CHAPTER VII
CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The relation of surfactant adsorption and wettability on various hydrophobic surfaces was investigated in this work. The surface tension, contact angle and surfactant adsorption were measured as a function of surfactant concentration for cationic surfactants as a member of homologous series (C_nTAB: n = 16, 14 and 12) and anionic surfactants with different head group (sulfate, benzene sulfonate and carboxylate) on eight different polymers with varying hydrophobicity. The Zisman equation was used to describe this relation and it was found that the critical surface tension (ST at which contact angle is zero extrapolated from the Zisman plots) differed for the different surfactants studied on a given polymer, emphasizing the limited applicability of the Zisman hypothesis for surfactant solutions and indicating the effect of interfacial tension reduction and surfactant adsorption at the solid/liquid interface on wettability, which is ignored for pure solvent system. In this study, the Zisman equation was related to the Young and Gibbs equations to estimate the solid/vapor interfacial tension (γ_{SV}) which is characteristic of a given polymer. From the calculation, the value of γ_{SV} was found to be fairly invariant with polymer type over a wide range of polymers (γ_{SV} = 33.3±6.5 mN/m) at 30°C. Besides, C8 showed to be the most effective wetting agent since the contact angle reduction by C8 was highest, including to surfactant adsorption and surface pressure at solid/liquid interface. Furthermore, the reduction in contact angle at the CMC compared to pure water was higher with increasing polymer hydrophobicity corresponding to a higher solid/liquid surface pressure and the fraction of horizontal force attributable to solid/liquid interfacial tension reduction increased compared to surface tension reduction effects (f_{SL}).

For the study of the surfactant adsorption on polymer surfaces carried out by the solution depletion method with varying the solution pH (3, neutral (5.5-6) and 9), the surfactant adsorption increased with a decrease in hydrophobicity of polymer surface. For the effect of cationic tail group (a homologous series), CTAB (highest tail length) provided the highest adsorption below the CMC while the plateau adsorption was not different significantly for the three cationic surfactants. The bilayer could be formed on lower hydrophobicity surfaces (PCL and PA66) and on moderate ones like PC and PVC for all three cationic surfactants. For the effect of anionic surfactant with both different tail length and headgroup, the adsorption below the CMC was higher for the longer alkyl tail group surfactant as well. Above the CMC, C8 provided the highest adsorption for all polymers possibly due to less polarity for carboxylate compared to benzene sulfonate and sulfate, respectively. The pH level only slightly affected the adsorption level for CTAB on both polymers and SDS on PTFE due to very low charged sites on hydrophobic surface (polymer). However, the SDS adsorption on PVC was quite high at pH=3.

For the study of fundamental mechanism of flotation deinking via the adsorption of SDS and C8 with various calcium ion concentrations and pH values on hydrophobic carbon black and a hydrophilic paper fiber. In the absence of calcium, at a high enough concentration for aggregates to form, C8 was found to adsorb as a bilayer on both carbon black and paper fiber as did SDS on paper fiber. However, SDS adsorbed as a tail-down monolayer on carbon black. When calcium was added to the surfactant solutions, in addition to these bilayer or monolayer surfactant aggregates, surfactant adsorption is synergized due to calcium adsorption on negative surface sites and co-adsorption of the anionic surfactant on the positively charged cation (calcium bridging effect). At high surfactant concentrations, the surface patches are increasingly filled, covering up potential calcium adsorption sites, causing a reduction of calcium adsorption for SDS on carbon or C8 on paper fiber. These results help explain why calcium is an effective activator and carboxylate of C8 surfactants are more effective than alkyl sulfates of SDS in flotation deinking of paper.

7.2 Recommendations

The recommendations for future work are as follows:

1. To create the empirical equation related to Zisman equation to determine the universal parameter of critical surface tension of hydrophobic surfaces using surfactant solution from the present work.
2. To study the surfactant adsorption on smooth sheet plastic to compare to that on powdered plastic.
3. To investigate the ink removal from real wastepaper such as printed office paper and newspaper.