

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.0 Introduction

In the fabrication of any mono-molecular thick electronic devices, it is crucial to obtain a functionally active good quality monolayer deposition on the required substrate. The most common optimum condition for the deposition of good quality LB films is when the monolayer is in a compact, highly packed state at the air-water interface. Usually this highly packed state is identified as the solid or condensed solid phase from the surface pressure – area per molecule isotherm. However, the solid or condensed solid phase is extended over a range of surface pressure and the most optimal surface pressure for the deposition is difficult to determine. As discussed in Chapter 4, we analyzed the mechanical and thermodynamic properties of the bR Langmuir film to determine the optimal conditions for film deposition. In this chapter we will conclude the results and discussion that we made in chapter 4.

5.1 Conclusion

From the analysis of effect of bR suspension concentration on the area per molecule, we found that as the concentration of bR suspension increases, the hysteresis between annealing and full isotherm increases as well. For bR suspension of 1 mg/ml concentration no hysteresis was observed. We hypothesize that at higher concentration, once spread on the water surface, bR molecule tend to dissociate themselves. This increases the number of bR molecules that floats on the water surface. Since the increase in the number of bR molecules into the film could change the state of the

system and shift its equilibrium, we have proposed to use a bR suspension concentration of 1 mg/ml to study the mechanical and thermodynamic properties of the bR film.

Next we analyzed the mechanical properties of bR Langmuir film by calculating its compressibility modulus (K). Compared to the not so distinguishable phase transitions seen in the π - A isotherm, the peaks in the K - A graphs is more obvious and provides more information about the phase transitions consequently the microscopic changes. The maximum Elastic modulus or Compressibility modulus K occurs at a surface pressure of 12.5 mN/m. At this range of surface pressure the film is at its solid state. The condensed solid state where the molecules are highly compact occurs between the surface pressure of 12.5 mN/m to 28 mN/m. As such it is highly possible to deposit a good quality monolayer film in this range of surface pressure.

From the thermodynamic properties that we calculated, the minimum Entropy of compression which corresponds to highest order of molecular ordering occurs at surface pressure of 22 mN/m. Beyond this we hypothesize that due to high surface pressure, the bR molecules start to slip on one another causing some increase in the molecular disorder which shown by the increase in the entropy. The slipped molecules creates voids which upon further compression causes some re-ordering of the film and again shown by the second decrease in the system's entropy. Beyond the second minimum at around 38 mN/m surface pressure, more molecules starts to slip and shown by the abrupt increase in the entropy of the system. The reorganization phenomena of the monolayer is graphically illustrated in figure 5.1.

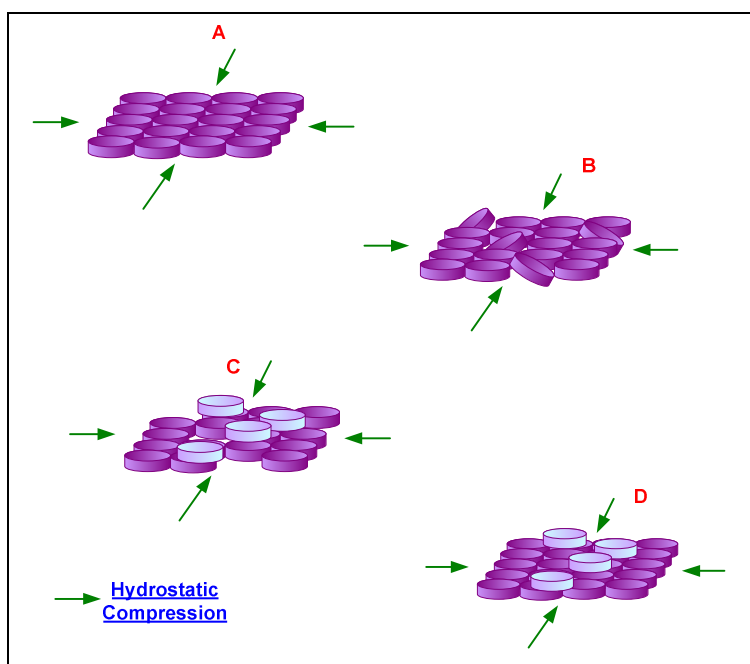


Figure 5.1: Schematic that explains the entropy of compression for 1mg/ml bR suspension. A) Compactly packed monolayer film at Solid Condensed Phase. B) Molecules start to slip on each other. C) Slipped molecules create vacant area between molecules. D) Upon further compression the bR molecules fill up the void created by slipped molecules.

The results from the calculated entropy, agree well with the results obtained from the K - A plot. Due to high molecular ordering at around 22 mN/m surface pressure, we suggest that this would be the ideal surface pressure to deposit a monolayer film.

The absorption spectrum that we obtained for monolayer film deposited at surface pressure of 22mN/m, shows a typical profile with maximum wavelength absorption at around 568 nm. However, different methods and materials used in the preparation of the monolayer caused the slight variation in the peak absorption wavelength and the profile of absorption[14]. This confirms that the reconstituted bR thin film is still functionally active or able to successfully generate photocycle.

As concluded from our mechanical and thermodynamic analysis, beyond the optimal surface pressure of 22 mN/m, molecules tend to slip on each other and form aggregates.

This was confirmed from the SEM micrographs of the bR monolayer that deposited at surface pressure of 25 mN/m where aggregate of bR molecules can be clearly seen.

Thus, thermodynamically and mechanically, the most ideal surface pressure to obtain a good quality monolayer film is at 22 mN/m and the concentration of 1 mg/ml of bR suspension. Furthermore from our spectroscopic characterization, it shows that the film deposited using this surface pressure indeed produced functionally active monolayer [20] film with a thickness of 4.5 nm.

5.2 Future Work

In the work presented, we have only considered thermodynamic and mechanical properties to determine the ideal condition for film deposition. Future work should include the electrical properties (surface potential) to determine the ideal condition for film deposition. In this way we could produce bR monolayer films that are mechanically, electrically and thermodynamically optimized film for future bR based devices and other biotechnological applications.