

CHAPTER V

CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

Smart PNIPAm-PET composite membranes were successfully fabricated using solvent- and microwave-assisted polymerization techniques, providing a simple, scalable, and efficient method for advanced membrane production. The neat PET membranes were dissolved in DMSO in the optimal condition of 100 °C and 3 hours.

Among the microwave-assisted polymerization parameters including microwave power and irradiation time were used to optimize condition on weight gain (WG). The optimal condition was 600 W, 15 min achieving a WG of 192%. The effect of crosslinker addition increased WG by up to four times through covalent bonding between polymer chains, enhancing the functional properties of the membranes. The aero-press and vacuum-assisted technique enhanced the WG same 1.5 times due to pressure penetration into the pores.

Morphological and chemical analyses confirmed the successful incorporation of PNIPAm, with vacuum-assisted polymerization improving monomer penetration and distribution on the PET surface. The membranes exhibited thermoresponsive behavior, with water contact angles shifting from 55.9° at 25 °C to 72.8° at 40 °C, demonstrating hydrophilic-to-hydrophobic switching near the LCST. Membranes with WG greater than 120% enabled effective "open-closed" pore switching for selective water vapor and gas transmission. Despite the crosslinker's restriction of PNIPAm chain mobility, high thermoresponsive performance and permselectivity were maintained. The composite membrane fabricated under optimal conditions exhibited a permselectivity of 1.36 at 25 °C, indicating efficient gas barrier performance at lower temperatures, and a reduced

permselectivity of 0.73 at 40 °C, corresponding to increased gas permeability due to the thermoresponsive pore opening behavior.

The optimized composite membrane demonstrated effective shelf-life extension for green asparagus by regulating O₂ and CO₂ concentrations to meet storage requirements, achieving quality comparable to commercial LDPE film. Solvent- and microwave-assisted polymerization thus offers a versatile approach to fabricating thermoresponsive membranes for gas separation and smart packaging applications. Future studies should focus on validating these membranes' performance in extended storage periods and with different produce types to fully explore their industrial potential. In addition to extending the shelf life of fresh produce by preserving their quality, smart packaging can also be reused multiple times owing to the reversibility of PNIPAm (Todsapol Kajornprai et al., 2023). This characteristic contributes to more sustainable material utilization

5.2 Recommendations

In the development of PNIPAm–PET composite membranes via solvent- and microwave-assisted polymerization, further optimization is ongoing to achieve a more uniform coverage of PNIPAm across the substrate. The incorporation of compatibilizers, such as ethylene glycol, represents a promising approach to enhance the interfacial compatibility between PNIPAm and PET. Improved deposition and homogeneous coverage of the thermoresponsive film may enhance gas exchange properties, particularly the carbon dioxide–oxygen transmission ratio (β), thereby broadening the potential applications of these membranes for a wider range of fresh produce.