INVESTIGATION OF INTERACTIONS OF CARBOFURAN WITH Pb (II) AND Cr (VI)

A. N. Navaratne and K. G. S. A. Samaranayake

Department of Chemistry, Faculty of Science, University of Peradeniya

Introduction

A pesticide is any substance or a mixture of substances intended for preventing, destroying, repelling or mitigating any pest. Pests include those that destroy property, spread disease or are a vector for a disease or cause a nuisance. Because of their benefits, humans used pesticide even before 20 BC. Carbofuran is one of the most toxic carbamate pesticides. It is marketed under the trade names of Furadan and Curater. It is used to control insects in a wide variety of field crops. It is a systemic insecticide. Base-catalyzed hydrolysis to carbofuranphenol is the major degradation pathway of carbofuran in both water and sediments. Other degradation products can include 3-hydroxy-7-phenolcarbofuran, N-methylcarbamic acid via hydroxylation of the benzofuranyl moiety (Bachman & Patterson, 1999). Carbofuran and metabolites of it which remain in the environment may interact with heavy metals and potential of heavy metals entering the food chain may increase (Baily & Kroll, 1996). Studying these interactions is important to investigate their transportation and accumulation in the environment. Because both pesticides and heavy metals are toxic to the environment, Pb (II) and Cr (VI) were selected as the two heavy metal ions. This study provides UV-Visible, Cyclic voltammetric and conductometric evidence to support interactions between carbofuran and heavy metal ions.

Materials and Methods

In this experiment 99.9 % pure analytical grade carbofuran, analytical grade K_2CrO_4, and $Pb(NO_3)_2$ from Aldrich were used. A solution mixture was prepared by mixing 20.00 cm^3 of carbofuran (1.00×10^{-4} mol dm^{-3}) and 20.00 cm^3 of Pb (II). The cyclic voltammograms for the above solution mixtures were obtained from pH 1 to pH 10. UV-Visible spectra were obtained for the mixtures of metal ion and carbofuran in different molar ratios at pH 1 & 10. Above procedure was repeated for the Cr (VI) instead of Pb (II). Conductance for the different molar ratio solutions of carbofuran and Pb (II) was measured.

Results and Discussion

Cyclic voltammograms of 1:1 mixture (Pb (II): carbofuran) in Figure 1(a) shows peak shift in reduction potential. When pH is 2, the reduction peak of the Pb (II) shifted to the positive potentials. If the metal ion interacts with carbofuran where the bonding is through oxygen or nitrogen, the reduction potential and peak current should change.

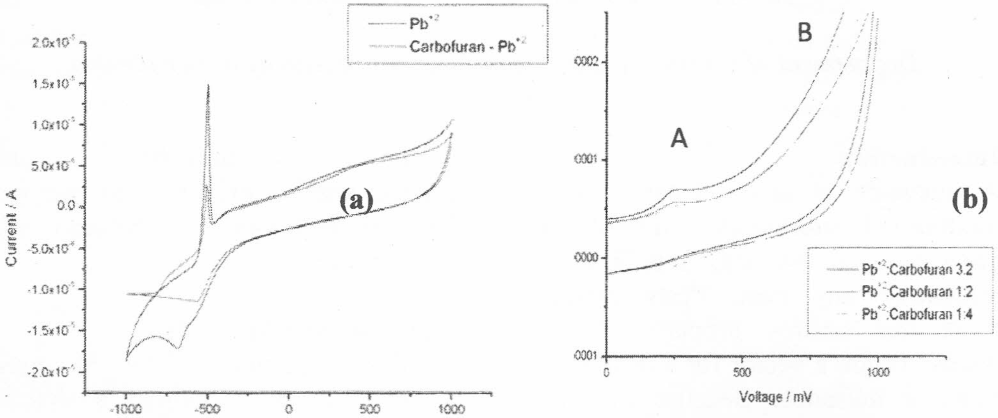
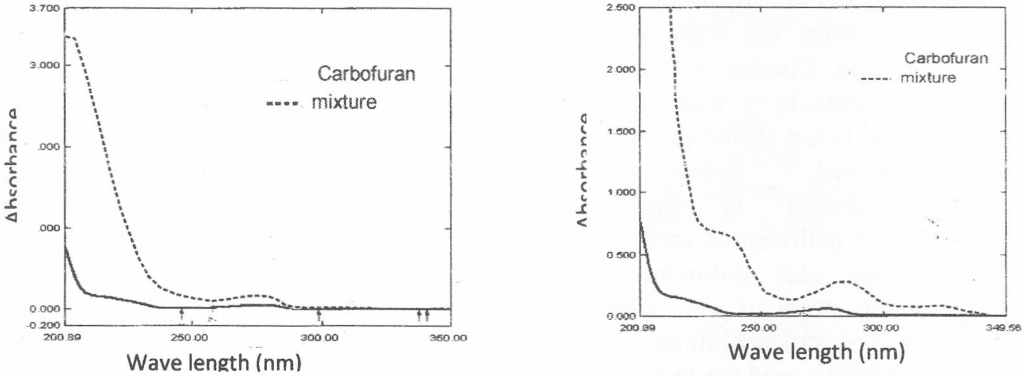


Fig. 1 Cyclic Voltammograms for the Pb (II) and Carbofuran at pH 2(a) and pH 10(b).



(a) Pb (II): carbofuran at pH 1

(b) Cr (VI): carbofuran at pH 1

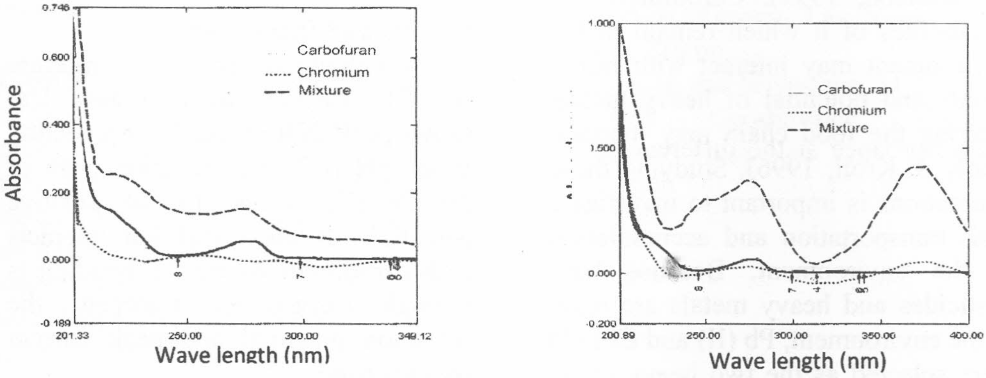


Fig. 2 UV-Visible spectra for the mixtures of carbofuran with heavy metal ions.

Increase in the electron density cause the metal to reduce more easily than uncomplexed ion and its reduction potential should be more positive than the uncomplexed ion. The intensity of the oxidation peak of the metal ion is due to the availability of the electrons of the metal ion. Since the metal ion binds with carbofuran the electron availability of metal ion should decrease. Therefore, intensity of the oxidation peak of the mixture should decrease compared to the uncomplexed ion (Yonggang, *et al*, 2003). Similar effect is expected at the pH of 10, because the degradation products are quite similar at lower and higher pH (Bachman & Patterson, 1999). The important observation in the Figure 1(b) is that it shows new oxidation peaks in positive potentials. New oxidation peak **A** is obtained for the Pb (II): carbofuran 3:2 & 1:2 systems with low intensity. Another new oxidation peak **B** was obtained for the Pb (II): carbofuran 1:4 system. These observations once again suggest that there should be an interaction between lead and carbofuran.

Figure 2 shows significant differences in the UV-Visible spectra of the mixtures of heavy metal ion and carbofuran in the continuous variation method. Furthermore, differences in the absorbance at the different wave lengths may be due to the degree of complex formation with carbofuran and heavy metal ion.

The conductance of the mixtures decrease with time while the conductance in the control lead solutions did not decrease significantly. This can be attributed to the interaction of lead with carbofuran, thereby reducing the conductance.

Conclusions

In acidic medium Pb (II) show 1:1 complexation with carbofuran. However, at pH of 10 Pb (II) complexes with carbofuran in several molar ratios, which are 1:2 and 3:2 (Pb (II): carbofuran). The complexation of carbofuran with Cr (VI) takes place to a lower extent than lead. Carbofuran with Cr (VI) in acidic medium shows lower interaction than that in a basic medium. In acidic medium, Cr (VI) shows 1:2 complexation with carbofuran. However in basic medium it is 1:1 (Cr (VI): carbofuran). The interactions of the above mixtures give a decrease in the conductance due to the low mobility of metal ions upon complexation. In order to confirm the metal carbofuran interactions, further spectroscopic investigation including FTIR will be necessary.

References

Bachman J and Patterson H.H. (1999). Decomposotion of Carbamete Pesticide. Environ. Sci. Technol. 33:874-881.

Baily H.C and Kroll C. (1996). Environmental Fate of Carbofuran. Environ. Toxicol. Chem. 15 (6):837-845.

Yonggang Z. Mingmin Y and Zhiying H. (2003).Polagraphic Determination of Carbofuran. Chinese Journal of Analytical Chemistry. 31(5): 584-586.