

CHAPTER 6

SUMMARY AND CONCLUSIONS

In the present study, microcalorimetric measurements and various contact angle measurement techniques were applied to study the surface characterization of powdered mineral surfaces. The major conclusions of this study are summarized as follows:

1. Direct contact angle measurements conducted on various flat and powdered talc surfaces and surface free energy components obtained using Van Oss-Chaudhury-Good (OCG) thermodynamic approach on these surfaces are reported. It was found that the surface hydrophobicity of talc increases with decreasing particle size. On the other hand, both the Lifshitz- van der Waals (γ_s^{LW}) and the Lewis acid-base (γ_s^{AB}) surface free energy components and hence, total surface free energy (γ_s) on talc surface decrease as the particle size decrease associated with increase in the values of contact angles. The increase in the surface hydrophobicity of talc and decrease in the values of total surface free energy (γ_s) and its components (γ_s^{LW} and γ_s^{AB}) is attributed to the exposure of more basal plane surfaces upon pulverization. It was also found that the Lewis electron-donor (γ_s^-) component on talc surface is much higher than the Lewis electron-acceptor (γ_s^+) component, suggesting surface basicity of talc.
2. Heats of immersion measurements were conducted by a flow microcalorimeter on a number of powdered talc surfaces using various liquids. The heat of immersion values were then converted to the contact angles using a rigorous thermodynamic relation derived in the present work. The measured heat of immersion values in water and contact angles showed that the surface hydrophobicity of talc samples increase with decreasing particle size, which agrees with the direct contact angle measurements. A relationship between advancing water contact angle θ_a , and heat of immersion ($-\Delta H_i$) and surface free energies was established. It was found that i) the value of $-\Delta H_i$ decrease as θ_a increases, ii) the increase in the value of θ_a is essentially due to a decrease in the values of both Lifshitz-van der Waals (γ_s^{LW}) and Lewis acid-base (γ_s^{AB}) surface free energy components. The most interesting finding was that

the basic surface component (γ_S^-) on talc surface increased with increasing θ_a , while the acid component (γ_S^+) slightly decreased.

3. The heats of adsorption of butanol on various talc samples from n-heptane were determined using a flow microcalorimeter. The heats of adsorption values were used to estimate % hydrophilicity and hydrophobicity and the basal-to-edge surface area ratio values, of various talc samples. In addition, contact angle measurements and heat of butanol adsorption measurements were conducted on a run-of-mine talc sample that is ground to two different particle size fractions, i.e, $d_{50}=12.5 \mu\text{m}$ and $d_{50}=3.0 \mu\text{m}$, respectively. The results were used to estimate the surface free energy components at the *basal* and *edge* surfaces of talc. It was found that the total surface free energy (γ_S) at the basal plane surface of talc is much lower than the total surface free energy at the edge surface. The results of the work suggest also that both the basal and edge surfaces of talc are monofunctional, i.e., the basal surface is *basic*, and the edge surface is *acidic*. The results explain why the basicity of talc surface increases with decreasing particle size as defined from contact angle and microcalorimetric measurements, simply due to the increased basal plane surfaces that are basic in character.
4. The flotation and selective flocculation tests conducted on the east Georgia kaolin clay to study the possibility of removing discoloring impurities such as anatase (TiO_2) and iron oxides and producing high-brightness clay with GE brightness higher than 90%. The results show that a clay product with +90% brightness can readily be obtained with recoveries (or yields) higher than 80% using selective flocculation technique. It was also found that the proper control of surface hydrophobicity of anatase, which is a main discoloring impurity found in east Georgia kaolin, is crucially important for a successful flotation and selective flocculation process. Heat of immersion and contact angle measurements conducted on anatase surface showed: i) the magnitude of the contact angle value, and hence surface free energy and its components on anatase surface is critically dependent on the amount of surfactant (e.g. hydroxamate) used for the surface treatment, ii) as the concentration of

hydroxamate increases from 2 lb/t to 4 lb/t the surface becomes more hydrophobic and the γ_s decreases. Due to a decrease in the value of γ_s with increasing surface hydrophobicity, the Gibbs free energy of interaction ($-\Delta G_{131}$) between two anatase particles in water increases, and so does the efficiency of the separation process.