STUDY OF THE PROPERTIES OF POLYANILINE-BASED NANOCOMPOSITES

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ИССЛЕДОВАНИЕ СВОЙСТВ РАЗЛИЧНЫХ НАНОКОМПОЗИТОВ НА ОСНОВЕ ПОЛИАНИЛИНА

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ABSTRACT

This article provides an in-depth study of the effects and properties of various polyaniline-based nanoparticles. It also examines the different oxidation states of polyaniline and their innovative effects.

АННОТАЦИЯ

В данной статье представлено углубленное исследование эффектов и свойств различных наночастиц на основе полианилина. Также рассматриваются различные степени окисления полианилина и их инновационные эффекты.

Keywords: Polyaniline, electrical conductivity, TiO2, ZnO, Cu2O, graphene, electrical and optical properties, doping, oxidation states, electroactive polymers, innovative applications.

Ключевые слова: полианилин, электропроводность, TiO2, ZnO, Cu2O, графен, электрические и оптические свойства, легирование, степени окисления, электроактивные полимеры, инновационные области применения.

INTRODUCTION

Polyaniline (PANI) has attracted significant attention in recent decades due to its unique combination of environmental stability, electrical conductivity, and ease of synthesis. As one of the most researched conducting polymers, PANI has a diverse range of applications, from electronics to energy storage devices. The ability to modulate its conductivity by changing its oxidation state or through doping makes PANI an excellent candidate for use in flexible electronics, sensors, batteries, and supercapacitors.[1]

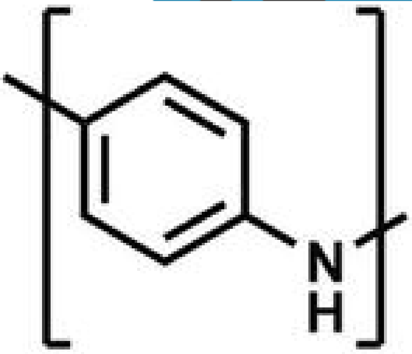


Figure 1

Polyaniline (PANI) is one of the most promising materials among conductive polymers, which can be used to obtain anticorrosive coatings, energy conversion devices, batteries, sensors of various designations, and electrochromic devices. PANI is easily synthesized from aniline, it forms a complex structure with many organic and non-organic compounds, which allows the cell to grow in size, and its characteristics are obtained by obtaining different compositions. When aniline is oxidized, it forms 3 different types of polyaniline. They perform different functions. The polyaniline we need is emeraldine, or emerald salt.[2]

Molecular structure of polyaniline (PANI).

The type of PANI that has been investigated the most is the EB type. PANI is available in a range of colors.[4] Leucoemeraldine is white or colorless, emeraldine is blue structurally and green as a salt, and pernigraniline varies from blue to violet. EB can be made conductive by using protonic acids and oxidative doping methods, however, this method may not work for LEB and PAB.

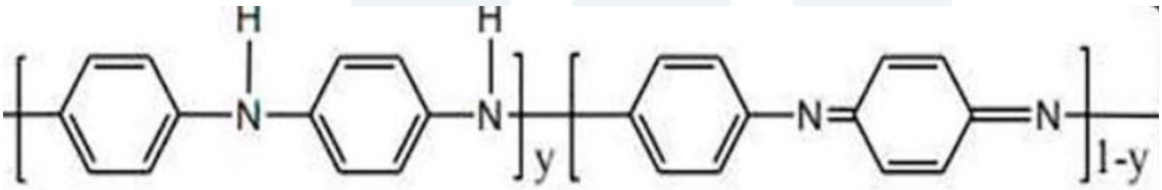
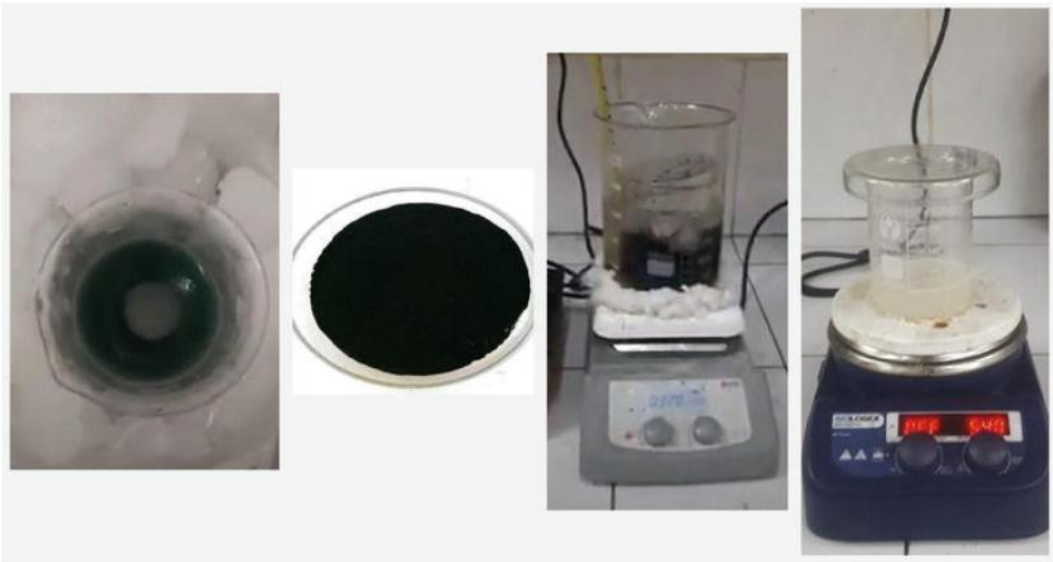


Figure2

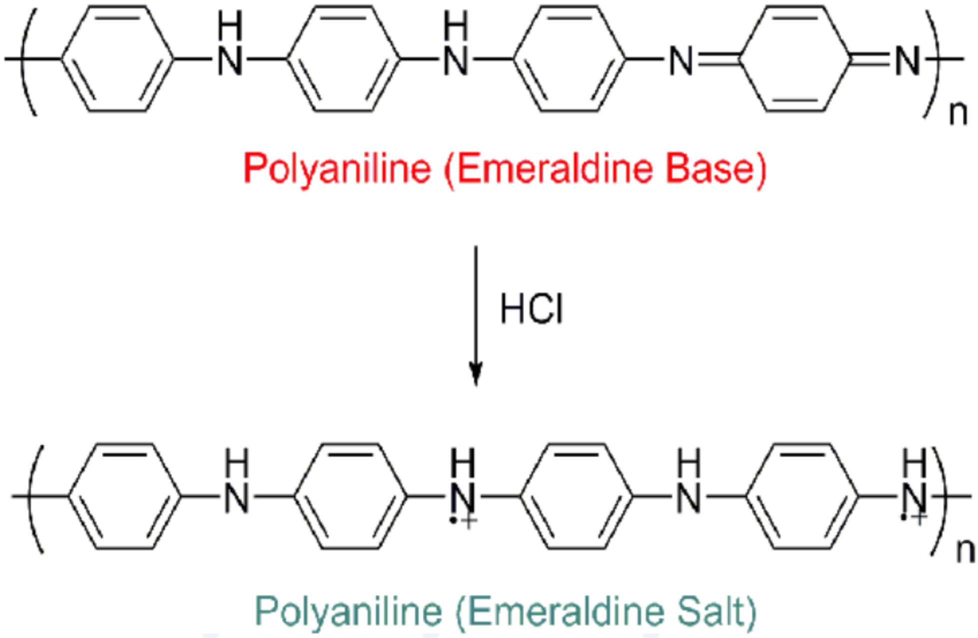


Emeraldine PANI	powder of emeraldine PANI	pernigraniline PANI	Leucoemeraldine PANI

Basically, polyaniline is doped to increase its electrical conductivity and its properties are enhanced. To produce polyaniline from aniline, (NH4)2S2O3 polyaniline is produced by adding an oxidizing agent. To increase its electrical conductivity, it is doped using HCl acid.[6]

Protonic acid doping

The most common doping agents for polyaniline (PANI) are protonic acids, which provide protons (H+) that interact with the polymer backbone. Protonic acid doping significantly enhances the electrical conductivity of PANI by converting it from its insulating form (emeraldine base) into the conductive emeraldine salt form. The protonation of the polymer backbone leads to the formation of positively charged sites, allowing for charge delocalization and facilitating electron transport.[10]



To synthesize emeraldine hydrochloride (PANI HCl), aniline (4.56 ml) was first added to 50 ml of a 1M HCl solution, and 50 ml of an aqueous solution of ammonium persulfate containing 11.4 g of the substance was added dropwise with constant stirring. The reaction was carried out in an ice bath (at a temperature of 0°C) for 60 minutes and then, to complete it, Afterwards, to complete the reaction, it was kept at room temperature for 24 hours.[12] During this time, the color of the solution changed from colorless, first to blue, and then to dark green. The resulting polymer was washed several times with distilled water and dried at 80-90°C to constant weight. To synthesize compositions of PANI emeraldine salt with ZnO (PANI HCl/ZnO), 4.56 ml of aniline were added to 50 ml of 1M HCl solution; after the formation of a homogeneous solution, ZnO nanoparticles (1.0125 g), obtained according to the method [5], were added to it in portions with vigorous stirring for 30 minutes. Next, 50 ml of ammonium persulfate solution containing 11.4 g of the compound was added to the resulting suspension. The reaction was carried out in an ice bath (at 0°C) for 60 minutes and then kept at room temperature for 24 hours to complete the reaction. The solution's color changed from colorless, first to blue, and then to dark green. The resulting polymer was washed several times with distilled water and dried at 80-90°C to constant weight. The IR spectra of PANI and its complexes were recorded using a Cary 640 FTIR spectrometer (Agilent, USA).[15]

CONCLUSIONS

This chapter encompasses the work done on PANI nanocomposites/nanostructures for the removal of heavy metal ions and dyes from aqueous solution. Adsorption technology was widely studied due to its flexibility in design and operational simplicity. The use of PANI nanocomposites as adsorbents has been investigated for adsorption of pollutants owing to their inherent properties such as high surface area, environmental stability, easy preparation and good water dispersion. The literature showed that a variety of morphological structures can be obtained, which depend strongly on the method of synthesis, and thus have various effects on the adsorption of the pollutant.[14] For example, PANI based nanocomposites and nanostructures are preferable prepared via in-situ polymerisation. It was demonstrated that the pH, contact time, temperature, adsorbent dosage, concentration, nature of adsorbent and the presence of competing ions have an influence on the removal efficiency of nanocomposites. Hence, optimisation of adsorption parameters has been studied for the removal of heavy metals such Cr(VI), Hg(II), As(V), Co(II) and dyes such as CR, MB, MO, MG and RB5 from wastewater using various PANI nanocomposites and nanostructures.[17] Overall, these nanocomposites display improved removal efficiency towards heavy metals and dyes adsorption. Hence, data in this chapter provides insight into PANI based materials for potential use as economically valuable adsorbents for the removal of dyes and heavy metals ions from wastewater.[16]

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