Chapter 3:
Rheological Characterisation

3.1 Introduction

Rheological technique that studies the flow and deformation of material due to applied stress and strain is useful in predicting the mucoadhesive properties of polymers or formulations. These techniques have been widely used by previous researchers to study the mucoadhesion properties and mechanisms of interaction of some biopolymers such as pectin, sodium alginate, chitosan and others (Hassan and Gallo, 1990; Mortazavi, 1995; Rossi et al., 2000; Thirawong et al., 2008; Sriamornsak and Wattanakorn, 2008). The interaction between the mucoadhesive polymers with mucin (or mucous) through chain interpenetration, structure conformation and chemical reaction will be reflected by the viscosity and rheology properties (Thirawong et al., 2008). Hence, the reflection of intermolecular friction as characterised by viscosity could be used to describe the mucoadhesion properties. The rheological characterisation for assessing the mucoadhesiveness of polymers *in vitro* was first discovered by Hassan and Gallo (1990). They have tested the interaction of several polymers (e.g. polyethylene glycol, dextran, chitosan, polyacrylic acid and others) with porcine gastric mucin. They introduced the term viscosity synergism and bioadhesion force in order to rank the adhesive strength of the polymers. The viscosity synergism is the increase in viscosity due to bioadhesion between polymers and mucin components in the mixture. The assessment has been considered successful when the results obtained by Hassan and Gallo (1990) were consistent with the results obtained by others.

Several different strategies can be used to study mucoadhesion when using rheology. One of them is the direct method of measuring the viscosity increment or

synergism at different shear rate using shear rheology. Besides the viscosity, the viscoelastic properties of the polymer-mucin mixture can be determined by oscillatory rheology. Rheological enhancement (synergism) is the term used to describe the magnitude of changes in viscoelastic properties of the sample due to mucoadhesion (Sriamornsak and Wattanakorn, 2008). In this technique, the sample is subjected to an oscillatory stress which is enough to excite the sample without breaking its molecular structure. Riley et al. (2001) have successfully investigated and characterised the polyacrylic acid (PAA) as mucoadhesive polymer and its interaction with homogenised pig gastric mucous using the rheological techniques. In their study, concentration and pH of the polymer and mucous were identified as some of the factors affecting the interaction. Another technique is the advanced frequency sweep analysis proposed by Mortazavi (2003). He used lower range frequency (0.0001 - 10 Hz) as compared to ordinary limited frequency sweep study (0.1 - 10 Hz) and reported that the technique could provide a more detailed and accurate data on change in intermolecular structure during the interaction of polymer with mucous layer.

Likewise, the purpose of this investigation is to study the mucoadhesion properties of five well known mucoadhesive biopolymers (chitosan, high DE pectin, low DE pectin, sodium alginate and sodium carboxymethylcellulose) and the factors that affect their interaction with mucin using similar rheological characterisation. However, there was a small modification in the technique used in this research. Instead of using mixtures of biopolymers and mucin as in previous studies, a thin