

## CHAPTER V

### CONCLUSIONS

#### 5.1 Flocculation Characterization

The results of this study are largely in agreement with those of others workers, such as Vincent et al. Surface tension studies have demonstrated that the cationic polymer and SLES interact to produce a species with properties independent of either the SLES or the cationic polymer. FTIR studies further indicate that in the two phase region the isolated floc consists of both cationic polymer and SLES.

From the discussion in the preceding sections it is apparent that the properties of the flocs produced at all points in the two-phase region, and indeed the phase diagram itself is largely driven by two factors: the concentration of the key ingredients and the kinetics of flocculation.

The concentration of key ingredients appears to influence whether or not phase precipitation is possible, but perhaps more interestingly determines the amount of phase precipitation that occurs. From these studies it is apparent that the amount of floc isolated is largely a consequence of the concentration of cationic polymer, only at very low surfactant/polymer ratios does the concentration of the surfactant have any controlling influence over the amount of floc isolated.

It can be argued that all the other properties of the flocs produced are a consequence of kinetic processes rather than being driven by chemical equilibrium. Indeed it was argued that even the shape of the two phase region was a consequence of kinetics, in that precipitation was observed in areas where chemical equilibrium would predict flocculation would not occur. The CFC and CRC largely appears to be independent of polymer concentration, hence suggesting that flocculation first occurs through precipitation of a stoichiometric ratio of polymer and surfactant. Excess of either component does not redissolve this stoichiometric floc. Only large excesses of surfactant result in the prevention of precipitation, assumedly through the excess of surfactant preventing the aggregation of the polymer/surfactant complex. As such it is suggested that the precipitation process is akin to crystallisation processes.

Furthermore, it is argued that kinetics plays a major role in determining many of the physio-chemical properties of the precipitates. For example, it is apparent that the particle size of the flocs is mainly determined by the hydrophobicity of the flocs. As such the mechanism proposed is that upon first mixing an SLES solution with a cationic polymer solution a precipitate is first formed which contains a stoichiometric mix of the cationic polymer and SLES. Formation of this precipitate is rapid and nucleation occurs at many sites throughout the sample. This process is rapid because at this stoichiometric ratio it is most energetically favourable for precipitation to occur, due to the maximum difference in hydrophilicity between the floc and the aqueous solution.

As a consequence, in samples where the SLES and polymer concentration in the bulk are at this stoichiometric ratio the flocs produced have a minimum particle size and tend to have a zero electrophoretic mobility as well as having a molar sulphur/nitrogen ratio of approximately 1:1.

For non-stoichiometric mixes of cationic polymer and SLES in the bulk flocculation first occurs through precipitation of flocs of the stoichiometric ratio (maximum hydrophobicity). Further flocculation appears to primarily occur through growth of the initial flocs. Growth on these flocs occurs through additional precipitation of non-stoichiometric mixes of cationic polymer and SLES. Where the bulk has an excess of SLES this additional precipitation would tend to be rich in SLES and hence anionic in nature; thereby resulting in larger, hydrophilic flocs with a negative electrophoretic mobility and a S/N ratio indicative of being rich in SLES. Where the bulk has an excess of cationic polymer this additional precipitation would tend to be rich in cationic polymer, hence resulting in larger, hydrophilic flocs with a positive electrophoretic mobility and a S/N ratio indicative of being rich in cationic polymer.

## 5.2 Frictional Properties

The impact of floc characteristic on the frictional property has demonstrated different result for wet and dry application. The results indicate that the flocs impacted on the wet friction to a greater extent than the dry friction. In addition, the

results indicate that the degree of differentiation between the flocs is greater for the wet friction than for the dry friction. The difference may be a consequence of the different frictional regimes in operation in which boundary lubrication is applied for the dry friction where hydrodynamic is involved in the wet stage. Hence, lower friction values could be observed in the wet as not only the floc layer separate the two surfaces but water also acts like a lubricant to prevent the contact between the two surfaces. Moreover, the results suggest that the charge of floc, either identified by electrophoretic mobility or through the mole ratio of S/N, play the most important role in determining frictional properties. The less negative charged floc gives lower friction. The effect in reducing friction is more pronounced when the floc carries a positive charge as it increases the affinity of the flocs for binding to the hair fibre, thus providing a more robust boundary lubricant.