Polymer Processing: Coating Lab

Objectives: To become familiar with a simple coating operation and to consider other coating operations.

Background: Middleman's chapter 8 deals with coating operations and chapter 7 deals with calendars which are usually an integral part of most coating applications. Figures 1 to 7 in chapter 8 show schematics of typical coating applications. In our tour of international paper we saw examples of most of these coating operations. Since we do not have a calendar for this lab the only coating operation we can do is withdrawal coating, Middleman figure 8.5, although this is probably the least used of the coating operations described. Coating is a critical polymer processing operation for a wide range of industries form paper to photographic film processing. It is important to get some feel for the issues involved in a typical coating process.

Middleman Free Coating P. 211 to 224 are most important for this lab. Figure 8.20 shows three regions of the coating film as a substrate is withdrawn from a solution.

Experimental:
The lab will consist of dip coating of paper sheets using polyethylene oxide solutions of variable concentration. The paper will be inserted and withdrawn from the bath by hand.

1) Prepare polyethylene oxide (PEO) solutions of 20%, 15%, 10%, 5% and 2% of the molecular weights available (100, 200, 600 and 900 kg/mole) in deionized water. Also prepare a bath of water for a control.
2) Measure the viscosity of these solutions and of the water using the Couette viscometer.
3) Make coated paper samples with approximate withdrawal rates of 1 cm/s, 5 cm/s, 20 cm/s on sheets of copier paper and other paper that is available for each of the solutions and for the DI water. Do a similar dip coating for the DI water for a control. Dry the sheets as rapidly as possible using a hair drier.
4) Qualitatively compare the meniscus profile to that predicted in Middleman in figure 8-20 and figure 8-21.
4) Rapidly dry the sheets by hanging the sheets and passing a hair dryer over the sheets.
5) Measure the thickness of the original paper, the paper from the water bath and the coated papers.
6) Weigh the paper and the coated paper to calculate the entrainment rate, q.
7) Compare the measured thickness with calculations using equation 8-102 p. 215, 8-124 p. 219, 8-126 p. 219, 8-128 p. 220
8) Compare the measured entrainment rate with that calculated using equation 8-104 p. 215.
9) Plot thickess of the coating versus concentration
   Thickness versus speed of withdrawal
   Thickness versus molecular weight.
   Do the same for entrainment rate.

*Note the normal stress discussion for PEO solutions on page 222 to 223.

Questions:

1) Discuss the meniscus profile observed and the physical reasons for such a profile following Middleman's discussion on pages 212 to 218.

2) Discuss the agreement between the calculated and measured thickness. Explain differences.

3) Discuss the agreement between the calculated an measured entrainment rate. Explain the effects of "wicking" of the paper. Calculate the amount of polymer that is involved in wicking and the amount that is involved in surface coating.

4) Middleman question 8.3

5) Middleman question 8.4

6) Middleman question 8-16

7) Middleman question 8.18

8) Discuss differences between the dip coating process used in this lab and other coating processes including those shown in figures 8-1 to 8-7 and spin coating (a process used to coat microelectronic wafers prior to etching.