CHAPTER V

CONCLUSION AND DISCUSSION

5.1 Conclusion and discussion

The applications of nuclear tracks have been developed and applied in a wide variety of technical fields. Recently, one of the most attractive aspects of nuclear track-etch is the investigation of optical properties of nuclear tracks. Many researchers are interested in the investigation of optical properties of nuclear tracks in order to describe the process of track appearance in solid state detectors. The main objective of this dissertation is to create proton tracks in thin sheet of polymer to be used as a light filter or light diffuser. This is based on light scatterings by nuclear tracks which depend mainly upon track density and track size. The track density is directly proportional to the number of neutrons impinging upon the plastic sheet while the track size depends upon the type and energy of charged particles as well as the etching condition.

These studies presented simplified and economical development of light filter film from track-etch polymer. A locally available polycarbonate plastic for sunshade, 1.5 mm thick, was used as a commercial PC because it was inexpensive and available. It is a versatile and tough plastic used for a variety of applications. It is commonly used to make sun shelter and awning. The main advantage of polycarbonate over other types of plastic is the unbeatable strength combined with light weight.

The study could be concluded as follows:

5.1.1 Formation of proton tracks using thermal neutrons from the Thai Research Reactor

The study showed that variation of etching temperature affected track density and distribution of track diameter. Track density at lower temperature of etchant was larger than that at higher temperature of etchant due to lower etching rate corresponding to Figure 2.9, which mentioned that etching rates are typically exponential functions of inverse temperature and increase with concentration [3]. Higher etching rate causes removal of some of tracks on the surface of PC. Track diameters at lower temperature were distributed within small size. When the temperature increased, the distribution of track diameter was shifted to large size due to etching condition reaching to transitional phase and spherical phase. This was demonstrated in Figures 2.7 and 2.10 in Chapter II. Variation of track density and distribution of track diameter led to variation of transmission of visible light and infrared. The mean and standard deviation of distributions (SD) of track diameters at 65, 70, 75 and 80°C were within 6.47 ± 2.78, 9.27 ± 4.16, 7.58 ± 3.75 and 8.65 ± 3.40 μm, respectively. The most variation of the distribution of track diameter was track-etched PC at 70°C. The minimum diameter was 2.31 μm and the maximum diameter was 24.82 μm.

In case of transmission of UV, PC can totally absorb by itself due to its inherent property. In this study, the maximum effect on the transmission of visible light and infrared were seen in track-etched PC at temperature 65°C. The calculated percentage differences of maximum effect of transmission of visible light and IR through proton track-etched PC chips decreased about 24% and 17% compare to without PC and about 11% and 9% compare to through original control PC, respectively. It can be concluded that temperature of etchant affected track density and distribution of track diameter leading to variation in transmission of visible light and IR.

5.1.2 Formation of proton tracks using neutrons from a Cf-252 source

5.1.2.1 Effects of etching temperature and etching time

The study on variation of etching temperature and etching time with fixed irradiation condition was performed to observe the correlation of etching condition, track density and distribution of track diameter including percentage transmission of light. The results showed that track density at 65°C continuously increased and became constant at etching time of 75 minute, whereas track density at 70°C and 75°C increased to maximum values at etching time of 45 minute and 60 minute, respectively. Then, track density decreased and increased again because some of the tracks were removed, allowing new tracks to be observed. Neutrons from Cf-252 source induced random formation of proton tracks. The productive reactions of recoil-proton can occur anywhere inside the polymer volume along the neutrons trajectories depending upon neutron energy, so new tracks are probably created due to the increasing in etching condition [13].

The study of distribution of track diameter showed that track diameter at 65°C for 15 minutes distributed within small diameter. Mean and SD of track diameter were 5.01 ± 1.49 μm. The minimum and maximum diameters were 2.19 and 10.32 μm, respectively. When etching time increased, some of track diameters distributed to larger size, leading to increased mean and SD of track diameter. The maximum mean and SD of track diameter was found at etching time 90 minute with the value 7.57 ± 3.39 μm. The mean and SD of track diameter at 45, 60 and 75 minutes were not different significantly.

The mean and SD of track diameter at 70°C, etching time of 15 minutes were 6.02 ± 2.39 micrometer. When the etching time increased, the mean of track diameter did not change significantly. But the SD of track diameter was slightly different.

The maximum variation of the mean and SD of track diameter was found in PC with etchant temperature of 75°C and at etching time of 75 minutes. The mean and SD were 9.12 ± 5.11 μm. Figure 4.18 showed that track diameter in each etching time distributed randomly.

Results of transmission of UV, visible light and IR showed that UV was totally absorbed by PC. The calculated percentage difference of maximum effect of transmission of visible light an IR through track-etched PC decreased about 20% and 12% compared to without PC and about 6% and 4% compared to through original PC, respectively. The study found that transmissions of visible light and IR through track-etched PC with etching time longer than 30 minutes at every temperature were not different significantly, leading to no difference in transmission of visible light and IR.

It can be concluded that transmission of visible and IR through track-etched PC with a few track density and small track diameter distribution were not affected, because there was more area with no proton track on PC with a few track density and small track diameter distribution, leading to transmission of visible light and IR can transmit through PC. When the etching time increased, track diameter was distributed within larger size reducing area with no proton track. It also increased the effect of transmission of visible light and IR.

5.1.2.2 Variation condition of tracked-etch PC

Track-etched PCs with different track density and distribution of track diameter were observed for the effect of transmission of light to evaluate the proper condition to create a filter or diffuser film. Neutron irradiation time was varied to form various track density and etching condition was also varied to create the different distribution of track diameter. The results showed that PC with condition 6 (Track density 1.11×10^6 tracks/cm^2, neutron irradiation time 7 days, etched with PEW 70°C, 60 min.) demonstrated the maximum effect of transmission of visible light and IR, and PC with condition 4 (Track density 5.39×10^5 tracks/cm^2, neutron irradiation time 7 days, etched with PEW 70°C, 45 min.) showed the minimum effect. The calculated percentage difference of maximum effect of transmission of visible light and IR through track-etched PC decreased about 28% and 20% when compare to without PC and about 15% and 12% compare to through original PC, respectively. The calculated percentage difference of minimum effect of transmission of visible light and IR through track-etched PC decreased about 19% and 10% when compare to without PC and about 5% and 1% compare to through original PC, respectively.

The results showed that for the same track density such as PC with conditions 2 (Track density 3.74×10^5 tracks/cm^2, neutron irradiation time 3 days, etched with PEW 70°C, 15 min.) and condition 3 (Track density 3.85×10^5 tracks/cm^2, neutron irradiation time 3 days, etched with PEW 65°C, 30 min.) or PC with conditions 4 and 5 (Track density 5.83×10^5 tracks/cm^2, neutron irradiation time 3 days, etched with PEW 70°C, 35 min.), transmission of visible light and IR through PC with higher SD decreased more than that with lower SD. It was demonstrated that at the same track density, PC with wide distribution of track diameter affected transmission of visible light and IR more than narrow distribution of track diameter. For the same distribution of track diameter or same the SD such as PC with conditions 2 and 5 or PC with conditions 4 and 6, transmission of visible light and IR through PC with higher track density decreased more than that lower with track density. It can be concluded that variation of track density and distribution of track diameter affected transmission of visible light and IR.

For the experiment of transmission of laser beam from a laser pointer, the results showed that track-etched PC can diffuse laser pointer beam 1-3 times. PC with conditions 5 and 6 showed the maximum diffusion of laser pointer beam. The minimum diffusion effect was PC with condition 4. The result of transmission of IR was similar. It can be explained by optical model that when light passes through proton track on PC, light will be scattered. Different track sizes and shapes caused different scattering patterns. Groetz et al. [13] performed the scatter pattern in geometries of conical track and oblique track [Figure 2.20-2.21]. The result corresponded with the study of Al-Saad et al., [13] which demonstrated the effect of transmission of He-Ne laser light through proton track-etched PC with varying etching time. The relation was illustrated in Figure 2.23 in Chapter II.

From the above data, it can be concluded that PC with proton track cannot properly be used as a filter because of less effect on transmission of visible light and IR but it can be used as a light diffuser. Recently, PC plastic is widely used as sunshade, skylight and coverway. Track-etched PC can be used instead of normal PC or combined with a lamp in order to diffuse light. IR diffusion decreases or distributes heat.

5.2 Limitation

Limitations of this study are as follows:

5.2.1 Manual evaluation of track properties such as track size, track shape and track density is tedious and may cause human errors. An appropriate track evaluation software is required to obtain a better result and to save time.

5.2.3 This study could not define relation of track shape, track length and transmission of light due to limitation of analysis method and facilities.

5.3 Suggestion

Suggestions are as follows:

5.3.1 More accurate equipment and method for analysis of the track properties should be employed. It will perform appropriate analysis of track characteristics including track length and shape which affect the properties of light transmission.

5.3.2 Use stronger activity of neutron source for irradiation, as the irradiation time will be reduced.

5.3.3 In case of using stirring technique for etching or adding the sensitizer, it will decrease the etching time. The effect of sensitizers on the etching should be studied in laboratory in the future. These factors might play an important role in the quality of proton tracks.

5.3.4 In this study, physical properties in terms of tensile strength and impact strength were evaluated but there was no change between original and track-etched PC. However, other physical properties such as bending strength, impact strength, etc. should also be tested.

5.3.5 It is interesting also to study track etching at low temperature due to high track to bulk etching rate (V_T/V_B). This will take much longer time but it can be performed without a heat source, with no energy consumption. In doing so, track length will be increased and may affect light transmission or diffusion in some extend.