CHAPTER VIII
CONCLUSION AND RECOMMEDATIONS

8.1 Conclusions

Copper nanoparticles were synthesized via a one-step chemical method in aqueous solution using ascorbic acid to be a reducing agent and polyvinylpyrrolidone as a dispersant without any inert gas protection. From TEM images, it is seen that the CuNPs were nearly spherical with small size in nanoscale range, however, coated layer of PVP could not be observed. Narrowly distributed copper nanoparticles with an average diameter of about 6 nm was obtained and characterized with XRD to confirm the formation of pure copper nanoparticles. Mixing synthesized copper nanoparticles with Bentonite organoclay changed the XRD patterns of OBEN slightly due to adsorption of CuNP onto clay structure.

With the presence of OBEN-CuNP, PP nanocomposite blown films were haze and had higher yellowish tinge. Adding OBEN or OBEN-CuNP into PP films reduced the elongation at break of the films due to loss of film homogeneity. However, these nanocomposite films showed good elongation at break in machine direction over 300% compared to neat PP with elongation at break of 400%. Adding PVP-coated CuNP into PP films showed positive effect on tensile strength of nanocomposite films. This is due to Surlyn ionomer and nanoparticles acted as nucleating sites to increase crystallinity of PP nanocomposite films. Thermal stability of PP nanocomposite films was improved with the presence of nanoparticles. From the overall mechanical properties and clarity, it indicates that the PP nanocomposite films would be capable to be used in prepacked chilled fish packaging since these films could be used to wrap around chilled fish with ease and could present the products properly.

Having ionic aggregates, the PP film was less water vapor permeate due to increasing in crystallinity. Organoclay caused flow path of water vapor to be more tacttoids and thus reduced water vapor flow rate compared to homogeneous PP matrix. The decrease in water vapor permeability in PP nanocomposite films is favor for the prepacked chilled fish since it would prevent it drying. However, adding

OBEN-CuNP with CuNP more than 10 wt% into PP films increased water vapor permeability slightly due to hydrophilicity of PVP coated on CuNP. In contrast, all PP films adding Surlyn or nanoparticles increased oxygen permeability because there were flow channels at the interfaces between Surlyn and PP matrix. This would allow oxygen to flow in and out from the prepacked chilled fish packages easier and prevent bad odor trapped in the packages.

From the agar diffusion tests, it is found that there were inhibition zones surrounding OBEN-CuNP pastes. This indicates that OBEN-CuNP has antibacterial activity against the bacteria. However, the clear zone was not observed when using film samples which would be result from very low diffusivity of copper ion from the film samples into agar. This is favor for the prepacked chilled fish packaging since the films could prevent the growth of bacteria that might come along the in-flow of oxygen that would carry out bacteria from outer atmosphere to cause spoilage of the fresh fish.

Natural dyed film was prepared and studied the feasibility for using as a indicator for food spoilage. Red dye was extracted from Mangosteen pericarp using citric acid and mixed with EVA in a twin-screw extruder at 120 ^{o}C to produce dye compound. The dye film was prepared by using mangosteen extracted solution 2, 4, and 6 wt%. In the ammonia sensing test, the steeper slope in the 4 wt% dye EVA film indicates better sensitivity to detect change in ammonia concentration. The TVBN value of 40.32 mg/100g of fish meat was reached after about 9 hr of storage indicating that the spoilage fish was not acceptable for human consumption.

In the fish spoilage test, it is seen that the color of the 4 wt% MGT-EVA film was changed gradually with the lower C* than those in the ammonia test. The relationship between the change in color and time is equal to $C^* = 0.01767t + 0.0104$ where t is time in hrs. The R^2 of the linear fitting of the data is 0.98. The sensitivity of the MGT/EVA films to detect the fish spoilage is better than those in the ammonia solution test due to lesser basic environment. The gradual change in color is detected with the color reader; however, they were not easy to differentiate with naked eyes.

8.2 Recommendation

Based on what have been discovered in this study, the following recommendation is suggested.

Further studies on the optimum weight ratio of Surlyn to nanoparticles added into PP nanocomposite films should be investigated because the weight ratio affects the properties of the films directly. Adding Surlyn in too high content increases voids inside PP nanocomposite films, causing in decrease of mechanical properties and increase of water vapor permeability which is not favor for chilled fish packaging.