CHAPTER V

CONCLUSION

This research involved the synthesis of marker dyes for petroleum products from the naturally occurring substrate, cardanol, which was obtained from partially purification of decarboxylated cashew nut shell liquid, with diazonium salts of aniline derivatives, whose structures possessing different substituents on the benzene ring. Aniline derivatives used in this research include *p*-nitroaniline, *m*-nitroaniline, *o*-nitroaniline, *p*-chloroaniline, *m*-chloroaniline, *o*-chloroaniline, 2-chloro-4-nitroaniline, 2-chloro-5-nitroaniline, 4-chloro-2-nitroaniline, 4-chloro-3-nitroaniline, *p*-toluidine, *m*-toluidine, *o*-toluidine, 2-methoxy-4-nitroaniline, Fast Blue B salt, Fast Blue BB salt, and Fast Red RC salt. These synthetic marker dyes provided invisible colors in gasoline and diesel fuel at an effectively usable level (2-5 ppm). On the other hand, when the dyed fuel oils were extracted with 50% ethylenediamine in a solution of 1:1 ethylene glycol and methanol, they provided distinctive colors in the extracted phase. The treat rate of marker dyes in this research were 2 to 5 ppm, which were much lower than the treat rate of marker dyes obtained from esterified cashew nut shell liquid and aniline derivatives (reported by other references: in Master thesis of Thowongs, K., and Silapakumpeerapab, S.). The amount of marker dyes could be measured spectroscopically using an UV/VIS spectrophotometer. The colors were developed differently, since the aniline derivatives used in this research had different substituents. Substitutions of electron-withdrawing groups at *para* or

ortho-position to the amino group gave the most effect to the shade of the developed color; some exhibited the maximum wavelength shifted to the longer wavelength (near 600 nm), which were visible as purple to violet. It was found that the suitable volume ratio of fuel oils to extraction solution was 5:1.

As revealed by the ASTM methods, these marker dyes did not show any effect on the physical properties of both gasoline and diesel fuel. Moreover, the stability of marker dyes in gasoline and diesel fuel was found to be stable over a period of at least three months. It was concluded that these marker dyes were suitable to use as marker dyes in both gasoline and diesel fuel.

Suggestion for further studies:

1. Other aniline derivatives, especially that with the *para* or *ortho*-substituted by electron withdrawing groups, should be used to perform coupling reactions with cardanol to give a purple to blue shade, when extracted these marker dyes into an appropriate basic reagent.

2. Marker dyes, which gave the yellow color in an extracted phase, could be used in fuel oils as "mixed marker dyes" with others that gave the purple or violet shade in an extracted phase. These marker dyes would be silent in fuel oils, but when detected by extraction with an appropriate basic reagent, and measuring with an UV/VIS spectrophotometer, they will give two maximum wavelengths. Using mixed marker dyes will prevent the imitation of pattern of the absorption spectra of the color developed.