CHAPTER IV

PART II : THE INFLUENCE OF FLOC CHARACTERISTICS ON FRICTIONAL PROPERTIES

4.6 Introduction

In this part of this chapter we shall explore the impact of different floc characteristics on the ability of the flocs to reduce the frictional properties of treated hair switches. From the previous discussion of this chapter, the results suggest that there are variations in the mass of floc produced from those eight different compositions in the phase diagram. Hence, the study of the floc characteristics on the impact of the surface friction properties should be conducted under constant mass of floc condition. Therefore, two experiments in this part will be explored. Firstly, we shall examine the effect of dosage of the dry floc on the impact of friction in order to justify the right amount for the next experiment. Secondly, the effect of different floc characteristics on dry frictional properties under constant mass will be examined. In these experiments the floc system will be allowed to attain equilibrium, the isolated flocs will be redispersed in fresh water and applied to the switches. Friction was then measured in both the wet and dry at a macroscopic scale by using a Texture analyzer (see chapter III).

4.7 Friction as a Function of Applied Floc Mass

A graph showing the relationship between frictional properties of hair fibres and the dosage of floc applied on to the hair fibres is shown below in Figure 4.27. This data was constructed using a polymer concentration of 1g/l and a surfactant level of 30mmol.

The results in Figure 4.27 clearly indicate a minimum in the friction as a function of different dosage levels. Such a minimum can be explained by reference to the pictures of the hair switches also shown in Figure 4.27.

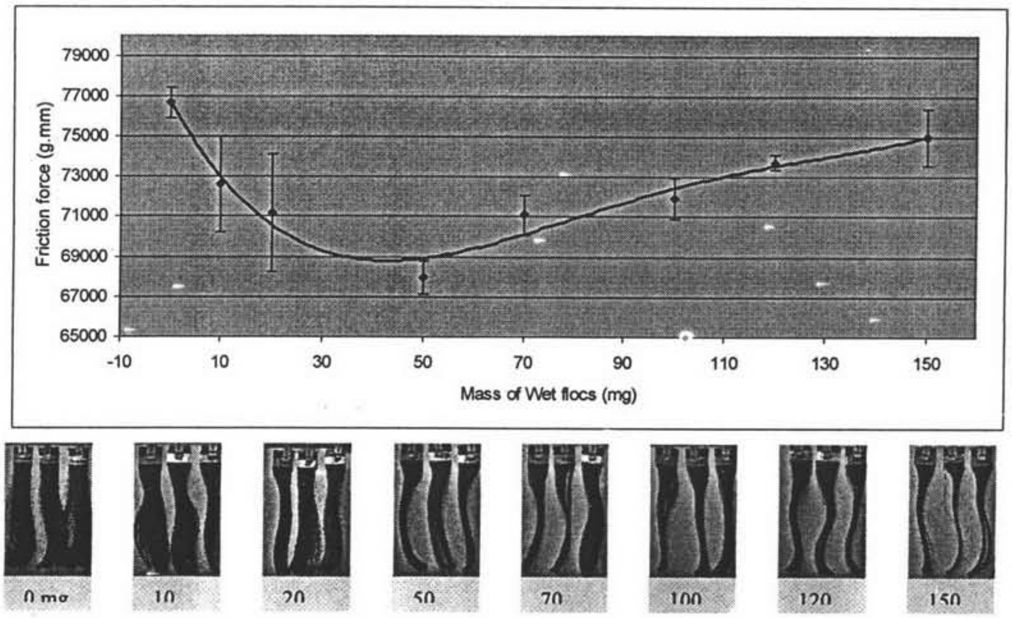

Figure 4.27 Change in Frictional forces on hair switches as a function of different floc loading. Using 1g/l of polymer, 30mmol of SLES and 20 mmol NaCl.

At a low dosage of applied floc it is apparent that the floc behaves as a boundary lubricant through reducing contact between the hair surface and the rubber probe. As the dosage of the floc is increased the additional floc helps to further reduce the contact between probe and hair surface, presumably this would be due to increasing surface coverage. The photographs in Figure 4.27 clearly indicate an increase in adhesion, as the hair fibres become increasingly 'stuck' together. In itself the increased adhesion between the fibres does not have a major impact on the measured friction, it is assumed that this is because that during the friction measurement the hair array is forced to be highly aligned, as such adhesion between fibres should not have a major impact. However, the profile in Figure 4.27 clearly indicates a minimum in friction at an applied dosage of approximately 50mg dried floc. At higher applications of flocs the measured friction between the hair fibres and the probe starts to increase. This effect is presumably a consequence of increased adhesion between the probe and the hair surface. This increased adhesion would arise from the increased thickness of the floc layer and the probe 'ploughing' through the floc layer film.

4.8 Friction as a Function of Floc Characteristic under Constant Floc Mass

The impact of floc characteristics on the macroscopic friction at constant applied floc mass was determined for the eight different compositions. The friction was measured both in the wet (applied aqueous dispersion of floc) and the dry. 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. This effect is demonstrated below in Figure 4.28.

From Figure 4.28 it is apparent that at higher frictional values there is a strong relationship between wet and dry friction, i.e. as the wet friction increases then so does the dry friction. However, at lower wet friction values it is apparent that the dry friction is independent of the wet friction value. Alternatively, these results could be explained simply by the fact that the instrument may not be able to differentiate the flocs with different characteristics.

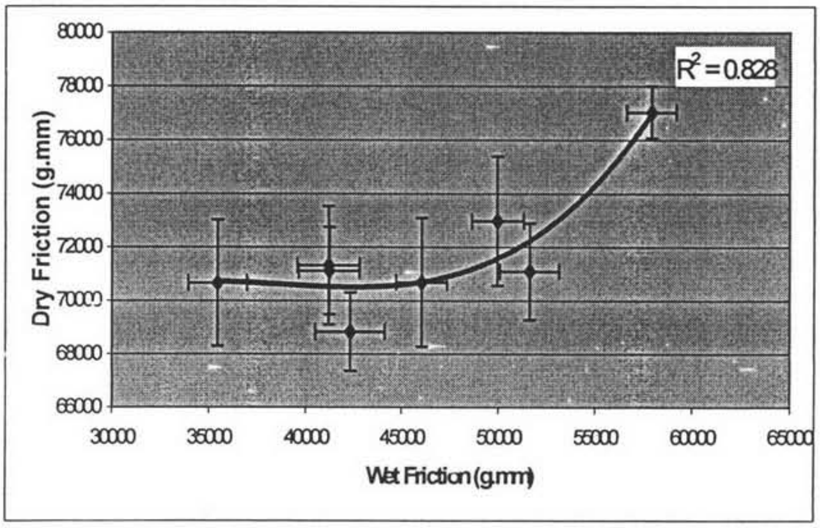

Figure 4.28 Relationship between wet and dry friction for the eight compositions, conducted under constant floc mass.

4.8.1 Relationship of Friction of Treated Hair Fibres and Chemical Composition of Bulk

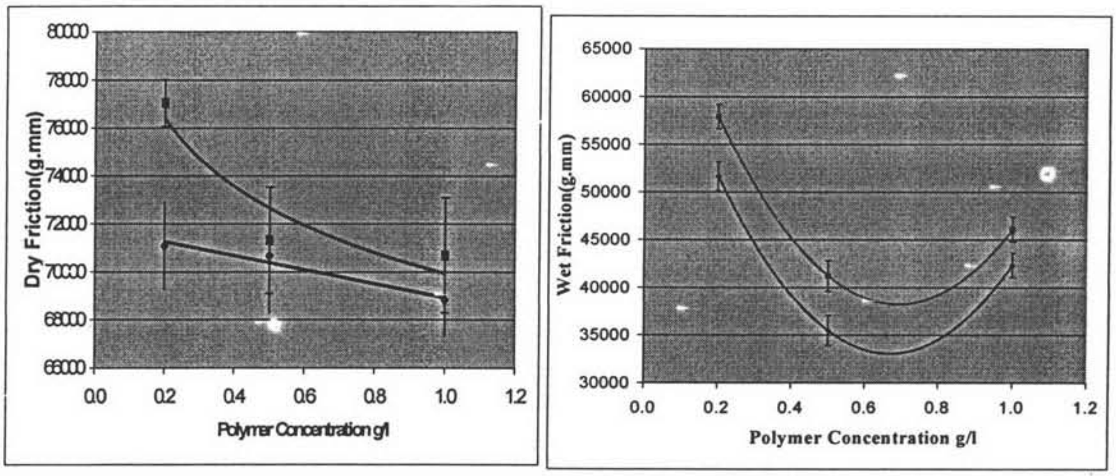

Figure 4.29 Relationship between wet and dry friction with varying polymer concentrations. Blue – at an SLES concentration of 1mmol and Pink at an SLES concentration of 30mmol.

It is apparent from Figure 4.29 that increasing the polymer concentration reduces the friction, this appears to be equally true for both wet and dry friction. This is possibly a consequence of the fact that high cationic polymer concentrations would lead to a low negatively charged floc or possibly positively charged. Hence, such flocs would have a higher affinity for the hair surface. Increased binding to the hair surface would result in a stronger boundary lubricant resulting in reduced 'ploughing' and hence improved friction efficiency.

In addition, the results indicate some differences between wet and dry friction. For the dry friction it is apparent that friction continues to decrease with increasing polymer concentration, however, for the wet friction there is an apparent minimum in the friction curve. This difference may be a consequence of the different frictional regimes in operation. As discussed previously, under the dry friction the system operates as a boundary lubricant. As such a boundary lubricant is dependent on the ability of the lubricant to release the pressure at the asperities of the hair cuticles and probe coming into contact. The effectiveness of such a boundary lubricant will be dependent upon the binding affinity of the floc with the surface of the hair. In the wet, the system is in the hydrodynamic friction regime. In this region the frictional properties would be dependent on the ability of the lubricant to induce a normal force to prevent contact between the hair fibres and the probe contact. Higher levels of polymer concentration in the bulk would result in a higher viscosity of the supernatant, which in turn would lead to chain entanglement and hence increased resistance and friction.

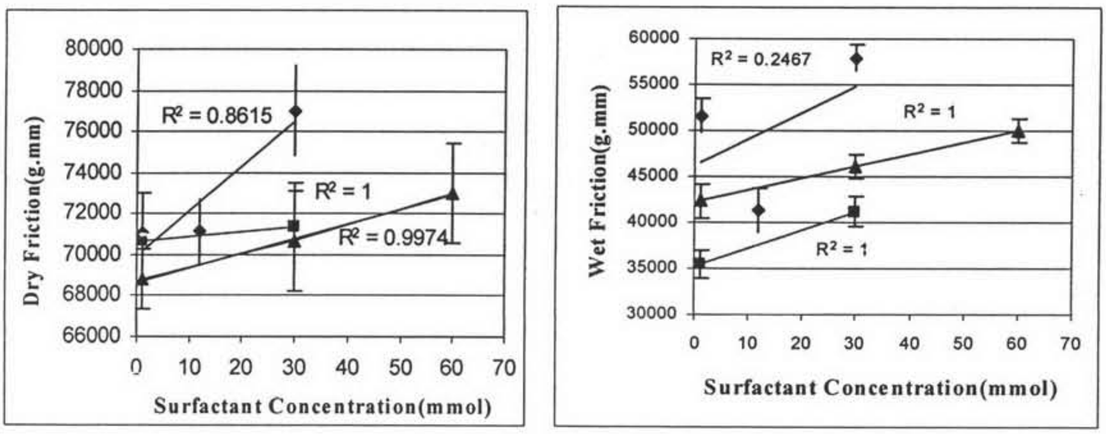

Figure 4.30 Relationship between wet and dry friction with varying surfactant concentrations. Blue – at a polymer concentration of 0.2g/l, Red at a polymer concentration of 0.5g/l and green a polymer concentration of 1g/l.

Figure 4.30 illustrates the frictional results as a function of surfactant concentration. The results show an increasing wet and dry friction with increasing surfactant concentration is apparent. This is possibly a consequence of the fact that high levels of anionic surfactant in the bulk would lead to the formation of anionic flocs, as discussed in the previous chapter. Such anionic flocs would not have the same affinity for the anionically charged hair surface. Furthermore the different effects on wet and dry friction of the different polymer concentrations can also be observed.

4.8.2 Relationship of Friction of Treated Hair Fibres and Characterisation of Flocs

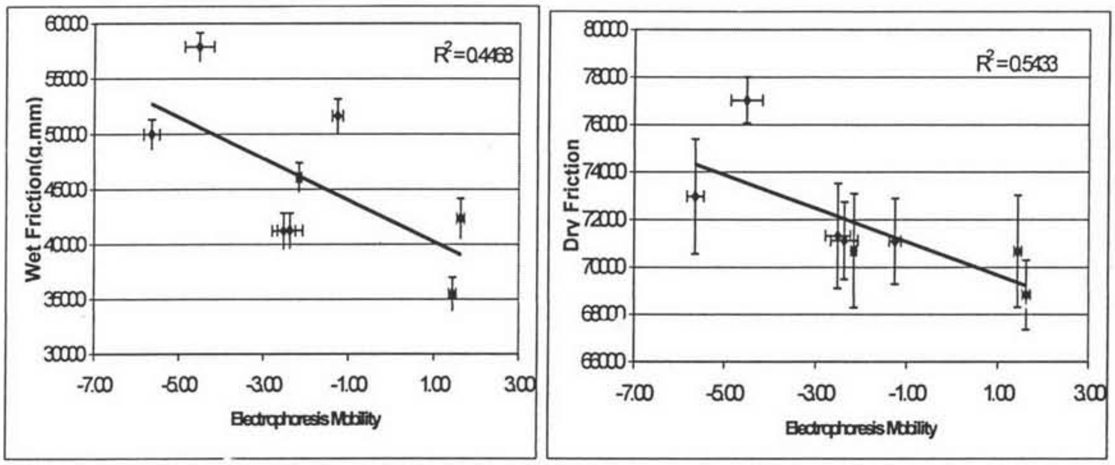

Figure 4.31 Wet and Dry friction as a function of Electrophoresis mobility of the pre-prepared flocs.

The wet and dry friction of hair fibres treated with the eight flocs of different compositions as a function of electrophoresis mobility are illustrated in Figure 4.31. The results tend to indicate a relationship between dry friction and electrophoretic mobility, however, there does not appear to be any relationship between wet friction and electrophoretic mobility. This difference may be attributable to the discussion above, in that the positive charge on the floc increases the affinity of the flocs for binding to the hair fibre, thus providing a more robust boundary lubricant.

A similar picture is observed when we examine the relationship between the wet & dry friction and the chemical composition of the flocs, i.e. the S/N ratio, as illustrated in Figure 4.32. Likewise a small S/N ratio would tend to indicate a floc rich in cationic polymer and would hence tend to be more cationic in nature resulting in lowering the friction of treated hair fibres.

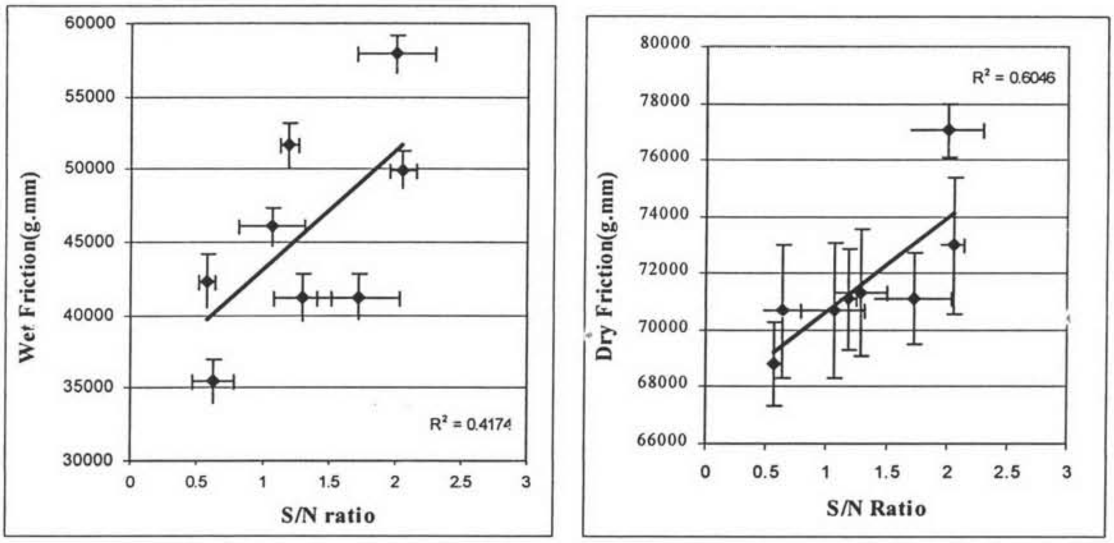

Figure 4.32 Wet and Dry friction as a function of the chemical composition of the pre-prepared flocs as determined by the S/N ratio.

In addition the relationship between wet and dry friction and the particle size of the floc was examined. However, no relation between particle size and wet or dry friction could be discerned. This could potentially be a consequence of the fact that during the application stage the aggregated dense floc is re-dispersed in water. Moreover, the floc suspension undergoes a high shear rate over the surface of the hair and hence the floc size generated at rest/under a zero shear regime may be different to that under an applied shear.