UNIVERSITI TEKNOLOGI MARA

SYNTHESIS, CHARACTERIZATION AND APPLICATION OF POLYPYRROLE GRAPHENE OXIDE NANOCOMPOSITE AS SORBENT IN GREEN MICROEXTRACTION OF TETRACYCLINE ANTIBIOTICS IN AQUEOUS MATRICES

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ABSTRACT

The widespread use and improper disposal of tetracycline antibiotics has led to their contamination in water sources, posing a significant threat to public health, necessitating the urgent development of sensitive and reliable analytical methods for detecting antibiotics at low concentrations to ensure public safety and preventing the emergence of antibiotic-resistant diseases. Sample preparation for pharmaceutical contaminant analysis poses significant challenges due to the multi-step and time-consuming procedures of conventional methods. Hence, motivated by the arising issues, this research is conducted to explore the application of the synthesized polypyrrole-graphene oxide (PPy-GO) for dispersive micro solid phase extraction (D-μ-SPE) sorbent and its manual packing into the online solid-phase extraction liquid chromatography (online SPE-LC) column, introducing a novel and green approach for tetracycline antibiotic analysis in water samples through efficient processes that reduce solvent usage. Selected commonly used TCs namely oxytetracycline (OTC), tetracycline (TC), demeclocycline (DMC), chlortetracycline (CTC), and doxycycline (DC) were used as target analytes. PPy-GO composite sorbent was synthesized and characterized by Fourier Transform Infrared (FTIR) spectroscopy, Field Emission Electron Microscope (FESEM), thermogravimetric analysis (TGA), X-ray diffraction (XRD) and Brunauer-Emmet-Teller (BET) analyzer. Several parameters were optimized in D-μ-SPE method. The optimum conditions were as follows: amount of GO, 0.03g; polymerization time, 60 min; sample pH, pH 7; extraction time, 15 min; desorption time, 10 min; desorption solvent, methanol; sorbent mass, 50 mg. All five TCs were successfully extracted using the same conditions in D-μ-SPE. Good linearities were achieved for the analytes with coefficients of determination, R^2 in the range of 0.9989-0.9995. The method was successfully applied for the analysis of river water and tap water samples, with good relative recoveries in the range of 80-105%. The prepared sorbent was then applied for the extraction of TCs by online solid phase extraction liquid chromatography. Several important parameters of online SPE-LC were optimized using half-fraction Central Composite Design of Response Surface Methodology (RSM). Under the optimized conditions (0.75 mL/min for solvent flow rate, 1.6 min for valve switching time, 55 mg sorbent mass, 80:20 ACN:buffer composition and pH 2.5 for buffer pH), PPy-GO-online-SPE-LC provided good linearity in the concentration range of 10 to 1000 μg/L with R^2 of 0.9990-0.9997 and low limits of detection in the range of 3.2–6.7 μg/L. The method showed high relative recoveries in the range of 82–102% for river water and tap water samples, respectively with RSDs of ≤ 3.5 (n=3). Then, the analysis of tetracyclines was conducted by using C_{18} commercialized sorbent to compare the performance with PPy-GO composite sorbent. In comparing the optimization and performance of PPy-GO and C_{18} sorbents for online SPE-LC analysis, PPy-GO exhibits environmentally friendly elution conditions, requiring lower solvent flow rate and smaller sorbent mass, and demonstrates higher sensitivity with a lower limit of detection, slightly better accuracy, and comparable precision for the analysis of tetracycline antibiotics. Hence, online SPE-LC method by using PPy-GO as sorbent proved to be a rapid, selective and efficient technique for the extraction and separation of tetracyclines in aqueous matrices and stands out as a comparable alternative to commercially available sorbent materials in the market.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

A bacterial infection is an infection caused by the invasion and growth of harmful bacteria within the body. Bacteria are single-cell microorganisms that can cause a wide range of infections in humans, including respiratory infections, skin infections, gastrointestinal infections, urinary tract infections, food poisoning and many more (Dhagat & Jujjavarapu, 2022). Back in the old days, bacterial infection diseases were treated using folk medicines and herbal therapies. However, these remedies were often insufficient and these infections frequently led to serious illnesses such as pain, fever, redness and caused high mortality rates (Tam et al., 2020). The discovery of antibiotics in the 1940s is a 'golden era' in bacterial infection treatment (Nassar et al., 2022).

Antibiotic is an important medicine and commonly used to treat bacterial infection. Antibiotic is defined as a low molecular substance produced by microorganisms that are at a low concentration inhibits or kills other microorganisms (Etebu & Arikekpar, 2016). Antibiotics can be classified into several different groups and chemical structures. Some common type of antibiotics including penicillin, tetracycline, macrolides and fluoroquinolones. Tetracycline antibiotics, collectively referred to as TCAs, form a group of broad-spectrum antibiotics characterized by a shared chemical structure and mechanism of action, effectively targeting both Gram-positive and Gram-negative bacteria (Bayliss et al., 2019). They include tetracycline, doxycycline, minocycline, and others. Since their discovery, tetracyclines (TCs) have played a prominent role in veterinary and human medicine specifically for the treatment and prevention of microbial infections and as additives in animal foodstuffs (Przeniosło-Siwczyńska et al., 2020). The increasing demand of antibiotics has led to the improper disposal of these pharmaceuticals into the environment and threaten public health.

Pharmaceutical residues such as antibiotics, antivirals, antifungals and antiparasitics can enter water systems through a number of pathways. These medications may come from variety of sources such as through landfill or waste water leachate (Ramakrishnan et al., 2015), drug manufacturing effluent (Beijer et al., 2013),