CHAPTER VII
CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Na-bentonite clay was modified via ion exchange reaction using STPANTEX^{TM} SP-90 as a surfactant. The effect of the molecular structure and functional groups of the surfactant on the organoclays was investigated by XRD, TGA and FT-IR spectrometer. It was shown that the organo-surfactant intercalated into the silicate layer resulting in the greater interlayer spacing.

For the preparation of PP/organoclay nanocomposites, the compounding process was performed through a twin screw extruder by using PP as polymer matrix, Surlyn® ionomer as a reactive compatibilizer and varied the organoclay content from 1, 3, and 5wt%. The presence of organomodified bentonite had insignificantly effect on the crystallite size on PP matrix. The results of mechanical properties showed that the modulus of nanocomposites was improved significantly compared with the PP compatibilized system. In addition, Surlyn® ionomer was improved strain at break, tensile strength, and toughness of the nanocomposites. Subsequently, PP/organoclay nanocomposites films were prepared by blow film extrusion machine. However, the mechanical properties of the nanocomposites decreased when the organoclay content exceed 1wt% due to the aggregation of the organoclay. Additionally, oxygen barrier properties of nanocomposites increase with increase clay content. So, at 5wt% of PP/organoclay nanocomposites were suitable for preparing the nanocomposites pH sensor films due to the optimum on oxygen gas permeability properties than another one.

Subsequently, the pH sensor was fabricated by using a spin-coater and was attached to PP/clay nanocomposite films using a laminating machine (at 160°C). All nanocomposites pH sensor films were evaluated the capability to use as fish spoilage indicator in next step. Moreover, prepared sensor was tested with pH measurement, TVB-N, and microbial analysis in order to found fish spoilage period of barramundi fish. Quality changes and shelf life of whole Barramundi fish stored at room temperature were monitored by pH measurement, TVB-N method, and microbiological analyses (APC). An estimation of the samples' shelf-life can be made based on the following criteria: (a) the pH of 6.8-7.0, (b) the TVB-N limit of 30-35 mg /100g of fish muscle, and (c) the level of 10^7cfu/g for APC. By combining these criteria the shelf-life of our samples was 12 hours for the Barramundi fish stored at room temperature. The presence of exceeding pH, TVB-N and microbial count standard value in fish samples may be related to bacterial activity during fish spoilage.

Moreover, Fish spoilage was assessed through aerobic plate count (APC), total volatile basic nitrogen (TVB-N), and the color changes of the nanocomposite pH sensor. The color change was measured and expressed as Hunter values and then total color difference (TCD). The TCD values of bromocresol green (BCG) type indicator also changed continuously with the response of the indicator. The suitable choice of pH sensor disc was fabricated by using a spin-coater at 1000 rpm and 3%wt BCG. Since at these condition sensor could provide a higher intense color change observed by human eyes and chroma meter. Then, they were attached onto an appropriate PP/clay nanocomposite films at 5%wt nanoclay using a laminating machine (at 160°C). At this level clay content, sensor color would be changed slower than other clay content. According to increase oxygen barrier properties of nanoclaycomposite, because organoclay are believed to increase the barrier properties by creating a maze or tortuous path that retards the progress of the gas molecules through the all of matrix resin.

The color changes of the developed nanocomposite indicator film properly represent the degree of fresh fish spoilage. Fish spoilage was assessed through APC and the color changes of the pH sensor were measured and expressed as Hunter values and then total color difference (TCD). Consequently, the suitable choice of pH sensor disc was fabricated by using a spin-coater at 1000 rpm and 3%wt BCG. Since at these condition sensor could provide a more intense color change observed by human eyes and chroma meter. According to the changes in Hunter color values of the indicator within the packages of fresh fish at room temperature, the TCD value would be increased with time during fish spoilage as well as in standard ammonia investigation. The TCD values about 50 of BCG type indicator which signify fish begin spoilage during stored at room temperature. The color of the pH sensor turned from an initial yellow to a final green for BCG type. The color changes of the developed pH sensor properly represented the degree of spoilage of the fresh fish with very small amount of indicator leakage. The nanocomposite pH sensor could be employed as an effective smart packaging technology.

7.2 Recommendations

Based on what have been discovered in this study, the following recommendations are suggested.

(1) Na-bentonite should be purified before organomodification to remove some impurity and obtain the colorless nanocomposites.

(2) The nanocomposite sensor film should be change to interesting pH indicator type for developing of smart packaging to be more effective.

(3) Further studies on the use of the porous nanocomposite indicator film for the packaged foods or other beverages focused in order to increase their potential value, e.g. pork quality.

(4) Further studies at the low/refrigerated temperature.