

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Firstly, PDPA was synthesized via chemical oxidative polymerization and doped with hydrochloric acid (D-PDPA). Then, D-PDPA was fabricated into a composite with YH to detect the toxic halogenated solvent vapors: DCM, DCE, chloroform, and hexane. The composites showed improving sensitivity responses towards DCM, DCE, and chloroform but not for hexane because of the differences in the chemical structures of the dipole moment, and the dielectric constants of the target vapors. The sensitivities of the composites increased with increasing Si/Al ratio, zeolite content, and vapor concentration due to greater interactions between the zeolite and target vapors. For the temporal response, the induction and recovery times of the composite were higher than those of the pristine D-PDPA due to more active sites being available for the vapor molecules. The UV-Vis spectra showed that the interaction between the composite and DCM does exist: the UV absorption band of D-PDPA and YH was shifted by the delocalization of the Cl⁻ atom. The electron donor, acceptor interaction occurred between YH and the -H atom when exposed to DCM.

To enhance the sensing properties towards DCM, DCE, and chloroform of the composites, zeolite Y with Si/Al ratio of 80 was modified by the dealumination process to increase Si/Al ratios of zeolite Y. The highest Si/Al ratio obtained was 263 at the acid treatment time of 12 hrs. The composites of D-PDPA and DYH[80] were then used as a sensing material to investigate the electrical sensitivity towards those three halogenated solvents. The composites with the dealuminated zeolite Y had higher sensitivity towards those solvents because they had a higher number of reactive sites in DYH[80] to react with the vapors. The acid treatment time of 12 hr and 30 %v/v of zeolite provided the highest sensitivity towards the halogenated solvents. The results of the cyclic response showed the interaction between the composite and the vapor was irreversible, as confirmed by FT-IR spectra and EFM images.

nPDPA was successfully synthesized by emulsion polymerization in the presence of three surfactants. The size and shape of the nPDPA depended on the surfactant type, micelle shape, and surfactant concentration. The nPDPA particle size varied between 50 nm and 500 nm and new morphologies were obtained – leaf, coral reef, red blood cell shapes—in the presence of SDS, CTAB and TW80, respectively. FT-IR and XRD studies of nPDPA revealed the incorporation of surfactants in the nPDPA. The electrical conductivity of nPDPA increased by four orders of magnitude in the presence of surfactants relative to cPDPA. The electrical conductivity of nPDPA was in the order of nPDPA-TW80 > nPDPA-CTAB > nPDPA-SDS. However, the sensitivity of nPDPA-SDS towards DCM was higher than that of nPDPA-CTAB, and nPDPA-TW80. This was due to a difference in: (i) the strength of the intermolecular interaction between the polymers and the vapors; (ii) steric effect of surfactant molecules. Stronger interactions between the polymers and vapors induced greater sensitivity.

The composites of nPDPA-SDS and DYH[80] were fabricated. The sensitivity and selectivity towards DCM were drastically improved. DYH[80] concentration for the highest sensitivity toward DCM in nPDPA-SDS_1-0.5/15%DYH[80] was lower than that of cPDPA/30%DYH[80]. The higher sensitivity toward DCM vapor was 45.49% for the former and latter due to the synergistic effect between nPDPA-SDS and DYH[80]. Moreover, the nanoscale composite showed lower induction and recovery times toward the chemical vapors relative to those of the cPDPA/DYH[80] composite due to the weaker interaction between the composite and the vapors. Finally, nPDPA-SDS_1-0.5/15%DYH[80] composite was used to test the sensitivity towards various kinds of solvent vapors: high polar solvents; low polar solvents; and non polar solvents. With the use of linear discriminant analysis, it was determined that the composite was able to successfully discriminate low polar solvents from the non polar solvents group, but the case of high polar solvents was not successful. The interaction between the composite and DCM vapors was reversible as confirmed by cyclic response, FT-IR spectra, and EFM images. Based on the results, the composite of nPDPA-SDS_1-0.5/15%DYH[80] was shown to be a promising sensing material that can discriminate different kinds of chemical solvents.

7.2 Recommendations

There are several possible modifications to increase electrical conductivity of PDPA including varying of dopant types, modifying the functional group of the monomer and PDPA, PDPA blending, grafting, or copolymer with another electrical conducting polymer, and incorporating other electrical conducting fillers.

Sensitivity and selectivity of PDPA towards solvent vapors can be improved by incorporating another selective material such as porous silicon materials; carbon nanotube; carbon black; molecular sieves; and etc. and use other fabrication techniques such as using the electroless deposition of metals for coating process. Another method is to control temperature or pressure environment. Since, different gases have different temperatures and pressure dependences.

Further development of the sensor is the exquisite finger printing of extremely similar mixtures over a wide range of analyte types that discriminates among a wide variety of solvent vapors without the use of highly specific receptors known as an electronic nose. This is by making multi-sensing materials in one element which can detect two-kind or different kinds of gases or by increasing multi-dimensional signature of target gases.

For an economic interest, the composite should be in the forms of film, layer by layer, electro spinning, or thin layer coated on to a quartz plate in micro or nano-scale in order to develop into intelligent toxic gas sensing systems or lab-on-a-chip devices.