CHAPTER V

CONCLUSIONS

1. Paper mulberry films were prepared by film casting technique. The optimum condition for esterification reaction of paper mulberry in DMAc/LiCl using DMAP as a catalyst and lauroyl chloride as an esterifying agent under microwave energy, based on the highest % weight increase and % esterification, was 0.9 equivalent weight of DMAP and 10 equivalent weight of lauroyl chloride under microwave power of 90 watts for 2 min.

2. Significantly, from this experiment, it was found that impurities in cellulose such as hemicellulose and lignin have affected on the degree of esterification since they are cellulosic compounds embedding in the cellulose microfibrils, and probably preventing esterification of cellulose, and remaining insoluble in toluene and chloform. As a matter of fact, lignin could act as a competitor for the esterification reagent and/or had a negative influence on cellulose accessibility.

3. From SEM analysis, untreated paper mulberry exhibited smooth surface of short fiber whereas paper mulberry laurate showed aggregation of alkyl groups of lauroyl chloride on the surface.

4. From FTIR analysis, the esterification reaction was successfully verified by the decrease in the intensity of absorption band of O-H bond vibration at 3422.01 cm^{-1}, the increase in the intensity of alkyl chain absorption at 2,855.30-2,926.32 cm^{-1}, and the presence of a new band at 1,746.78 cm^{-1} which is the charactheristic peak of a carbonyl of ester group.

5. Paper mulberry laurate showed the low melting endotherm ($T_{m,l}$) at -17°C due to the melting of the side-chain crystalline. This endothermic peak presents the melting transition of the side-chain from ordered into disordered states. At higher temperature, the second order transition or glass transition temperature was observed at 70.69°C. The paper mulberry laurate showed five significant decomposition stages at 50-100 °C, 150-200 °C, 220-285 °C, 285-340 °C, and above 350 °C which were corresponding to the decomposition of water, alkyl chain of lauroyl chloride, hemicellulose, cellulose, and lignin, respectively.

6. The gloss values of paper mulberry laurate films increased with increasing % esterification because of an increasing in the smoothness of film surface that can be reflected easily by the light.

7. The wettability of paper mulberry laurate film increased with % esterification as indicated by decreasing in water contact angle. The higher the % esterification, the lower the degree of contact angle. This is because the crystallinity of cellulose structure was destroyed by esterifying agent leading to an increase in amorphous region. Therefore, hydrophobicity of cellulose laurate decreased. In other words, the hydrophilicity of paper mulberry laurate film increased.

8. Similary, the % water absorption of paper mulberry laurate film increased with increasing the % esterification. This is due to the fact that hydroxyl groups of cellulose was substituted by acetyl group of lauroyl chloride leading to an increase in free volume of the system, consequently, increasing the mass transfer of water through the paper mulberry laurate film.

9. Paper mulberry laureate films exhibited a plasticizing effect behavior without an addition of any plasticizer, unlike others biopolymers such as starch or proteins. As % esterification increased, the % elongation increased, whereas the tensile strength decreased. In other words, esterified fatty acid seemed to act as an internal plastizicer for the long chain fatty acid cellulose ester films.

10. After biodegradation by soil burial test for 60 days, % weight loss of the paper mulberry laurate films increased with increasing % esterification of the film. As % esterification increased, the amorphous regions of films increased. As a result, it became easily for microorganisms such as fungi and bacteria to attack the film. This result was comfirmed by SEM analysis that the presence of increasing the number of tiny holes on the film surface also increased with % esterification.

11. For photodegradation, similary, it was found that the % weight loss increased as the % esterification of paper mulberry laurate film increased.