REFERENCES

[1] Wang, Z., Fan, X., Li, D., and Feng, L. A highly selective and colorimetric naked-eye chemosensor for Cu^{2+}. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 71(4) (2008): 1224-1227.

[2] Prins, J.M., Brooks, D.M., Thompson, C.M., and Lurie, D.I. Chronic low-level Pb exposure during development decreases the expression of the voltage-dependent anion channel in auditory neurons of the brainstem. Neurotoxicology and Teratology 31(6) (2010): 662-673.

[3] Gilbert, M.E. and Lasley, S.M. Developmental lead (Pb) exposure reduces the ability of the NMDA antagonist MK-801 to suppress long-term potentiation (LTP) in the rat dentate gyrus, in vivo. Neurotoxicology and Teratology 29(3) (2007): 385-393.

[4] Suárez-Fernández, M.B., Soldado, A.B., Sanz-Medel, A., Vega, J.-A., Novelli, A., and Fernández-Sánchez, M.T. Aluminum-induced degeneration of astrocytes occurs via apoptosis and results in neuronal death. Brain Research 835(2) (1999): 125-136.

[5] Lévesque, L., Mizzen, C.A., McLachlan, D.R., and Fraser, P.E. Ligand specific effects on aluminum incorporation and toxicity in neurons and astrocytes. Brain Research 877(2) (2000): 191-202.

[6] Muckenthaler, M.U., *et al.* Molecular analysis of iron overload in β2-microglobulin-deficient mice. Blood Cells, Molecules, and Diseases 33(2) (2004): 125-131.

[7] Anderson, C.P., Shen, M., Eisenstein, R.S., and Leibold, E.A. Mammalian iron metabolism and its control by iron regulatory proteins. Biochimica et Biophysica Acta (BBA) - Molecular Cell Research 1823(9) (2012): 1468-1483.

[8] Lin, Q., Chen, P., Liu, J., Fu, Y.-P., Zhang, Y.-M., and Wei, T.-B. Colorimetric chemosensor and test kit for detection copper(II) cations in aqueous solution with specific selectivity and high sensitivity. Dyes and Pigments 98 (2013): 100-105.

[9] YanLi, *et al*. Colorimetric sensorstripsforlead(II)assayutilizingnanogoldprobes immobilized polyamide-6/nitrocellulosenano-fibers/nets. Biosensors and Bioelectronics 48 (2013): 244-250.

[10] Kim, S.H., *et al*. Use of squarylium dyes as a sensing molecule in optical sensors for the detection of metal ions. Dyes and Pigments 41 (1999): 221-226.

[11] Suresh, P., Azath, I.A., and Pitchumani, K. Naked-eye detection of Fe^{3+} and Ru^{3+} in water: Colorimetric and ratiometric sensor based on per-6-amino-β-cyclodextrin/*p*-nitrophenol. Sensors and Actuators B: Chemical 146(1) (2010): 273-277.

[12] Hashem, E.Y., Abu-Bakr, M.S., and Hussain, S.M. Interaction of nickel with 4-(2'-benzothiazolylazo) salicylic acid (BTAS) and simultaneous first-derivative spectrophotometric determination of nickel(II) and iron(III). Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 59(4) (2003): 761-769.

[13] Jurd, L. The fromation of metal and "co-pigment" complexes of cyanidin 3-glucoside. Phytochemistry 5 (1966): 1263-1271.

[14] Smyk, B., Pliszka, B., and Drabent, R. Interaction between Cyanidin 3-glucoside and Cu(II) ions. Food Chemistry 107(4) (2008): 1616-1622.

[15] Moncada, M.C., Moura, S., Melo, M.J., Roque, A., Lodeiro, C., and Pina, F. Complexation of aluminum(III) by anthocyanins and synthetic flavylium salts A source for blue and purple color. Inorganica Chimica Acta 356 (2003): 51-61.

[16] Dugo, G., Pera, L.L., Bruzzese, A., Pellicano, T.M., and Turco, V.L. Concentration of Cd (II), Cu (II), Pb (II), Se (IV) and Zn (II) in cultured sea bass (Dicentrarchus labrax) tissues from Tyrrhenian Sea and Sicilian Sea by derivative stripping potentiometry. Food Control 17 (2006): 146-152.

[17] Dugo, G., La Pera, L., Lo Turco, V., and Di Bella, G. Speciation of inorganic arsenic in alimentary and environmental aqueous samples by using derivative anodic stripping chronopotentiometry (dASCP). Chemosphere 61(8) (2005): 1093-1101.

[18] Muñoz, E. and Palmero, S. Determination of heavy metals in milk by potentiometric stripping analysis using a home-made flow cell. Food Control 15(8) (2004): 635-641.

[19] Kaur, K. and Kumar, S. 1-Aminoanthracene-9,10-dione based chromogenic molecular sensors: effect of nature and number of nitrogen atoms on metal ion sensing behavior. Tetrahedron 66 (2010): 6990-7000.

[20] Shi, B., *et al*. A reversible fluorescent chemosensor for mercury ions based on 1H-imidazo[4,5-b]phenazine derivatives. Tetrahedron 69(37) (2013): 7981-7987.

[21] Zhou, X., Yan, W., Zhao, T., Tian, Z., and Wu, X. Rhodamine based derivative and its zinc complex: synthesis and recognition behavior toward Hg(II). Tetrahedron 69(46) (2013): 9535-9539.

[22] Lin, Q., Fu, Y.-P., Chen, P., Wei, T.-B., and Zhang, Y.-M. Colorimetric chemosensors designed to provide high sensitivity for Hg^{2+} in aqueous solutions. Dyes and Pigments 96(1) (2013): 1-6.

[23] Czapski, J. Heat stability of betacyanins in red beet juice and in betanin solutions. European Food Research and Technology 191 (1990): 275-278.

[24] Alkema, J. and Seager, S.L. The chemical pigments of plants. Journal of Chemical Education 59 (1982): 183-186.

[25] Arapitsas, P., Sjöberg, P.J.R., and Turner, C. Characterisation of anthocyanins in red cabbage using high resolution liquid chromatography coupled with photodiode array detection and electrospray ionization-linear ion trap mass spectrometry. Food Chemistry 109 (2008): 219-226.

[26] Ukwueze, N.N., Nwadinigwe, C.A., Okoye, C.O.B., and Okoye, F.B.C. Potentials of 3, 3^1, 4^1, 5, 7-pentahydroxyflavylium of *Hibiscus rosa-sinensis* L. (*Malvaceae*) flowers as ligand in the quantitative determination of Pb, Cd and Cr. International Journal of Physical Sciences 4(2) (2009): 58-62.

[27] Hosseinian, F.S., Li, W., and Beta, T. Measurement of anthocyanins and other phytochemicals in purple wheat. Food Chemistry 109 (2008): 916-924.

[28] Mann, J., Davidson, R.S., Hobbs, J.B., Banthorpe, D.V., and Harborne, J.B. Natural products: their chemistry and biological significance. 1^{st} ed ed. England: Longman Scientific & Technica l, 1994.

[29] Kong, J.M., Chia, L.S., Goh, N.K., and Chia, T.F. Analysis and biological activities of anthocyanins. Phytochemistry 64(5) (2003): 923-933.

[30] Cooper-Driver, G.A. Contributions of Jeffrey Harborne and co-workers to the study of anthocyanins. Phytochemistry 56(3) (2001): 229-236.

[31] Marković, J.M.D., Baranac, J.M., and Brdarić, T.P. Electronic and infrared vibrational analysis of cyanidin-quercetin copigment complex. Spectrochimica Acta Part A 62 (2005): 673-680.

[32] Brouillard, R. and Dubois, J.-E. Mechanism of the structural transformations of anthocyanins in acidic media. Journal of the American Chemical Society 99(5) (1977): 1359-1364.

[33] Boulton, R. The copigmentation of anthocyanins and Its role in the color of red wine: A critical review. American Journal of Enology and Viticulture 52 (2001): 67-87.

[34] Foster, R. Organic charge-transfer complexes. London: Academic Press, 1969.

[35] Calzolari, A., *et al*. Optoelectronic Properties of Natural Cyanin Dyes. The Journal of Physical Chemistry A 113(30) (2009): 8801-8810.

[36] Lin, J.-Y., Li, C.-Y., and Hwang, I.-F. Characterisation of the pigment components in red cabbage (Brassica oleracea L. var.) juice and their anti-inflammatory effects on LPS-stimulated murine splenocytes. Food Chemistry 109 (2008): 771-781.

[37] Ravishankara, M.N., Shrivastava, N., Padh, H., and Rajani, M. Evaluation of antioxidant properties of root bark of Hemidesmus indicus R. Br. (Anantmul). Phytomedicine 9 (2002): 153-160.

[38] L, L. and G, V. Anthocyanins from bay (Laurus nobilis L.) berries. Journal of Agricultural and Food Chemistry 53(20) (2005): 8063-8067.

[39] Schwarz, M., Hillebrand, S., Habben, S., Degenhardt, A., and Winterhalter, P. Application of high-speed countercurrent chromatography to the large-scale isolation of anthocyanins. Biochemical Engineering Journal 14(3) (2003): 179-189.

[40] Tewari, P.K. and Singh, A.K. Preconcentration of lead with Amberlite XAD-2 and Amberlite XAD-7 based chelating resins for its determination by flame atomic absorption spectrometry. Talanta 56 (2002): 735-744.

[41] Shabani, A.M.H., Dadfarnia, S., and Dehghani, Z. On-line solid phase extraction system using 1,10-phenanthroline immobilized on surfactant coated alumina for the flame atomic absorption spectrometric determination of copper and cadmium. Talanta 79 (2009): 1066-1070.

[42] Chamjangali, M.A., Farooji, S.T., and Bahramian, B. Application of chloromethylated polystyrene functionalized with N,N-bis(naphthylideneimino)diethylenetriamine in an on-line preconcentration system for the determination of cadmium by FAAS. Journal of Hazardous Materials 174 (2010): 843-850.

[43] Goswami, A., Singh, A.K., and Venkataramani, B. 8-Hydroxyquinoline anchored to silica gel via new moderate size linker: synthesis and applications as a metal ion collector for their flame atomic absorption spectrometric determination. Talanta 60 (2003): 1141-1154.

[44] Ciopec, M., *et al*. Adsorption studies of Cr(III) ions from aqueous solutions by DEHPA impregnated onto Amberlite XAD7 – Factorial design analysis. Chemical Engineering Research and Design 90(10) (2012): 1660-1670.

[45] Hosseini-Bandegharaei, A., Hosseini, M.S., Sarw-Ghadi, M., Zowghi, S., Hosseini, E., and Hosseini-Bandegharaei, H. Kinetics, equilibrium and thermodynamic study of Cr(VI) sorption into toluidine blue o-impregnated XAD-7 resin beads and its application for the treatment of wastewaters containing Cr(VI). Chemical Engineering Journal 160 (2010): 190-198.

[46] Lyubchik, S.B., *et al*. Simultaneous removal of 3d transition metals from multi-component solutions by activated carbons from co-mingled wastes. Separation and Purification Technology 60 (2008): 264-271.

[47] Freitas, P.A.M., Iha, K., Felinto, M.C.F.C., and Suárez-Iha, M.E.V. Adsorption of di-2-pyridyl ketone salicyloylhydrazone on Amberlite XAD-2 and XAD-7 resins: Characteristics and isotherms. Journal of Colloid and Interface Science 323 (2008): 1-5.

[48] Domínguez, J.R., González, T., Palo, P., and Cuerda-Correa, E.M. Removal of common pharmaceuticals present in surface waters by Amberlite XAD-7 acrylic-ester-resin: Influence of pH and presence of other drugs. Desalination 269 (2011): 231-238.

[49] Navarro, R., Saucedo, I., Núñez, A., Ávila, M., and Guibal, E. Cadmium extraction from hydrochloric acid solutions using Amberlite XAD-7 impregnated with Cyanex 921 (tri-octyl phosphine oxide). Reactive and Functional Polymers 68(2) (2008): 557-571.

[50] Wang, F.-H., Ji, Y.-X., and Wang, J.-J. Synthesis of heavy metal chelating agent with four chelating groups of N^1,N^2,N^4,N^5-tetrakis(2-mercaptoethyl)benzene-1,2,4,5-tetracarboxamide (TMBTCA) and its application for Cu-containing wastewater. Journal of Hazardous Materials 241–242 (2012): 427-432.

[51] Jang, Y.K., Nama, U.C., Kwon, H.L., Hwang, I.H., and Kim, C. A selective colorimetric and fluorescent chemosensor based-on naphthol for detection of Al^{3+} and Cu^{2+}. Dyes and Pigments 99 (2013): 6-13.

[52] Kaur, P. and Sareen, D. The synthesis and development of a dual-analyte colorimetric sensor: Simultaneous estimation of Hg^{2+} and Fe^{3+}. Dyes and Pigments 88 (2011): 296-300.

[53] Kumar, A., Kumar, V., Diwan, U., and Upadhyay, K.K. Highly sensitive and selective naked-eye detection of Cu^{2+} in aqueous medium by a ninhydrin–quinoxaline derivative. Sensors and Actuators B: Chemical 176 (2013): 420-427.

[54] Hale, K.L., *et al*. Molybdenum sequestration in brassica species. A role for anthocyanins? Plant Physiology 126 (2001): 1391-1402.

[55] Starr, M.S. and Francis, F.J. Effect of metallic ions on color and pigment content of cranberry juice cocktail. Journal of Food Science 38(6) (1973): 1043-1046.

[56] Fuleki, T. and Francis, F.J. Lead acetate as chromogenic reagent for anthocyanins. Phytochemistry 6(8) (1967): 1161-1163.

[57] Borsari, M., Ferrari, E., Grandi, R., and Saladini, M. Curcuminoids as potential new iron-chelating agents: spectroscopic, polarographic and potentiometric study on their Fe(III) complexing ability. Inorganica Chimica Acta 328(1) (2002): 61-68.

[58] Li, G., Zhang, L., Li, Z., and Zhang, W. PAR immobilized colorimetric fiber for heavy metal ion detection and adsorption. Journal of Hazardous Materials 177(1–3) (2010): 983-989.

[59] Li, G., Xiao, J., and Zhang, W. A novel dual colorimetric fiber based on two acid–base indicators. Dyes and Pigments 92(3) (2012): 1091-1099.

[60] Ozay, H. and Ozay, O. Rhodamine based reusable and colorimetric naked-eye hydrogel sensors for Fe^{3+} ion. Chemical Engineering Journal 232 (2013): 364-371.

[61] Matsunaga, H., Kanno, C., and Suzuki, T.M. Naked-eye detection of trace arsenic(V) in aqueous media using molybdenum-loaded chelating resin having beta-hydroxypropyl-di(beta-hydroxyethyl)amino moiety. Talanta 66 (2005): 1287-1293.

[62] Wiczkowski, W., Szawara-Nowak, D., and Topolska, J. Red cabbage anthocyanins: Profile, isolation, identification, and antioxidant activity. Food Research International 51 (2013): 303-309.

[63] Salinas, İ., Esparza, I., Gómez, S., Santamaria, C., and Fernández, J.M. A study of heavy metal complexation in grape juice. Electroanalysis 17(5-6) (2005): 469-475.

[64] Pyysalo, H. and Kuusi, T. The role of iron and tin in discoloration of berry and red beet juices. Zeitschrift für Lebensmittel-Untersuchung und Forschung 153(4) (1973): 224-233.

[65] Skoog, D.A., West, D.M., and Holler, F.J. Fundamentals of analytical chemistry. 7 ed. United State of America: saunders college publishing, 1966.

[66] RP, A. and EC, M. Stability constants of aluminium fluoride complexes. Talanta 18(9) (1971): 873-80.

[67] Wickstrom, T., Lund, W., and Bye, R. Determination of selenium by hydride generation atomic absorption spectrometry: elimination of interferences from very high concentrations of nickel, cobalt, iron and chromium by complexation. Journal of Analytical Atomic Spectrometry 10 (1995): 803-808.

[68] Dean, J.A. Lange's handbook of chemistry. 13th ed. New York: McGraw-Hill 1987.

[69] Frasson, E., Bardi, R., and Bezzi, S. Structure of copper-dimethylglyoxime at low temperature. Acta Crystallographica 12(3) (1959): 201-205.

[70] Patnaik, P. Dean's Analytical Chemistry Handbook. 2nd ed. New York: McGRAW-HILL, 2004.

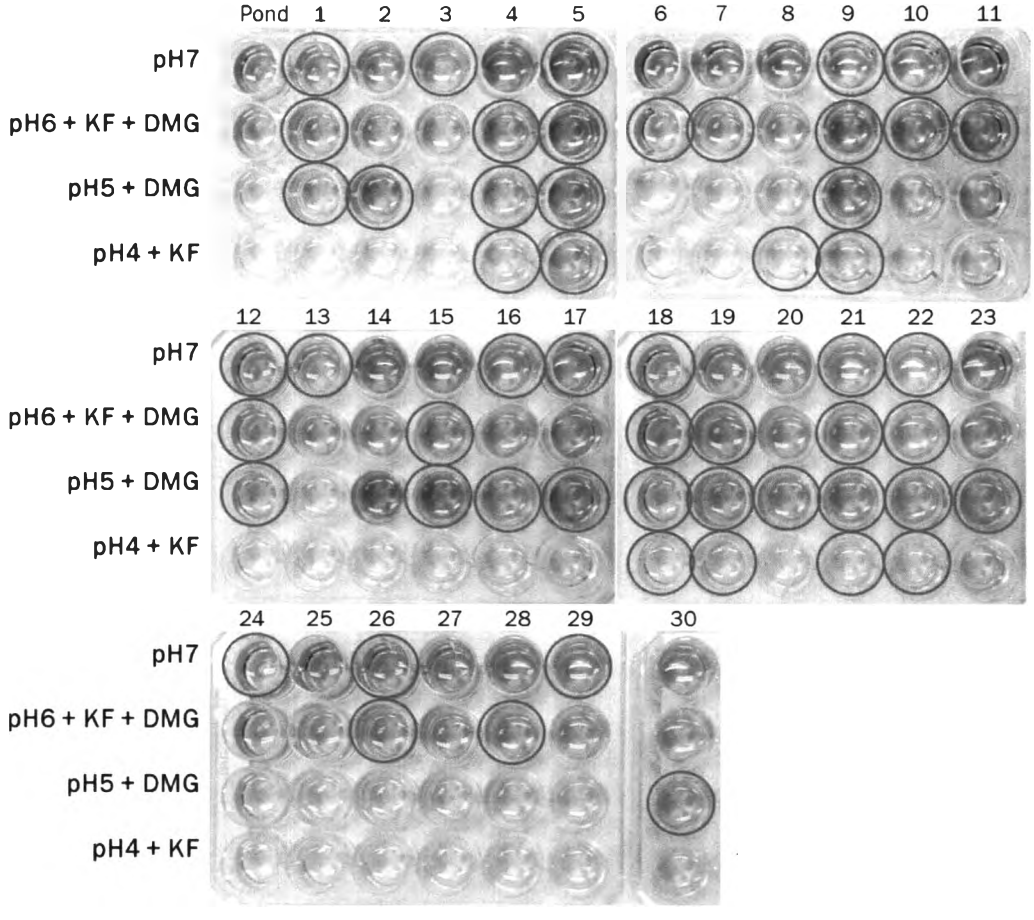
[71] Miller, J.N. and Miller, J.C. Statistics and Chemometrics for Analytical Chemistry. 4th ed. London: Pearson Education, 2000.

[72] Março, P.H., Poppi, R.J., Scarminio, I.S., and Tauler, R. Investigation of the pH effect and UV radiation on kinetic degradation of anthocyanin mixtures extracted from Hibiscus acetosella. Food Chemistry 125 (2011): 1020-1027.

APPENDIX

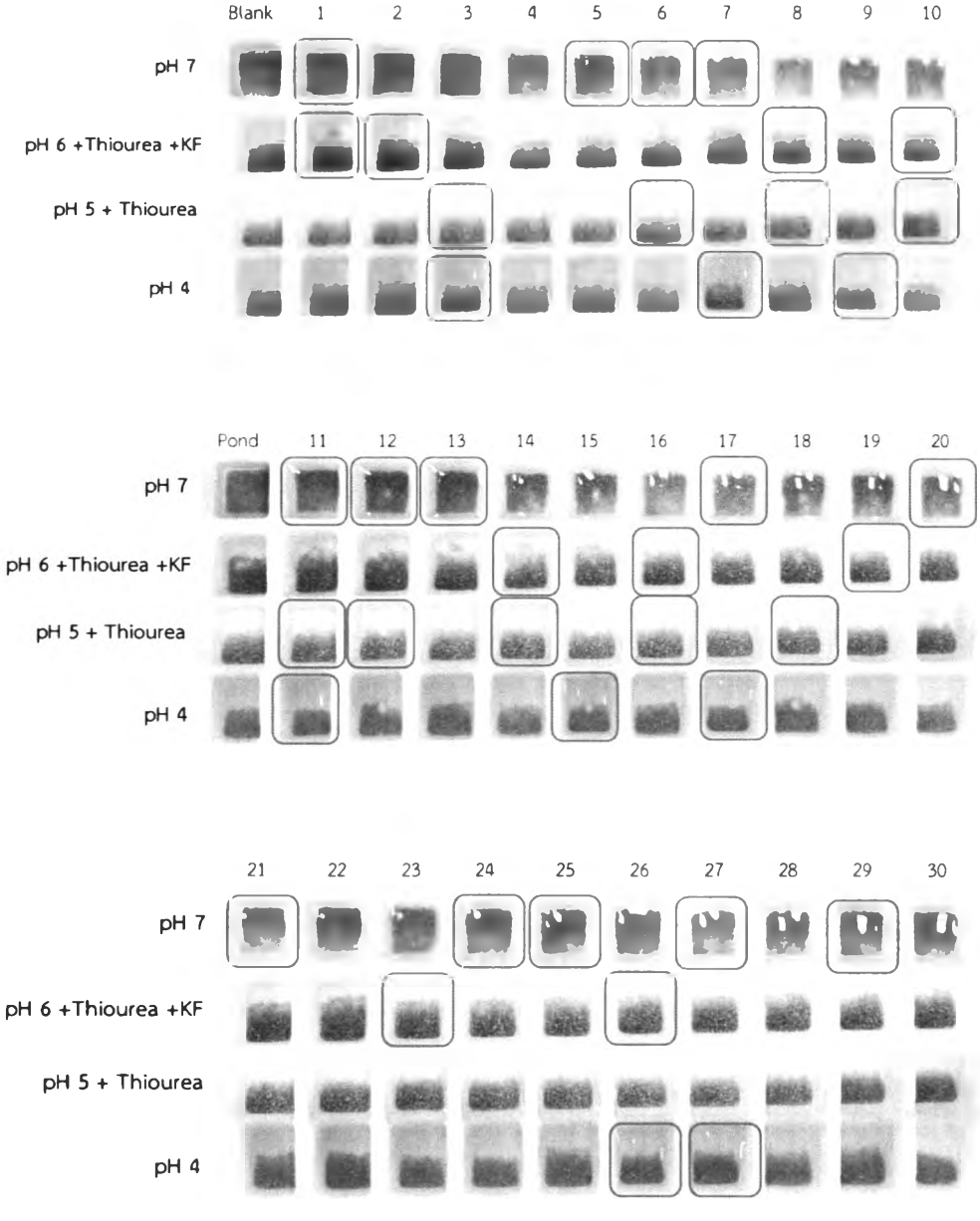
Appendix A

Application in real water sample using cyanidin solution



Appendix B

Application in real water sample using modified solid sorbent



VITA

Miss Warangkhana Khaodee was born on Aug 2, 1979 in Shukhothai, Thailand. She graduated with a Bachelor and Master of Science degree from Chiang Mai University in 2001 and 2005, respectively. She has been a graduate student in the Department of Chemistry, Faculty of Science, Chulalongkorn University and become a member of Environmental Analysis Research Unit since 2009. She finished her Doctor of Philosophy (Chemistry) in Academic Year 2013. She has been working as a lecturer at Faculty of Science and Technology, Chiang Mai Rajabhat University, Chaingmai. E-mail: warangkhana.k@hotmail.com

Publication

Khaodee, W., Aeungmaitrepirom, W., and Tuntulani, T. Effectively simultaneous naked-eye detection of Cu(II), Pb(II), Al(III) and Fe(III) using cyanidin extracted from red cabbage as chelating agent. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 126 (2014): 98-104.