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Mini Review

Carbonaceous Nano Materials for Adsorption of Psychotropic Drugs: A Mini-Review

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ABSTRACT

The increasing demand for psychological drugs due to the stressful modern lifestyle has resulted in elevated concentrations of these psychotropic substances in the environment, posing a threat to aquatic ecosystems. To mitigate this issue, the utilization of carbon based nanomaterials, such as graphene, graphene oxide, and carbon nanotubes, has shown positive potential. These materials possess unique properties, including a large surface-to-volume ratio and tunability, which make them suitable for adsorption applications. This mini review provides an overview of psychotropic drugs, their impact on aquatic life, and highlights studies investigating the adsorption of these drugs on various carbon-based nanomaterials.

Keywords: Psychotropic drugs; Carbon-based nanomaterials; Graphene; Graphene oxide; Carbon nanotubes; Adsorption; Aquatic systems; Environmental remediation

LITERATURE REVIEW

The modern lifestyle has contributed to increased stress levels, leading to a surge in the demand for psychotropic drugs. Unfortunately, the disposal of these drugs has resulted in their accumulation in aquatic systems, posing a threat to the ecosystem. This review aims to explore the potential of carbon-based nanomaterials for removing psychotropic drugs from aquatic environments. Any medication that alters behaviour, emotions, thoughts, or perception is referred to as a psychotropic. It serves as a catch-all phrase for a wide range of drugs, including illicit and prescribed medications. 47 million persons over the age of 18 reported having a mental health issue in 2018, according to statistics from the Substance Abuse and Mental Health Services Administration's (SAMHSA) National Survey on Drug use and Health (NSDH). About 1 in 5 adults in the USA fall into this category. Over 11 million people disclosed having a serious mental disorder. Antidepressants, anti-anxiety medications, stimulants, antipsychotics, and mood stabilisers are the five primary categories of psychotropic drugs. Heroin (3,6-diacetylmorphine, DAP) is a psychoactive drug that is misused by people and societies all over the world, and it has the second-largest proportion of the European Union (EU) retail drug market (28%). Other psychoactive drugs include amphetamine, methylphenidate, cocaine, morphine, and codeine [1]. It is well known that these illegal drugs alter the brain both temporarily and permanently. Additionally, it could result in mental illnesses, physical ailments, and even death [2]. Additionally, just like second-hand smoke, their presence in aquatic environments poses a serious concern to human health, therefore some people who abstain from stimulants are obliged to consider these risky substances. In the meantime, the effects of drug misuse result in the degradation of aquatic and animal life [3]. Increased efforts are needed to create sensitive, eco-friendly, quick, reliable, and selective monitoring systems due to the widespread use of heroin and other illicit drugs as well as their complex toxicological effects. Although Diazepam (DZP) and Carbamazepine (CBZ) are often given medications to treat stress, anxiety, alcohol withdrawal symptoms, convulsions, and epileptic diseases, abuse of these medications is a problem that affects their environmental fate. CBZ and DZP were shown to constitute an environmental risk (RQ) to surface waters when tested using the techniques recommended by the European Medicines Agency (EMA). Yet behavioural or other sub-lethal endpoints, which are important information, were not included in risk assessment studies on CBZ and DZP exposures in water bodies. The

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development of technologies including biological, chemical, physical, and electrochemical procedures for the remediation of pharmaceutical drug-related pollution has been the focus of scientific research for the past 20 years. While some of the technologies have been applied on a large scale in the field or in industry, others are still being studied as pilot projects. Nanofiltration, reverse osmosis, chemical oxidation, bioremediation, phytoremediation, photolysis, catalytic photodegradation, and adsorption are examples of remediation techniques now in use. Although they have considerable potential, electrochemical remediation, mycoremediation, phycoremediation, green Nano remediation, bio catalytic remediation, and integrated techniques are still in the early stages of development. The Sustainable Development Goals (SDGs) placed a strong emphasis on the necessity of clean, safe water for the ecosystem's survival. The development of electrochemical sensors most frequently makes use of carbon nanomaterials with unmatched chemical, mechanical, and electronic capabilities, such as carbon micro/nanospheres, graphene, and Carbon Nano Tubes (CNT) [4]. This mini review provides a general introduction of the psychoactive drugs, issues associated with them and some of studies on the sensing or removal of these drugs from the environment using carbon based nanomaterials which are discussed in upcoming section.

Sensing and removal of psychoactive drugs

As discussed above carbon based nanomaterials are proved to be good candidates as far as electrochemical sensing or the catalysis of the psychoactive drugs is considered. Various studies investigating the adsorption of psychotropic drugs on carbon-based nanomaterials are reviewed. The focus is on the experimental methodologies, adsorption mechanisms, and the efficiency of drug removal. The adsorption capacity and kinetics of different carbon-based nanomaterials are compared. When integrated with electrochemical sensing technologies, heteroatom and transition metal boride-doped carbon nanomaterials provides direct effective sensing platform. However, there is a significant unmet need for accurate and transportable psychoactive drug measurement instruments for applications in environmental science or forensics. Here, a highly sensitive mobile electrochemical sensing technology for the psychoactive substance was created. Building on this, we create a high performance sensor for the detection of heroin by fusing heteroatoms (N) and transition metal borides (WB) in a carbon nanotube. Furthermore, the flexible Screen Printing Electrode (SPE) can now function as a heroin electrochemical sensor because to this. It is significant to note that the experimental findings perfectly fit our suggested model, which generates hybrid nanocarbon layers with various charge densities and a lot of active sites on the surface of the carbon nanocomposites. The viability and sensitivity of the assay are both impacted by the density and diameter of these zones. This method enables real samples from the natural water environment to be analysed in a proof of-concept research, highlighting insights and factors to be taken into account when designing electrode materials and building sensors in the future. Employing heteroatom and transition metal-doped carbon nanomaterials as the active material, we have established a unique analytical platform for on-site monitoring of illegal substances (DAP). The electrical performance and electrocatalytic activity of composite materials were greatly improved by the doping of tungsten boride and heteroatomic nitrogen, which can give additional active sites for a single CNT. The well-known portable electrochemical sensor also exhibits great sensitivity, good linear ranges, stability, and reproducibility. Due to these characteristics, this portable platform may be used to create environmentally friendly monitoring systems and to implement this concept in criminal investigations [5]. DFT analysis was used to study the potential use of graphene, fullerene, and carbon rings as a potential nanosensor for promazine and trifluoperazine. We determined that all of the nanoclusters exhibit chemical enhancement when PME/TPE is applied over CG/CF/CR nanoclusters. The TPE-CG nanocluster exhibits higher adsorption energy and higher charge transfer than other systems as a result of the chemical interactions between the molecules. It is anticipated that a drug delivery system will be able to use PME/TPE pharmaceuticals over nanocluster. Each nanocluster's band gap decreases noticeably upon PME/TPE adsorption. Additionally, the electron-rich and electron-poor sites have been identified using the molecular electrostatic potential. The results of this study demonstrate that PME/TPE is susceptible to nanoclusters being present as a substrate and that CG/CF/CR nanoclusters are suitable for PME/TPE detection. The chemical increase for PME and TPE adsorption on the nanoclusters is confirmed by Mulliken charge analysis. According to the docking investigations, the hydrogen bond interactions and binding affinities can serve as supportive data for additional research. In the assembly of nanocluster-drugs, NLO property rises. PME/TPE with CG/CF/CR exhibit good binding energy and ligand receptor interaction, according to the data [6]. The U.S. Food and medicine Administration has approved the antipsychotic medicine olanzapine (OLZ, 2-methyl-4-(4-methyl-1-piperazinyl)-10H-thieno(2,3-b)(1,5)benzodiazepine) for the treatment of schizophrenia and conditions including alogia, avolition, and anhedonia. It is also useful in treating both the positive and negative symptoms of schizophrenia, such as delusions and hallucinations as well as social disengagement and speech impairment. OLZ has the unusual trait of antagonistic actions on dopaminergic, serotonin, and or adrenergic receptors when compared to other antipsychotics. The major metabolites N-oxide, 4-N-glucuronide, N-desmethyl, 10-N glucuronide, and 2-hydroxymethyl are produced in large quantities after oral administration of OLZ. It is necessary to analyse OLZ in biological fluids using quick, efficient, and affordable technologies due to its potential usage. Electrochemical methods are superior to other analytical methods for achieving this goal. Even though OLZ is an electroactive compound, at bare Glassy Carbon Electrodes (GCE), it exhibits low electrochemical responsiveness and electrode sediment problems. As a result, an advanced electrode material is required for the detection of OLZ in biological fluids and pharmaceutical forms. OLZ is electro-oxidized well because the electrode, compared to other modified electrodes, has a higher surface area. Low detection limit, excellent sensitivity, and selectivity were all characteristics of the developed sensor. The acquired electrochemical performance can be attributed to the nanocomposite's S-CQDs' synergistic effect and the phase stability of the S-Fe_2O_3 NPs.

DISCUSSION

It is determined that S-CQDs/Fe_2O_3 nanocomposite can be very advantageous for practical applications [7]. Chlorpromazine is an antipsychotic medication used to treat psychotic disorders. It lessens the manic phase of a manic depressive episode and reduces agitation, excitement, and other psychomotor abnormalities in individuals with schizophrenia. Additionally, it is given for the management of hyperkinetic states, aggression, and occasionally anxiety and stress. In palliative care, CPZ also functions as an anti-emetic. Chlorpromazine hydrochloride dosages range from 75 to 300 mg per day. Patients with psychosis have even received prescriptions for doses of 1 g or more. Around 1% of a dose of CPZ taken orally is eliminated in urine as an unaltered medication. Therefore, there is still a big need for developing a sensitive, accurate, and affordable analytical method for CPZ detection in pharmaceutical formulation and biological fluids to ensure the quality of preparation process and to provide an efficient and secure medication therapy. Many different analytical techniques have been created up to this point for CPZ determination. In this regard, electrochemical techniques were frequently employed for this goal. For the first time, a nano-composite made of Molecularly Imprinted Polymers (MIP) and Multi Wall Carbon Nano Tubes (MWCNT) was created using the suspension polymerization process. The pharmaceutical Chlorpromazine (CPZ) was used as a template molecule. The hand-designed and -made Screen Printed Carbon Electrodes (SPCEs) were modified using the MIP-MWCNT nanocomposite and the Non-Imprinted Polymer (NIP-MWCNT). Through a three-step process that comprises CPZ extraction from the sample solution, electrode cleaning, and electrochemical measurement, the modified SPCEs were used to determine the concentration of CPZ. After confirming that MIP-based sensors responded to CPZ correctly, the performance-affecting aspects of the sensor were looked at, and the calibration curve was produced under ideal circumstances. The detection limit was determined to be 2.9610^{-10} M. The peak current had a linear relationship with CPZ concentration in the range of f 7.50×10^{-10}-2.50×10^{-7} M ($R^2$0.9956). For the investigation of the repeatability and reproducibility of the sensor, the relative standard deviations were 3.76 and 4.13% (n5) respectively. Finally, it was employed for the CPZ assay in tablet and spiked human urine samples to assess the sensor's capacity to detect the drug in samples with complex matrices [8].

CONCLUSION

In the modern era of rapidly advancing technology, there is a growing fear among individuals of being left behind, resulting in increased cases of mental disorders such as anxiety and depression. Consequently, there is a significant rise in the demand for psychoactive drugs, including legal FDA-approved medications and illegal substances like heroin and morphine. The escalating consumption of these drugs poses a threat to environmental health. To address this issue, carbon-based nanomaterials have been identified as a potential solution for environmental remediation. Various strategies, such as advanced water treatment processes, efficient waste management, and nanotechnology-based solutions, have been proposed. However, these strategies require further refinement and improvement through continued research. It is crucial to prioritize the preservation of mental health to ensure a healthy environment. The interconnectedness of mental health and environmental well-being highlights the need for society to address the underlying causes of anxiety and depression, such as the fear of technological obsolescence. With these we can increase a more sustainable and resilient connection between individuals and the environment, basically granting towards environmental well-being.

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