AN ELECTROCHEMICAL DETECTOR FOR VINYL CHLORIDE IN GASEOUS PHASE

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According to the Material Safety Data Sheet [1], vinyl chloride was extremely flammable and has been confirmed to be carcinogenic to humans. It may have effects on the liver, blood vessels, and connective tissue. Approximately 4 percent loss estimate of vinyl chloride monomer (VCM) has been reported [2], based primarily on material balance studies. Losses to the outdoor atmosphere may be from a large number of valves, flanges, and other components in the manufacturing process and could be monitored with detectors at the locations where leakage occurs.

Several kinds of assemblies with metal electrodes electrochemically deposited on solid polymer electrolytes (SPE) have been developed to analyze the concentrations of organic reducing gases [3,4]. Nevertheless, the assemblies were generally not very suitable to analyze oxidative organic compounds at very negative potential due to considerable water electrolysis. This problem could be solved when the aqueous electrolyte was replaced with organic electrolyte since organic electrolyte was difficult to reduce and was sufficient stable in electrochemical reaction. It provided higher solubility and wider applicable potential range for oxidative electroactive species.

An electrochemical configuration, consisting of one porous alumina plate with two sputtered electrodes on the both sides and an organic electrolyte, was developed to in-situ detect vinyl chloride at the concentration level of percents in gaseous phase. The ppm level concentration of vinyl chloride was monitored by a non-direct sensing system, in which vinyl chloride was pyrolyzed before purged into the sensing cell. To determine the concentration of vinyl chloride, the pyrolyzed products, acetylene and hydrogen chloride, were analyzed indirectly by chronoamperometry and chronopotentiometry, respectively. The relationships between concentration of vinyl chloride and pyrolyzed products will be discussed in this report.

In the 50% toluene/50% DMF electrolyte containing 10 mM Bu_4NClO_4 and at applied potential –2.1 V (vs. Ag/Ag^+), the current response of Au/porous alumina plate/Pt assembly under step changes of various concentrations of vinyl chloride is shown in Figure 1. Compared with tetrabutylammonium tetrafluoborate, higher sensitivities were obtained while tetrabutylammonium perchlorate was used as the supporting electrolyte at applied potentials, –2.0 and –2.1 V (vs. Ag/Ag^+). The optimum concentration of tetrabutylammonium perchlorate for the highest sensitivity was found close to 10 mM, as shown in Figure 2. Nevertheless, the ppm level concentration of vinyl chloride could not be monitored exactly in the direct sensing system by the sputtered Au/porous alumina substrate/Pt electrode assembly due to small ratio of sensing current to background current. After pyrolysis of vinyl chloride, one of the pyrolytic products, acetylene, was detected significantly with the Au/porous alumina substrate/Pt electrode assembly in H_2SO_4 aqueous electrolyte. The other method to determine the concentration of vinyl chloride was to measure the concentration of chloride ion in one buffer solution containing KCl with a Ag/AgCl electrode. One flow sensing system was applied to dissolve the hydrogen chloride into the buffer solution. Effects of pH and flow rate of test solution on the sensing performance of chloride ion will be also reported.

References

[1] *Material Safety Data Sheet*, CAS #75-01-4.
[2] *Scientific and Technical Assessment Report on Vinyl Chloride and Polyvinyl Chloride*, U.S. Environmental Protection Agency, Washington, D.C. 1975.
[3] R. Liu et al., *J. Electrochem. Soc.* 139 (1992**)** 3514.
[4] P. C. Hauser et al., *Anal. Chem.* 69 (1997**)** 558.

Figure 1 Current response of the electrode assembly with step changes of various VCM concentrations.

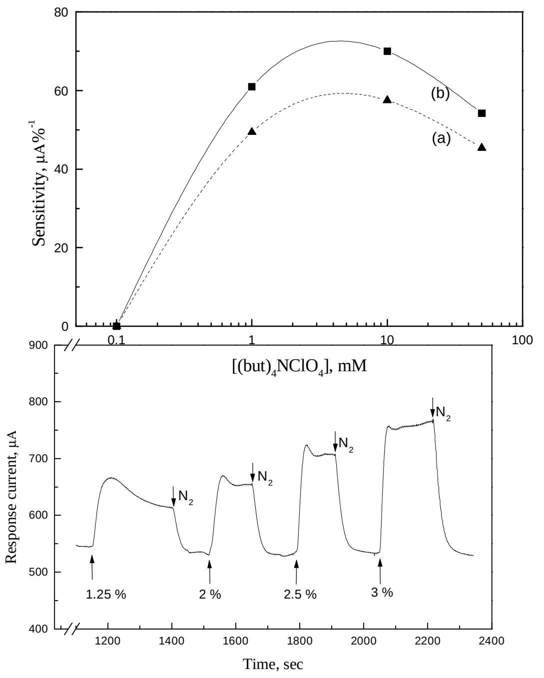

Figure 2 Effect of concentration of supporting electrolyte on the sensitivity of cathodic reduction of VCM at applied potentials (a) –2.0, and (b) –2.1 V (vs. Ag/Ag^+).