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Review paper

Conducting polymer functionalized graphene-based electrochemical sensors for sensing pollutants in water

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Abstract

Recent trends in electrochemical sensors based on conducting polymer functionalized graphene for the detection of pollutants in water are highlighted in this review. Graphene has been the subject of a lot of scientific research to be composited with conducting polymers. Researchers are interested in graphene and its variants because they have a lot of good qualities, like good electrical and mechanical properties and very high surface area. With this review, we intend to arouse interest in the important topic of graphene and conducting polymer nanocomposite that is making significant advances in electrochemical sensing, especially for sensing pollutants in water.

Keywords

Composites, voltammetry; sensing properties; water pollution

Introduction

Water is necessary for all living things to survive, although different species use it for different purposes. For example, water is an essential component of respiration for all oxygen-dependent species and serves as a solvent, temperature buffer, metabolic product, and habitat. However, water pollution has become one of the most pressing environmental problems of our time due to increasing industrialization and urbanization. Figure 1 shows the sources of emerging water pollution that may be of concern. The introduction of toxic substances into water bodies (*e.g.*, lakes, rivers, and oceans) results in water pollution, where the substances either dissolve, float, or accumulate and affect water quality. Not only is this harmful to aquatic ecosystems, but the pollutants that leach into groundwater also contaminate domestic water supplies, where water is

used for a variety of activities, including drinking. Therefore, it is important to limit human exposure to contaminants through proper water quality monitoring.

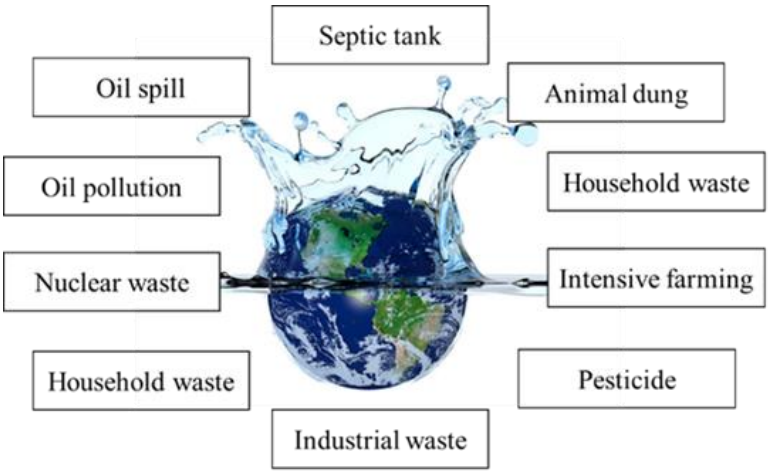

Figure 1. *Sources of emerging water contaminants that could be of concern*

World health organization (WHO) has continuously revised the guideline values for all water quality measures since 1983 (Table 1) [1]. The hazardous substances that accumulate in the human body through water are degraded only slowly. Therefore, limiting human exposure to toxins is critical and should be achieved through comprehensive water quality monitoring. Detection of water contaminants has traditionally been performed with hanging mercury drop electrodes or mercury-modified electrodes, as replacement of the mercury drop is sufficient to restore a pristine surface [2]. However, due to new regulations and the high toxicity of mercury, new alternatives for its replacement are being investigated. There are some reports of work using gold nanoparticles, microelectrodes, and also cathode stripping potential to detect heavy metals. Unfortunately, it is difficult to detect water pollutants using these methods [3,4].

Table 1. *Maximum permissible concentrations for water quality testing according to WHO* [1]

Parameter	Maximum permissible concentration
Antimony	20 ppb
Arsenic	10 ppb
Benzene	10 ppb
Chloramines	3 ppm
Chlorine	5 ppm
Chromium	50 ppb (total)
Copper	2 ppm
Fluoride	1.5 ppm
Lead	10 ppb
Mercury	6 ppb (inorganic)
Nitrate	50 ppm
Nitrite	3 ppm
Selenium	40 ppb
Toluene	0.7 ppm
Uranium	30 ppb

Recently, the electrochemical approach to water contaminant analysis has been gaining popularity due to its ease of use, low cost, rapid analysis, and high sensitivity [5,6]. In the past, electrochemical sensors have been used to monitor oxygen concentration in the industry since the 1950s, when they were first introduced [7]. At that time, the monitoring of hazardous gases and