CHAPTER IV
RESULTS AND DISCUSSION

In this study, there were three major variables that were investigated: the amount of styrene monomer, the concentration of NaDEHP, and the radiant power of the UV lamp. The results can be classified into 4 parts.

4.1 The effect of the percentage of styrene monomer at 0.5 mmol NaDEHP and 4 watt UV lamp

4.1.1 The molecular weight average, molecular number average, and polydispersity index

Samples containing 0.5, 1.0, 2.0 and 3.0% of styrene monomer were studied. Figures 4.1, 4.2, and 4.3 show the effect of percentage of styrene monomer on the molecular weight average (MW), the molecular number average (MN), and the polydispersity index (PDI) at 0.5 mmol NaDEHP and 4 watt UV lamp. The MW and MN curves exhibited in the same behavior. As the exposure time went on, the MW and MN increased and eventually reached a constant value. Consequently, the Figures 4.1 and 4.2 can be roughly divided into two regions. The first region referred to the growing of the MWs or MNs. The increasing of MWs indicated that the polymer chain was growing in the propagation step.
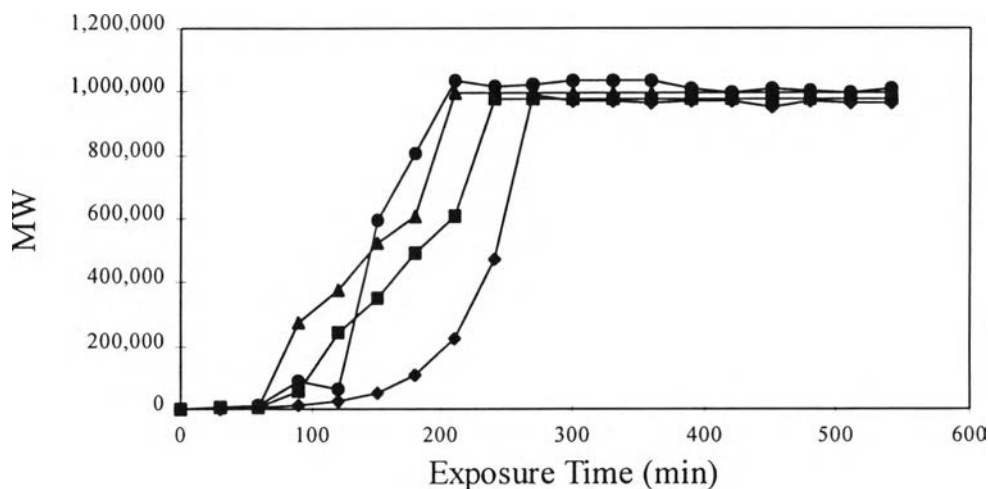
Figure 4.1 The effect of percentage of styrene monomer on molecular weight average at 0.5 mmol NaDEHP and 4 watt UV lamp: (◆) 0.5; (■) 1.0; (▲) 2.0; (●) 3.0% of styrene monomer.
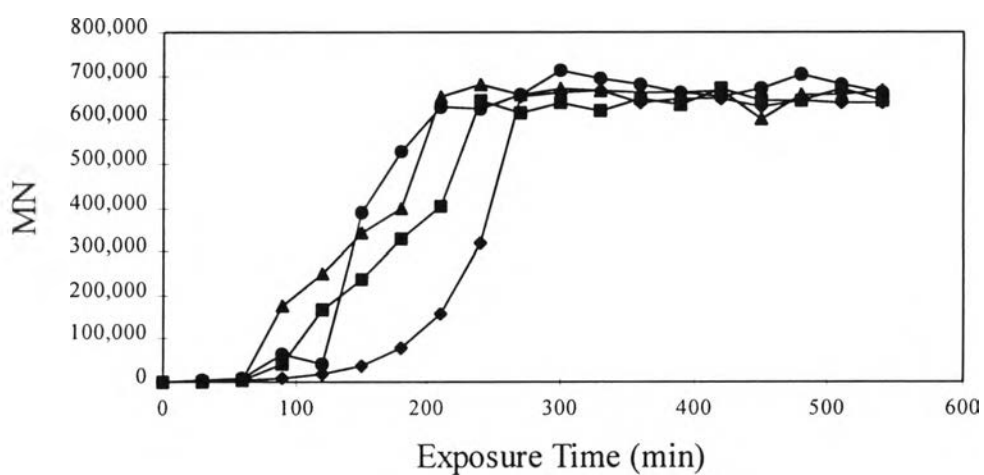

Figure 4.2 The effect of percentage of styrene monomer on molecular number average at 0.5 mmol NaDEHP and 4 watt UV lamp: (◆) 0.5; (■) 1.0; (▲) 2.0; (●) 3.0 of styrene monomer.

MWs were quite constant in the last region. However, the MWs in all events did not reach the stationary region in the same exposure time. It is noted that MWs of 0.5, 1.0, 2.0 and 3.0% of styrene monomer reach the last region at 270, 240, 210, and 210 minute, respectively. The higher the percentage of styrene monomer, the higher MW (1.0×10^6) in the last region. According to Siaw-Lee et al.(1995), the MWs of the product increased with the amount of the monomer. As shown in the Figure 4.3, PDIs increased from 1.0 to 1.5 and then was constant at approximately 1.5. There were two works which used the same initiator, potassium persulfate, $K_2S_2O_8$, but different surfactant. The PDIs were 1.77-2.62 (Williams and Grancio, 1969) and 3.1 (Kracheler and Naiclus, 1969) which were obtained in the case of lithium fatty acid soap and octylaphenoxypolyethoxyethanol, respectively. As a result, PDIs of the polystyrene product in this work were relatively narrow.

4.1.2   The rate of increasing molecular weight

Figure 4.4 shows the relationship between the MW and the exposure time. It can be concluded that the rate of increase in molecular weight of the samples increased with the monomer concentration when the 4 watt UV light was used.
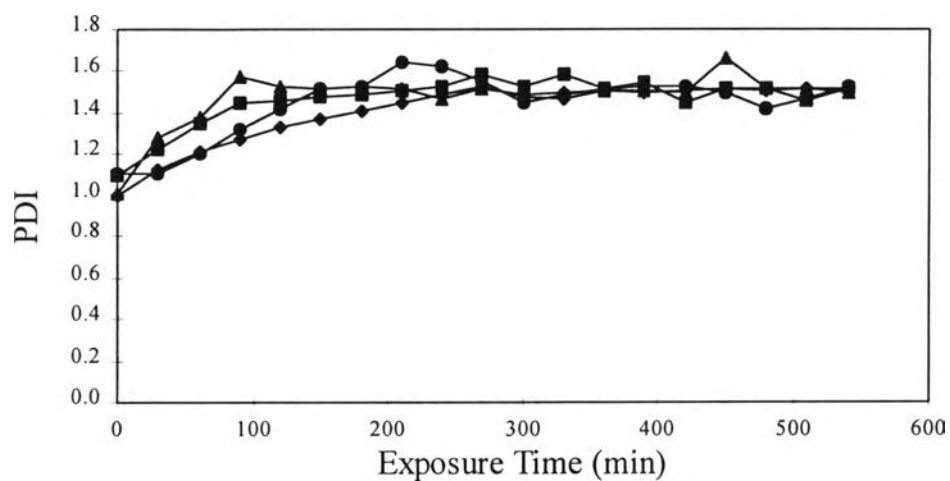
Figure 4.3 The effect of percentage of styrene monomer polydispersity index at 0.5 mmol NaDEHP and 4 watt UV lamp: (♦) 0.5; (■) 1.0; (▲) 2.0; (●) 3.0% of styrene monomer.
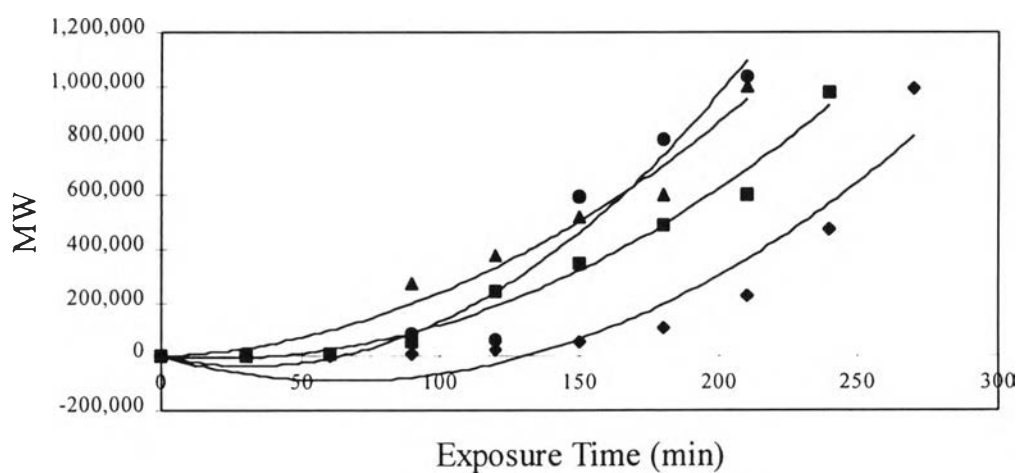

Figure 4.4 The relationship between the MW and the exposure time at 0.5 mmol NaDEHP and 4 watt UV lamp: (♦) 0.5; (■) 1.0; (▲) 2.0; (●) 3.0% of styrene monomer.
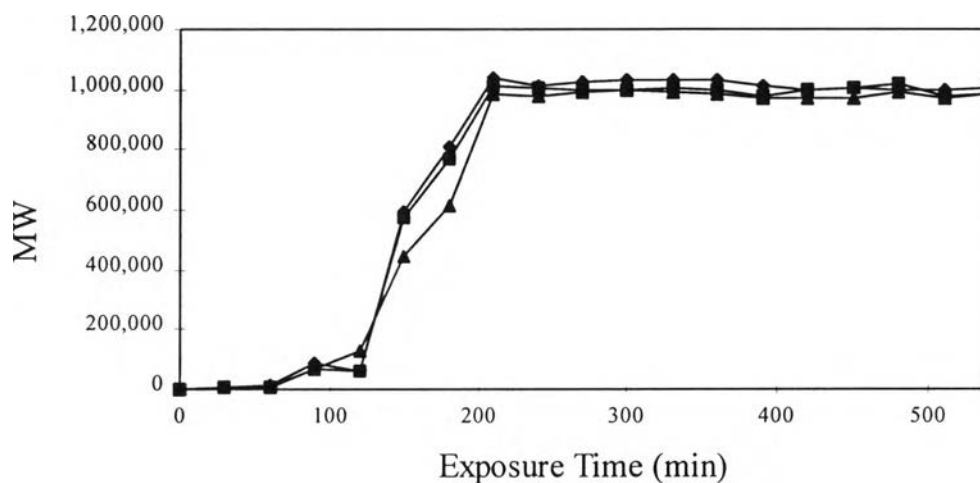
Figure 4.5 The effect of NaDEHP concentration on molecular weight average at 3% styrene monomer and 4 watt UV lamp ; (◆) 0.5; (■) 1.0; (▲) 1.5 mmol of NaDEHP.
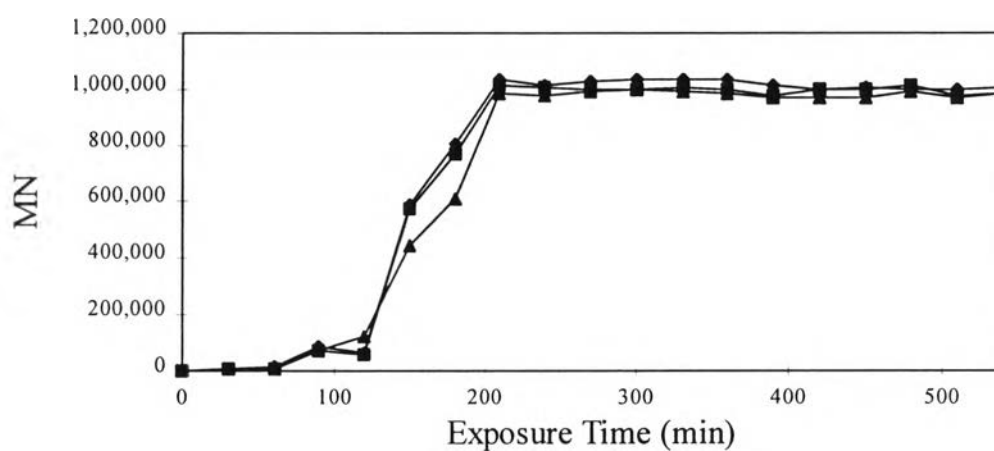

Figure 4.6 The effect of NaDEHP concentration on molecular number average at 3% styrene monomer and 4 watt UV lamp ; (◆) 0.5; (■) 1.0; (▲) 1.5 mmol of NaDEHP.

4.2 The effect of NaDEHP concentration at 3% styrene monomer and 4 watt UV lamp

4.2.1 The molecular weight average, molecular number average, and polydispersity index

Figures 4.5 and 4.6 show that the NaDEHP concentration had no effect on the polymer molecular weights (MW or MN). The value and the behavior of PDI shown in Figure 4.7 are similar to the styrene monomer results. PDIs increased form 1.0 to 1.5 and then was constant at approximately 1.5.

4.2.2 The rate of increasing molecular weight

The MW and the exposure time were plotted as shown in Figure 4.8. Moreover, Figure 4.9 shows that increasing the surfactant concentration decreased the rate of increase in molecular weight slightly.

4.3 The effect of percentage of styrene monomer at 0.5 mmol NaDEHP and 100 watt UV lamp

4.3.1 The molecular weight average, molecular number average, and polydispersity index

Figures 4.10, 4.11, and 4.12 present the effect of percentage of styrene at 0.5, 1, 2, and 3% styrene on MW, MN, and PDI. Comparing with the 4 watt UV lamp results, these figures are dramatically different. The molecular weight increased very rapidly at the beginning, reaching their peak at 25-30 min. The increasing molecular weight region is followed by a totally new region of rapidly decreasing molecular weight (35-50 min time interval).
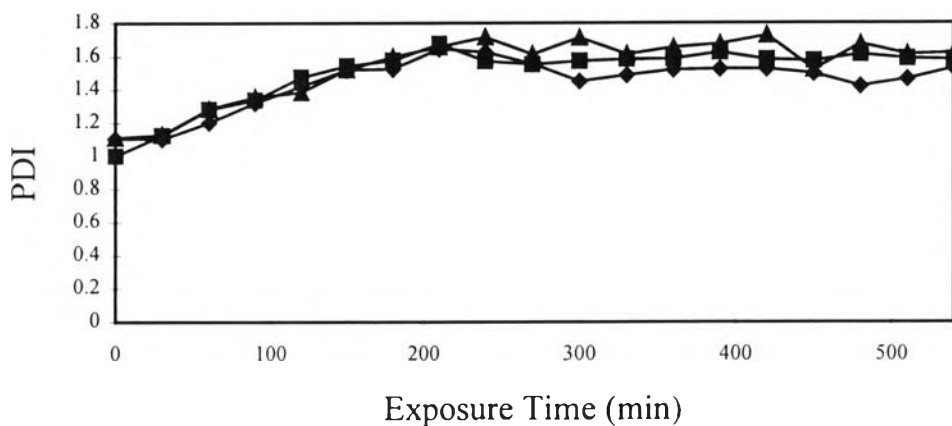
Figure 4.7 The effect of NaDEHP concentration on polydispersity index at 3% styrene monomer and 4 watt UV lamp; (◆) 0.5; (■) 1.0; (▲) 1.5 mmol of NaDEHP.
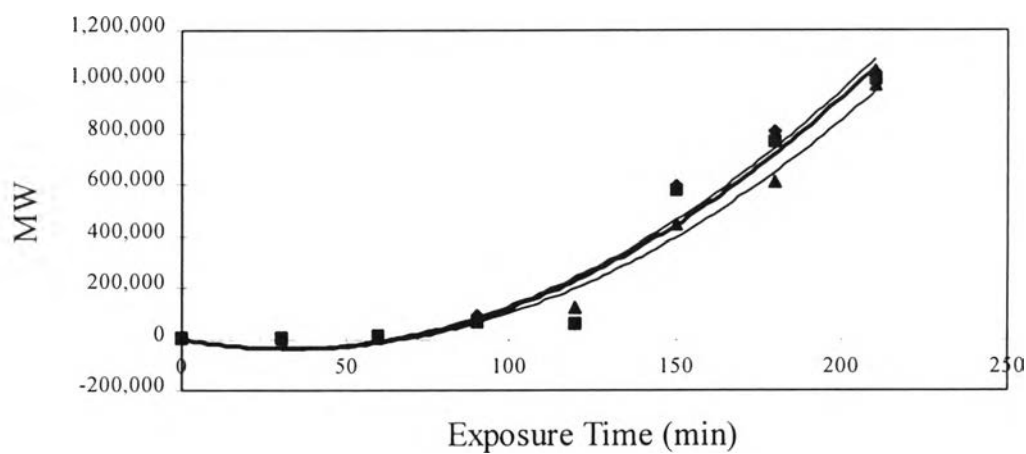

Figure 4.8 The relationship between the MW and the exposure time at 3% styrene monomer and 4 watt UV lamp: (◆) 0.5; (■) 1.0; (▲) 1.5 mmol of NaDEHP.
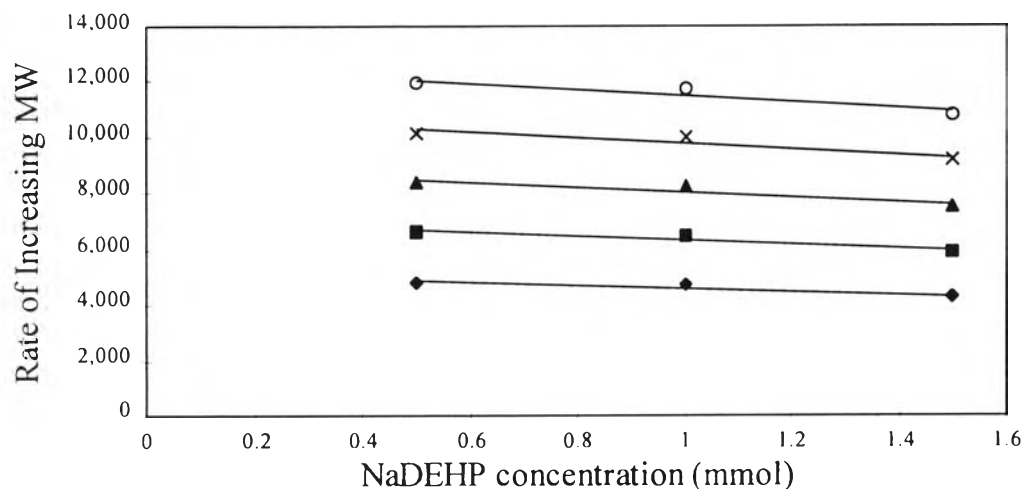
Figure 4.9 The relationship between the rate of increasing MW and the NaDEHP concentration at 3% styrene monomer and 4 watt UV lamp: (◆) 100; (■) 125; (▲) 150; (×) 175; (O) 200 min.
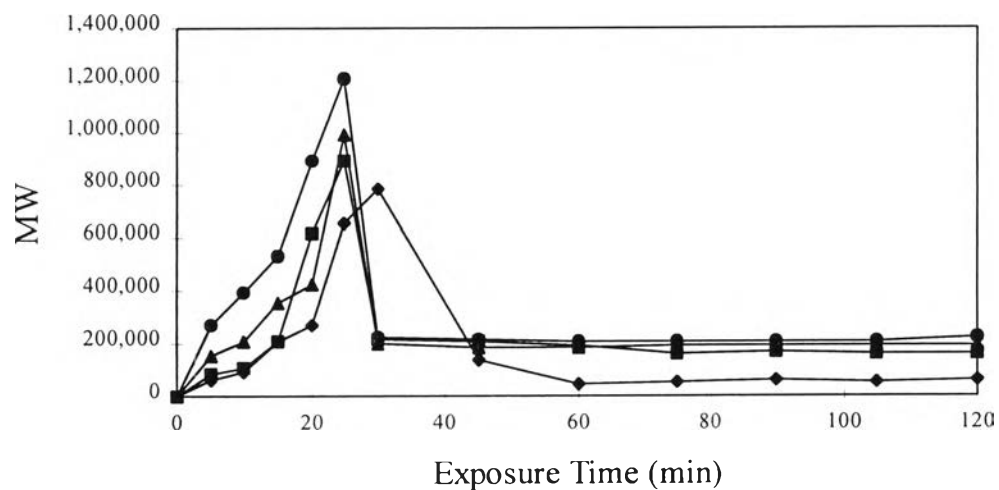

Figure 4.10 The effect of percentage of styrene monomer on molecular weight average at 0.5 mmol NaDEHP and 100 watt UV lamp: (◆) 0.5; (■) 1.0; (▲) 2.0; (●) 3.0% of styrene monomer.

As shown in Figure 4.12, the values and the behavior of PDI are similar to the results of the 4 watt. PDI reached a value of 1.6±0.2 and stayed constant.

4.3.2 The rate of increasing molecular weight average

Figure 4.13 shows the direct relationship between the MW and the exposure time. Consequently, the rate of increasing in MW shows a more systematic dependence on the monomer concentration (Figure 4.14). Eventually, the molecular weights stabilize and become independent of time. In this region the molecular weight increased with the starting styrene concentration.

4.4 The effect of NaDEHP concentration at 3% styrene monomer and 100 watt UV lamp

4.4.1 The molecular weight average, molecular number average, and polydispersity index

The MW, MN and PDI results were the same as the 4 watt lamp results given previously (Figures 4.15, 4.16, 4.17). Increasing NaDEHP decreased the MW and the rate of increase in MW very slightly.

4.4.2 The rate of increasing molecular weight

Similar to the Figure 4.13, MW showed the direct proportion with the exposure time (Figure 4.18). Figure 4.19 shows that increasing the surfactant concentration decreased the rate of increase in MW slightly.
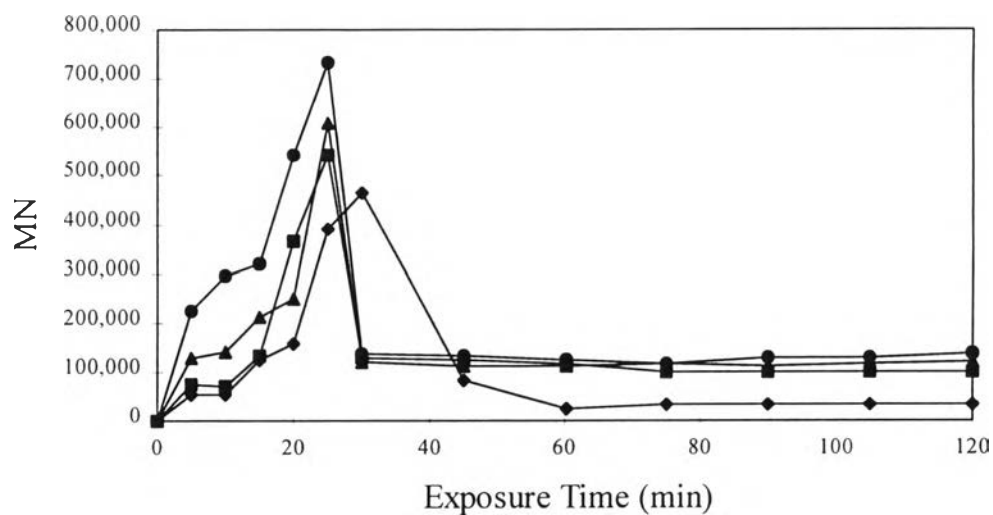
Figure 4.11 The effect of percentage of styrene monomer on molecular number average at 0.5 mmol NaDEHP and 100 watt UV lamp: (◆) 0.5; (■) 1.0; (▲) 2.0; (●) 3.0% of styrene monomer.
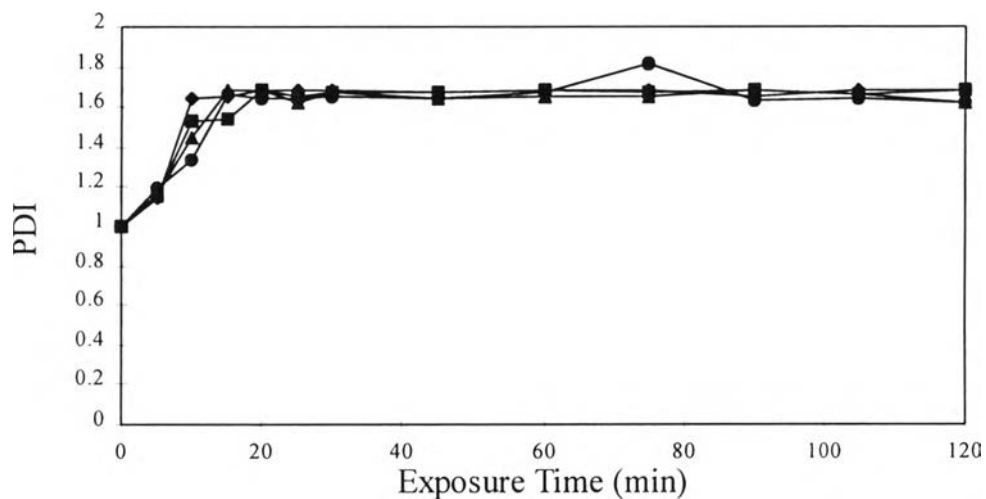

Figure 4.12 The effect of percentage of styrene monomer polydispersity index at 0.5 mmol NaDEHP and 100 watt UV lamp: (◆) 0.5; (■) 1.0; (▲) 2.0; (●) 3.0% of styrene monomer.
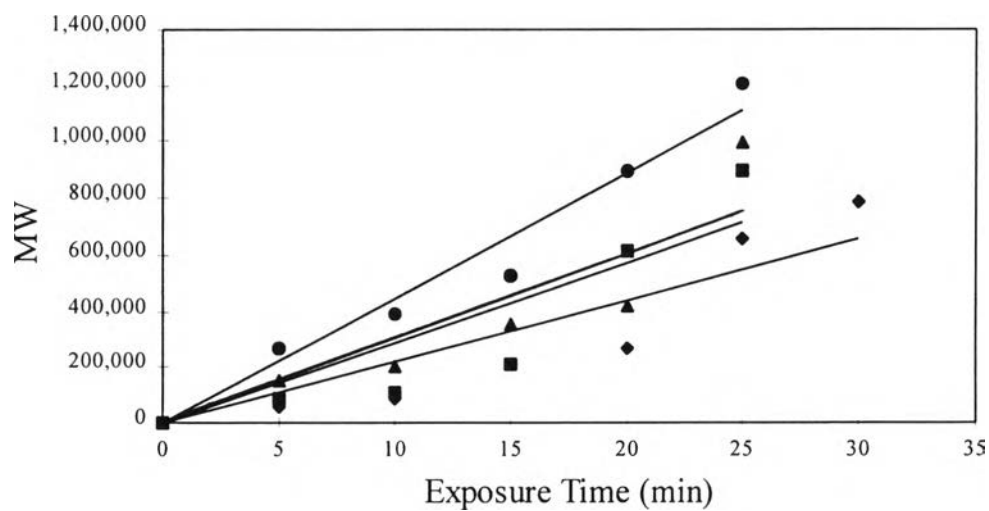
Figure 4.13 The relationship between the MW and the exposure time at 0.5 mmol NaDEHP and 100 watt UV lamp: (◆) 0.5; (■) 1.0; (▲) 2.0; (●) 3.0% of styrene monomer.
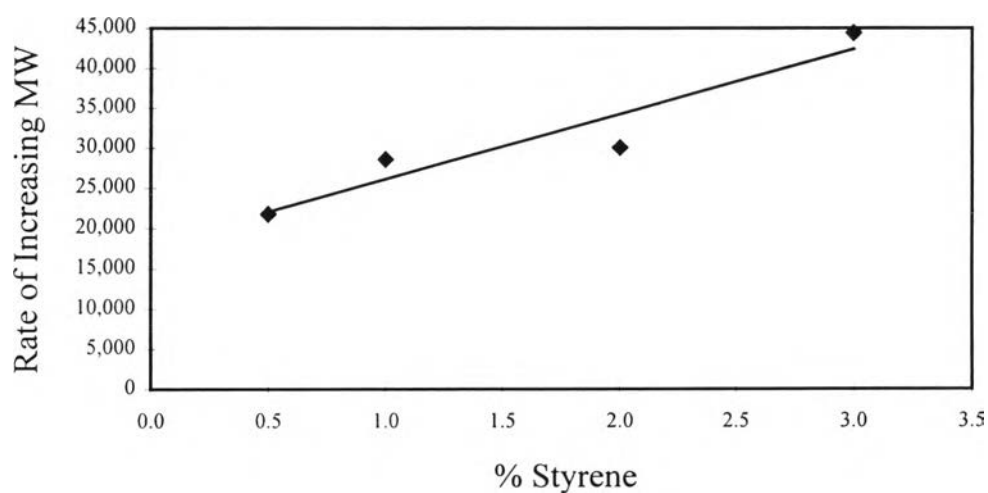

Figure 4.14 The relationship between the rate of increasing MW and the percentage of styrene monomer at 0.5 mmol NaDEHP and 100 watt UV lamp.
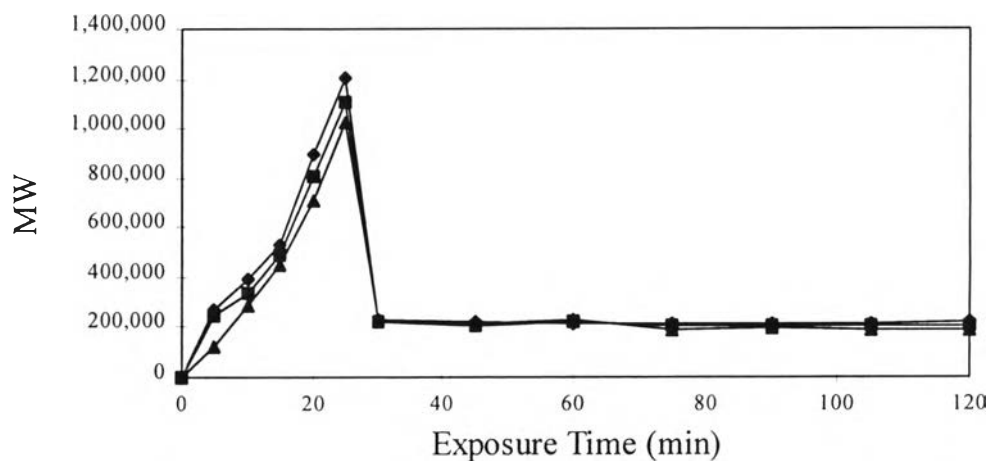
Figure 4.15 The effect of NaDEHP concentration on molecular weight average at 3% styrene monomer and 100 watt UV lamp; (♦) 0.5; (■) 1.0; (▲) 1.5; mmol of NaDEHP.
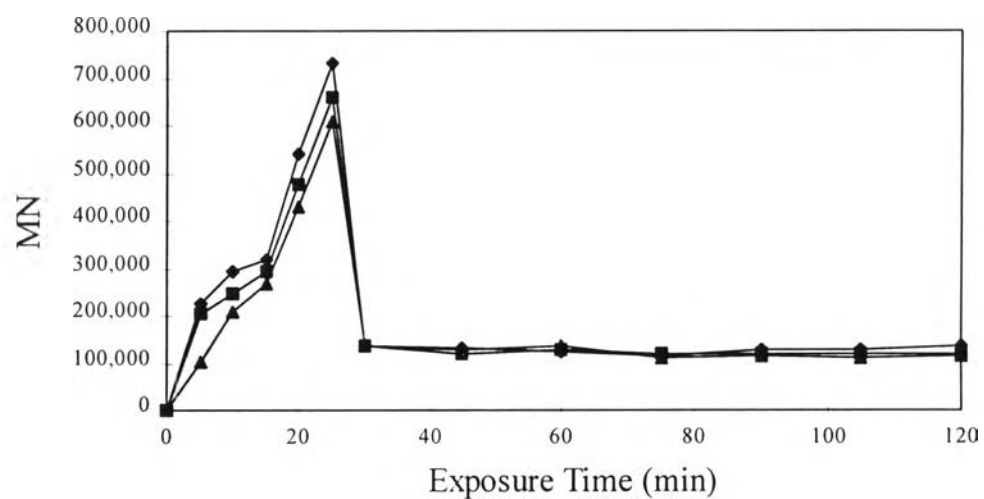

Figure 4.16 The effect of NaDEHP concentration on molecular number average at 3% styrene monomer and 100 watt UV lamp; (♦) 0.5; (■) 1.0; (▲) 1.5; mmol of NaDEHP.
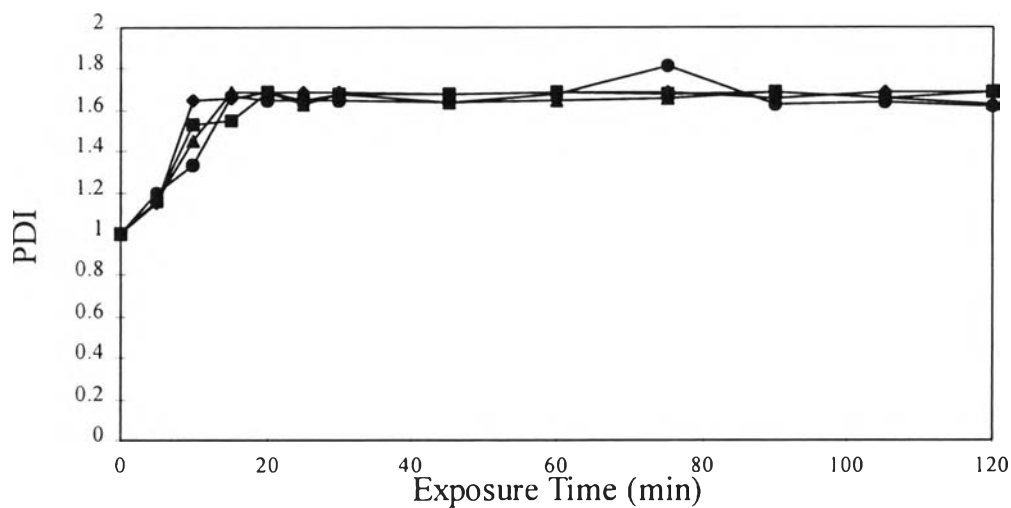
Figure 4.17. The effect of NaDEHP concentration on polydispersity index at 3% styrene monomer and 100 watt UV lamp; (♦) 0.5; (■) 1.0; (▲) 1.5; mmol of NaDEHP.
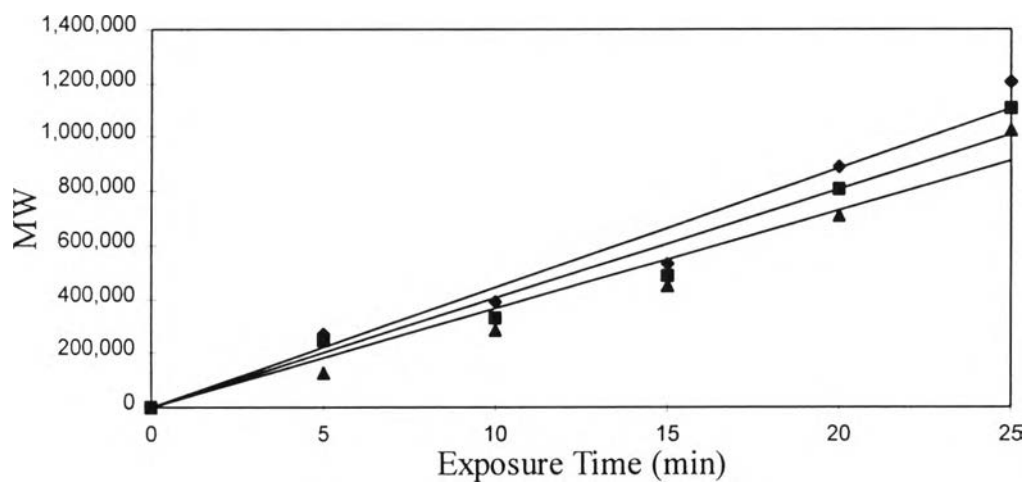

Figure 4.18 The relationship between the MW and the exposure time at 3% styrene monomer and 100 watt UV lamp: (♦) 0.5; (■) 1.0; (▲) 1.5; mmol of NaDEHP.
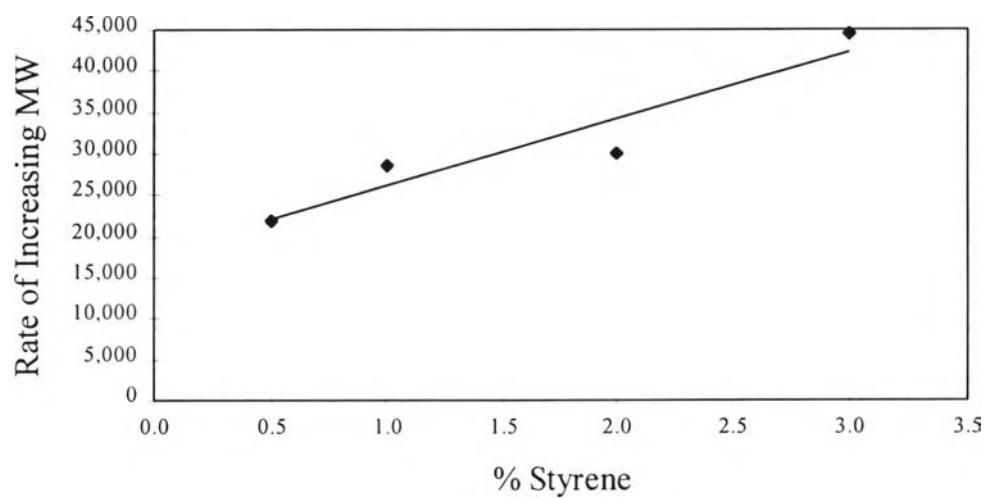
Figure 4.19 The relationship between the rate of increasing MW and the NaDEHP concentration at 3% styrene monomer and 100 watt UV lamp.