gain adequate time to create the growths. Nonetheless, it is noteworthy mentioning that the effect of temperature more considerably affects to the modified surface morphology, yield, and the average diameter of both synthesized ZnO-TiO_2 and Ag_2O-TiO_2 composite hollow fibers than the effect of time. Furthermore, XRD patterns revealed the successful formation of ZnO and Ag_2O after undergoing hydrothermal treatment. In BET surface area analysis, BET surface area leaned to decrease with increasing temperature and time. It can be assumed that the loss in surface area was probably took place due to either the changing in size of material from smaller to larger or a significant decrease of the pore structure combined with the crystallite growth at the higher time and temperature. The hydrothermally treated ZnO-TiO_2 composite hollow fibers under the condition of 115 °C 0.5 h offered the highest surface area of 25.164 m^2g^{-1} compared to other conditions. On the other hand, in case of Ag_2O-TiO_2 composite hollow fibers at various conditions, the fibers treated at 110 °C 1 h provided the highest surface area of 44.960 m^2g^{-1}. In lithium ion battery study, the hydrothermally treated ZnO-TiO_2 composite hollow fibers at 115 °C 0.5 h were used as anode materials. The results showed unsatisfactory capacity. For other types of materials employed as anode, they confronted failures in measuring probably attributed to vulnerability of packing technique and incoordination of instruments used for measurement, leading unsuitable conditions. However, this work has been already opened the novel routes in order to achieve the production of materials which are beneficial for employing as anode materials. Overall, this should be noteworthy that these obtained materials contained the merits of TiO_2 fibers which have the favorable structure of anatase phase to accommodate charges accompanied with the hollow structure with ability to shorten path length and cure volume change during cycling.

In addition, the modified surfaces by both ZnO and Ag2O outgrowths not only play crucial roles for suppressing pulverization of electrodes but also improve the electrical and ionic conductivity of TiO_2 hollow fibers.

5.2 Recommendations

Based on the present results, the following recommendations are suggested for further studies;

1. The other techniques for surface modification of TiO_2 hollow fibers should be investigated so as to enhance the surface area and theirs conductivity.
2. In order to examine lithium ion battery study, the improvement of cell assembly is absolutely required.
3. Examine for the new methods to coat the anode materials on the Cu sheet current collector without any binders.