Comparative Performance Evaluation Of Activated Carbon And Fly Ash/Activated Carbon Composite For Triphenyltin Chloride Removal By Adsorption

Olushola S. Ayanda [a, b]*, Olalekan S. Fatoki [b], Folahan A. Adekola [c], Erica Suana [b] and Bhekumusa J. Ximba [b]

This study proposed the use of activated carbon and fly ash/activated carbon composite for the removal of triphenyltin chloride (TPT) from simulated contaminated marine water. The effect of adsorbent dosage, contact time, pH, stirring speed, and temperature on the adsorption of TPT onto activated carbon and fly ash/activated carbon composite were studied and discussed. Four kinetic models, the pseudo first- and second-order equations, the Elovich equation, and the fractional power equation, were selected to follow the adsorption process. The adsorption equilibrium was analysed using the Langmuir, Freundlich, Temkin, and Dubinin-Radushkevich (D-R) isotherm models. It was found that the kinetic data for the adsorption process obeyed a pseudo second-order kinetic model while equilibrium data fitted well with the Freundlich and D-R models. The thermodynamic parameters showed that the adsorption of TPT onto these adsorbents is endothermic. The adsorbents investigated presented good potential for the removal of TPT from TPT contaminated marine wastewater.

Keywords: hazardous chemicals, triphenyltin chloride, activated carbon, fly ash, adsorption, marine wastewater.

* Corresponding Authors
Email: osayanda@gmail.com
Tel.: +2348054642362
[a] Environmental and Nano Science Research Group, Department of Chemistry, University of the Western Cape, Private Bag X17, Bellville, South Africa.
[b] Department of Chemistry, Faculty of Applied Sciences, Cape Peninsula University of Technology, P.O. Box 1906, Bellville, South Africa.
[c] Department of Chemistry, University of Ilorin, P.M.B 1515, Ilorin, Nigeria.

1. INTRODUCTION

Hazardous chemicals are materials that are toxic, reactive and are highly injurious to human if released. Relatively small exposures to hazardous chemicals may cause harmful effect to human, animals, plants, and the environment. Detrimental effects include birth defects, cancer, imposex, induce genetic damage, injury and death. Exposure normally occurs through inhalation, skin or eye contact, and ingestion [1, 2]. Many of these substances have also been regarded as endocrine disrupting chemicals. They include persistent organic pollutants (POP's), such as the polychlorinated biphenyls (PCB's), dichloro diphenyl trichloroethane (DDT), phthalates, alkylphenols and alkylphenol ethoxylates, bisphenol A (BPA), polybrominated diphenyl ethers (PBDE's), brominated flame retardants (BFR), and organotin compounds (tributyltin chloride (TBT) and triphenyltin chloride (TPT; Fig. 1)). The fact that hazardous chemicals are present in our environment has been confirmed by several studies and is becoming increasingly well documented [3, 4].

Organotin compounds are used in a wide range of applications including stabilizing agents in the polyvinyl chloride industry, plastic additives, industrial catalysts, insecticides, fungicides, bactericides, wood preservatives, and antifouling paints [5]. Due to the intensive use of TBT and TPT in antifouling paints for ships, the most significant effects have been observed in the marine environment [6]. Organotin compounds have therefore been detected at Cape Town harbour [7], Durban and Richards Bay harbours, and Knysna lagoon [8], seawater from Port Elizabeth harbour, river and dam water samples from areas around Johannesburg affected by mine tailings dumps [6].

The identification, quantification and remediation of TBT and TPT are of vital importance as they are generally more toxic than their inorganic analogues [2, 7]. Adsorption is one of the most promising and widely used techniques for the removal of both inorganic and organic pollutants from contaminated water. The adsorption of TPT unto nano oxides and fly ash has been reported in Ayanda *et al* [9] and Fatoki *et al* [10]. The adsorption of TBT onto fly ash, activated carbon and fly ash/activated carbon composite has also been reported [11]. However, it would also be necessary to investigate the kinetics, isotherms and thermodynamics of TPT adsorption unto activated carbon and fly ash/activated carbon composite. Hence, this work is aimed at the evaluation of the performance of activated carbon and fly ash/activated carbon composite for triphenyltin chloride removal.

2. EXPERIMENTAL

2.1. Adsorbents and chemical reagents

Activated carbon, TPT (purity 98%), hydrochloric acid (HCl), sodium hydroxide (NaOH), methanol, and hexane were purchased from Sigma Aldrich. Fly ash/activated carbon composite and artificial seawater used in this study were prepared following the method by Ayanda *et al* [11] (Table 1). Stock solution containing 1000 mg/L TPT was prepared in methanol and the simulated TPT contaminated marine water samples containing 12.5 – 100 mg/L TPT were prepared by spiking the artificial seawater with appropriate amount of TPT stock solution.

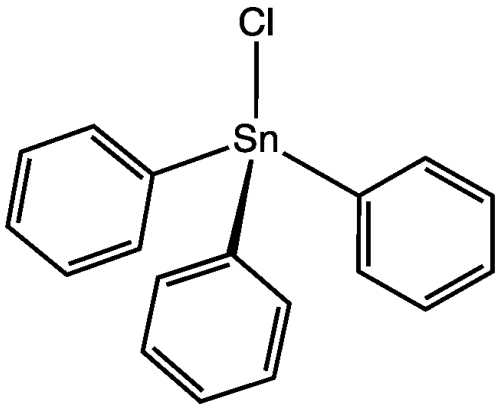

Figure 1. Triphenyltin Chloride

Table 1. Preparation of Artificial Seawater

Components	**Volume (mL)**
5 M NaCl	86.6
1.0 M KCl	9.0
1.0 M CaCl2.2H2O	9.27
4.9 M MgCl2.2H2O	4.68
2.0 M MgSO4.7H2O	12.75
1.0 M NaHCO3	2.15
Deionised water	Made up to 1000 mL