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A REVIEW ON SYNTHESIS OF CONDUCTING WITH POLYANILINE RICE HUSK ASH SILICA NANOCOMPOSITES AND APPLICATION

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Abstract

Nanostructures have a prominent place in Nanotechnology since more space can be used in different applications. In the past decades, a class of conductive polymers became famous because of their mechanical and electrical properties. Polyaniline is a conductive polymer popularly known as an environmentally stable and highly adjustable polymer given in an application form of powder, membranes or loose fibres. Low-cost polyolefin and large-scale production are widely used in broad applications. Rice Husk Ash (RHA) is the by-product of rice mill industry considered as waste material. Many types of research focused on RHA targets the high contain silicate to be converted to silica after Rice Husk (RH) pyrolysis undertaken in a furnace with the temperature at (800˚C). The sol-gel technique offered a simple route in producing silica from RHA, where 3-(chloropropyl) triethoxyscilane (CPTES) is used to convert the RHA into high-quality silica. Polyaniline/Rice Husk Ash Silica Nanocomposite (PANI/RHACCl (SiO_2)NCs) are prepared via chemical oxidative polymerization and can be used in various applications such as supercapacitors, pseudocapacitors, coatings, metal absorption, chemicals, encapsulation of light-emitting organs, proton exchange membrane, diffusion membrane, devices Sensor, Nanoelectronic flexible devices, as well as drug delivery.

***Keywords**: Nanostructures, Nanocompsite, silica, Rice husk Ash, Polyaniline, conductivity.*

Introduction

Recently, the development of Nanotechnology, Nanoscience and Nanomaterial have received more attention following its optical, mechanical, electrical and chemical properties [1], where it can be used to detect highly sensitive biological species. The various materials used in the preparation of Nanoparticles, Nanowires, Nanotubes and Nanocomposite are metals, semiconductors, silica and polymers [2]. Applications of these materials include optical and electronic devices as well as medical and biochemical fields. The manufacture and use of these materials have been reported for high-density arrays [3]. Silica-based NPs perform robust inorganic materials including a high

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specific surface area, a (3D) structure with highly open spaces interconnected including, in particular, a large concentration of silanol on the surface. It makes it easy to place functional groups such as amino, mercaptos and carboxyls on the surface of silica NPs to bind biomolecules further. Due to its promising properties, such as strong biocompatibility, thermal resilience, electro-active in aqueous media, non-toxicity, and suitability for several surface immobilization mechanisms, silica-based NPs have been found an outstanding substratum ideal for many biomolecule conjugations, including biotin-avidin, antigen-antibodies, peptides, enzymes, and DNA [4]. The resultant Nanocomposite determines both the compatibility and the suitability of the carriers towards the analyte. It provides new opportunities for its effective application in a wide variety of fields [5]. In 1976, conductive polymers were found via the first derivative with acetylene in the mid-1970s, which was mistakenly set up by Shirakawa [6]. It is capable of electrical conductivity; however, not soluble in the sun. Further tests with other recognized conjugated polymers culminated in the possibility that its effectiveness become conductive due to steroids. Since 1976, a variety of conductive polymers have been focused by various researches, including polypyrrole, polythiophene and polyaniline. The value of polymer leadership is shown by the 2000 Nobel Prize in Chemistry given to MacDiarmid, Shirakawa and Heeger for the discovery and development of conductive polymers [7]. Coherent polymers such as polyaniline (PANI), polypropylene (PPy), polyethylene and their derivatives are beginning to create a promising new field in materials science and engineering [8]. There has been increasing interest in Nanocomposite polymers in the last two decades due to its unique electronic and optical properties as well as their possible uses in numerous advanced devices ranging from organic electronics, sensors, electrodes, actuators, photovoltaic and electro-chromatography [9]. PANI is the most desirable conductive polymer following its unique features such as low cost, strong environmental resilience, reasonable electrical conductivity, fast synthesis and fascinating nitrogen-related oxidation and reduction properties [10]. A distinctive characteristic of PANI compared to other converging polymers is the reversible oxidation and reduction properties that allow full control of electrical conductivity via proton and doping [11]. This study relies on Rice Husk Ash silica RHA (SiO_2), which produces a large area, high low cost, and favourable thermal stability. Despite silica insulation, SiO_2 input to PANI demonstrated to improve mechanical PANI characteristics, increase electrochemical capacity, super-capacity, improve thermal and electrical conductivity as well as reduce degradation during the charging and discharge process.

Polyaniline (PANI)

Recent areas of growing science and technological interest include polymer structures with unusual properties, providing the ability to synthesize a broad array from exciting new technologies, which consists of a broad spectrum from optical, electrical and magnetic characteristics. Technological applications depend crucially on the reproducible control of the molecular, including the supramolecular architecture from the macromolecular via a simple methodology from organic preparation [12].

Polyaniline (PANI) is one of the polymers among the conductive polymers whose synthesis requires no specialized equipment or precautions. Conducting polymers typically exhibit extremely reversible redox activity, including visible chemical memory. Also, it has been regarded as accessible new materials to Nanofibers manufacturing and can be applied in many applicability. The properties of conducting polymers are highly dependent on the doping degree, degree of protonation, dopant ion size and water content. The PANI is prepared either through electrochemical oxidative polymerization or through the chemical oxidative polymerization mode [13].

The Polyaniline emeraldine base (PANI EB) layer consists of an electric insulator made up from two amine nitrogen atoms accompanied by two imine nitrogen atoms. Two separate doping processes turn the PANI (emeraldine base) into a conductive form, known as protonic acid doping and oxidative doping. Emeraldine base protonic acid doping refers to the protonation from the imine nitrogen atoms in which there is no sharing of electrons [14].

Structure of Polyaniline:

The protons, deprotonating and various physic-chemicals are among the properties of PANI caused by this presence of the -NH- group [15], as shown in Figure 1. Green & Woodhead [1]. Were the first to portray PANI as a series of aniline, where the particles are paired face to face in the paragraph position of the aromatic ring [16]. The authors suggested that the PANI have an octagonal linear structure and has a chemically flexible range (NH) in the polymer chain surrounded by the vinyl ring on one side [14]. The diversity in the physical and chemical characteristics of PANI is due to the NH group. Among many potential oxidation states, emerald salt oxidized by 50% shows the electrical conductivity [17], which is the manufacture and characterization of thin films with polymer conductions with gas detection applications. In conjunction with related findings obtained with other specific polymers such as PPy and PTh, PANI induces a rapid increase in experimental investigations in molecular and electro-optical structure process as well as kinetics fair application [18-19].

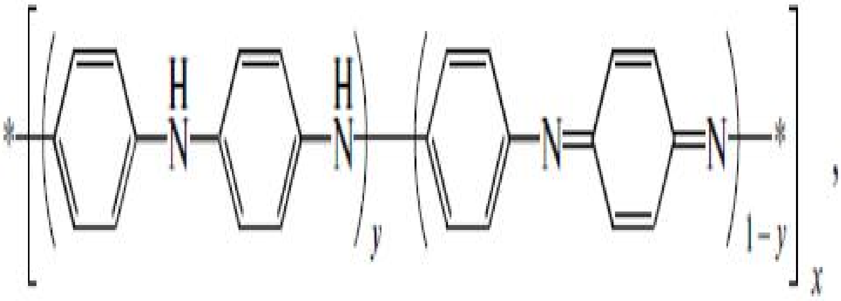

Fig .1. General structure of PANI [3] [4]

Green & Woodheap [1]. Were the first to describe the PANI as a series of aniline molecules coupled face to face in a vertebral position of the aromatic ring, where the authors proposed a linear octet structure to the PANI [20]. The Polyaniline, a phenyl-based polymer, contains a chemically flexible group in the polymer chain surrounded with vinyl rings on both sides. The diversity in the physical and chemical properties from the Polyaniline does trace to the NH group. Among many possible oxidation states, emeraldine salt is oxidized by 50% of the state, which shows the electrical conductivity [20-21]. Polyaniline is made up of monomer units composed from reduced (y) as well as oxidized (1-y) blocks: where ($0 \leq y \leq 1$) [17].The polymer's redox state is calculated by the value of y and may continually range from zero to unity. At $y = 1/2$, polyaniline appears in the form of emeraldine $y = 0$ corresponds to the fully oxidized form of pernigraniline, while $y = 1$ corresponds to the entirely reduced form of emeraldine, leucoemeraldine and pernigraniline, either as salts or as bases [16] [22]. Together with related findings obtained with other related polymers such as PPy and PTh, PANI has triggered a rapid rise in experimental investigations into the compositional process and kinetics, molecular structure and photoelectric as well as accredited application [23].

Chemical Synthesis of polyaniline (PANI)

Within the literature across the decades, there are many studies of PANI regarding the structure as well as constitutional nature about aniline polymerization. The polyaniline is the most common synthesis that includes oxidative polymerization, in which polymerization and doping arise concurrently, performed either electrochemically or chemically. Electrochemical processes tend to produce inferior to chemical yields [24].

Synthesis from PANI with chemical oxidation requires the use from either hydrochloric or sulphuric acid as the oxidizing agent in the aqueous solution with the presence of ammonium persulfate. The crucial role of the oxidant is to detach a proton from an aniline molecule, without creating a close bond of coordination by either the substrate/intermediate or the final component (Figure 2). The smaller volume of oxidant is, therefore applied to prevent oxidative degradation from the formed polymer [4].

With the introduction from monomer to the chain end, the polymer chains continue into a redox cycle through the chain as the aniline. At the initial stage of polymerization, the large concentration about a heavy oxidant $(NH_4)_2S_2O_8$ allows the rapid oxidation of oligomers as well as polyaniline and their presence in the oxidized state [20].

PANI is often manufactured either including a natural oxidant (natural route) or by electrochemistry through aniline oxidation. Certain original synthesis is discussed, such as polymerization by steam, autocatalytic polymerization or polymerization by reverse emulsion. Three reactants are needed for chemical synthesis, known as aniline, an oxidant, and an acidic medium (aqueous or organic). The more popular acids are, for example, hydrochloric acid (HCl) and sulfuric acid (H_2SO_4). Other suggested antioxidants are ammonium persulfate ($(NH_4)_2S_2O_8$), potassium dichromate ($K_2Cr_2O_7$), cerium sulphate ($Ce(SO_4)_2$), sodium vanadate ($NaVO_3$), potassium ferricyanide ($K_3(Fe(CN)_6$), potassium iodate (KIO_3) as well as hydrogen peroxide (H_2O_2) [25].

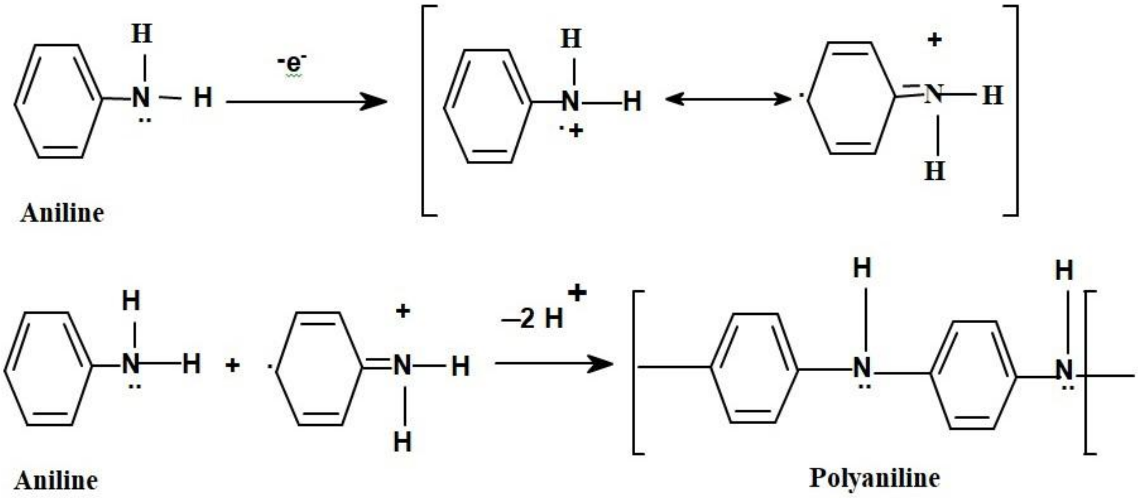

Figure 2: Homo polymerization of PANI [25].

Polyaniline of conductivity:

As stated below, PANI is categorized into three oxidation cases, known as emeraldine, leucoemeraldine, and pernigraniline, which vary in chemical as well as physical characteristics [6][23]. Only emeraldine green protons have conductivity at the semiconductor stage from (10^0 S cm^{-1}) where several orders about magnitude are higher from modern polymers ($< 10^{-9}$ S cm^{-1}) but are less than traditional metals ($> 10^4$ S cm^{-1}). When interacting with alkaline solutions, PANI protease becomes a non-conductive emeraldine base (see Figure 3) [26].

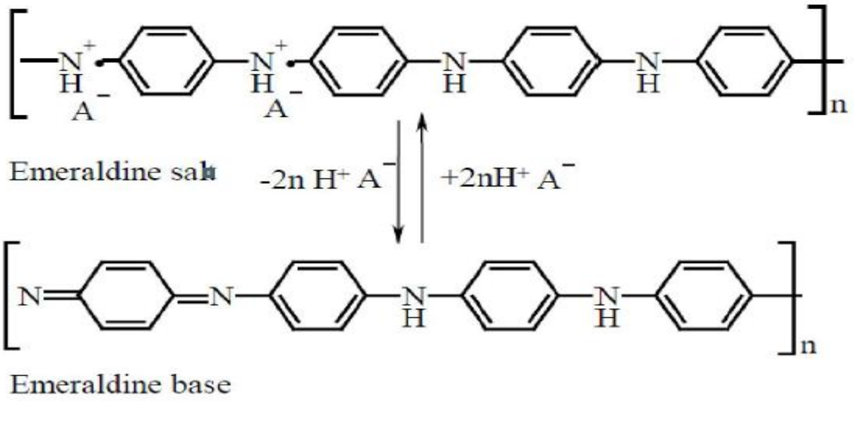

Fig .3 Emeraldine salt (ES) is protonated to emeraldine base in the alkaline form. A-is a random molecule, for example, the chloride [9][3].

PANI conductivity may be modified by steroids that span a vast spectrum depending on the steroid stage ($< 10^{-12}$ to 10^{5}) S cm^{-1}, implemented in applications such as sensors and actuators [4][14]. The other uses are based on adjustments in the physical as well as chemical characteristics from the polyaniline (PANI) that arise in response to different external stimuli. Many applications are based on a mixture of conventional electrical semiconductor properties with polymer features, such as the production of "plastic" microelectronics, and electromechanical systems. Therefore, it is of fundamental importance to develop the physical properties of PANI, which represent the conditions of preparation. The Polyaniline (PANI) and poly (ethylene deoxy-thiophene) (PEDT) have slightly greater conductivity and durability with reduced absorption relative to polythiophenes alkoxy substitution. It is believed that this is due to the toxicity mechanism in such compounds is specific, does not require any improvements in the absorption peaks and contributes to a small reduction in near-infrared absorption levels below 0.6 eV [21]. Such medium-stability cations decrease during the polymerisation process, and the additional radical coupling reaction leads to the formation of green polyaniline. Such medium-stability cations decrease during the polymerization process, and the additional radical coupling reaction leads to the formation of green PANI [21].

Interconversion of various PANI oxidation states (redox procedure):

The monomeric aniline oxidation, either electrochemically or in acid solution, results from insoluble polymers in at least three independent oxidation states. In that sense, in 1985, Alan MacDiarmid and his collaborators wrote a groundbreaking article on this matter Fig.4.Various possible oxidation states of PANI.

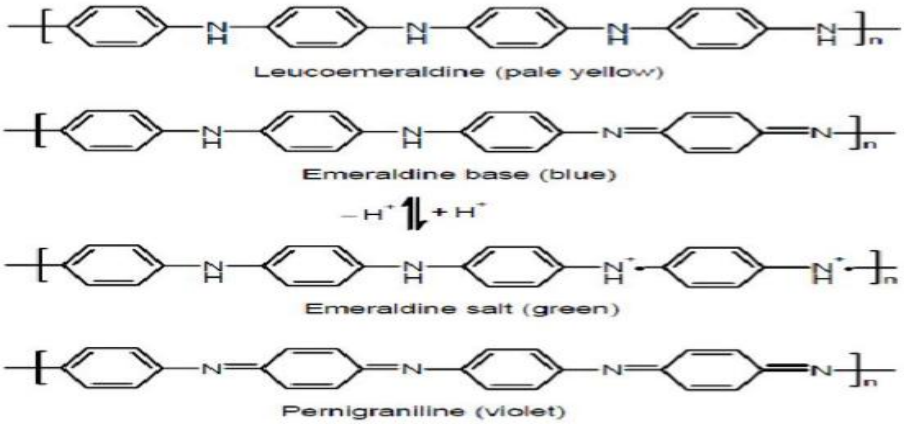

Fig.4. Diverse potential PANI oxidation states [22]

The disparity in the structure of PANI amine and imine fragments produces many oxidation states of this substance varying from entirely reduced leucoemeraldine to completely oxidized pernigraniline states as seen in Fig.3. The different types of PANI can conveniently be translated into one another using clear redox methods (Fig. 5) and Table 2 [28][24].

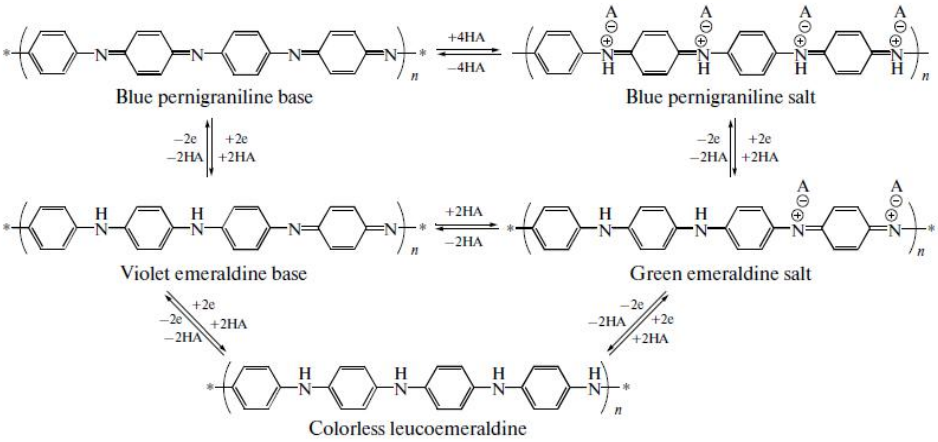

Fig.5. Interconversion of different oxidation states of PANI (redox procedure) [22].

Table 2. The different forms of PANI[10].

Type of form	Name	Colour	Conductivity S cm^{-1}
Reduced form	Polynigraniline base	Blue	$<10^{-5}$
	Polyemeraldine base	Blue	$<10^{-5}$
	Polyprotoemeraldine base	Transparent	$<10^{-5}$
	Polyleucoemeraldine base	Transparent	$<10^{-5}$
Oxidized form	Polypernigraniline base	Purple	$<10^{-5}$
	Polyemeraldine salt	Green	~15

The conductive type of PANI is a polyemeraldine salt or polyemeraldine proton with a green colour and conductivity of about 15 S cm^{-1}, while the conductivity of the polyemeraldine base is about 10^{-5} S cm^{-1}. Note that the metal has a conductivity of around 10^{3} S cm^{-1} [29].

Silica Nanoparticles

The silica (SiO_2) is the name given to a group of minerals, which consists of silicon (Si) and oxygen (O_2), the two most abundant elements into the shell of the earth. The silica usually presents in crystalline form, occasionally in the amorphous state [30]. It consists of one silicon atom, including two oxygen atoms resulting in the SiO_2 chemical formula. Silica leads to the Information Technology (IT) of today that is being used in electronic plastics and offers the raw material for silicon chips. Silica with the chemical formula SiO_2 is most often encountered in nature as quartz, which constitutes more than 10 per cent by weight of the crust of the planet [19]. In recent years, the increasingly emerging fields of nanotechnology and the innovative methods used to produce, manipulate and use Nanomaterial's have drawn significant interest and opened up an exciting age of bio-analytical, biotechnological and biomedical applications [31]. A burst of scientific activity is centred on Nanoparticles (NPs) synthesis and functionalization due to their featured physical (structural, mechanical, magnetic, and optical) chemical (catalytic), and electrochemical properties [32].

Rice Husk Ash

The Rice Husk Ash (RHA) is a fibre dependent on recyclable cellulose. Rice is cultivated in over 75 nations [33], where the world rice product amounts to 400 –545 million metric tons per annum, more than 10 per cent of which is a husk. Due to the high silica distribution within the husk, it makes business sense to use the free raw material [34].

RHA comprises nearly 20 per cent silica and can be processed and used in other fields of industrial silica [35]. Rice husk is made of 18% pentose, 20% powder, 22% lignin, 38% cellulose and 2% other organic materials, as shown in Table 3. Burning rice husk contributes to gas emissions that affect the environment; hence, attempts were made to cook the husks at low-temperature heat. White ash, which is porous silica with the particular large region of the surface, can be produced while cooking the rice husk. There is more than 95% silica in RHA, each earned at 800°C. This can be seen as 95% of silica ash consists of SiO2. My samples are collected from a rice mill in Al Warka city in Al Samawah, Iraqi [36].

Table 3: Chemical composition of RHA after burning out at (700-800)°C for 6 h [14].

Oxides	Component expressed as RHA%
SiO_2	94.95
P_2O_5	0.74
MgO	0.90
Na_2O	0.25
CaO	0.54
K_2O	0.94
MnO	0.16
TiO_2	0.02
Fe_2O_3	0.26
Al_2O_3	0.39
Loss on ignition at 700 °C	0.85

Structure of silica preparation from Rice Husk Ash

Biogenic Silica

Silicon (Si), available everywhere in large quantities as the second most common ingredient in the Earth's crust after oxygen (O), is released into the soil in biological or chemical ways. The chemosphere plants give a significant contribution to the biogeochemical cycle of silicon [37-38]. We extract silicone from surface water in the form of water-soluble silicon acid (H_4SiO_4), which is polymerized from precipitated amorphous silica (SiO_2), often in close proximity to the transpiration pipe [39]. Oxygen returns to the soil after plant death, which then decays to produce humic acid that enhances the soil weathering cycle. Microbial processes, including spores, bacteria, and actinomycetes, frequently occur in the soil to cycle SiO2. Thus, plants and microbes, through their dynamic interplay with soil minerals, give a significant contribution to the global silicon cycle. Silicon (Si) is generated predominantly in amorphous hydrated silica (SiO_2) by (5 –150) per cent H_2O) plants in the form of phytoliths [40- 42] [35].

Silica (SiO_2) Modification

Modification of the composition of silica has earned considerable coverage. This process enables researchers to monitor and modify the composite material's chemical and technical properties [5-6][40]. The modification of the silica surface is essential to the synthesis required to synthesize compounds with many specific characteristics. This may be ideal for the preparation from limited heterogeneous catalysts, Nanostructured silica products, as well as liquid crystals. The silanol groups at the surface of silica play a significant function during a surface modification with the alkylsilane. As the temperature increases, the groups of silanol are dried on the silica sheet [41]. The constant temperature rise results in the drying of the silanol groups, contributing to the forming of the siloxane bond. Modification of the silica is often achieved using organic molecules to enable the coating. Celylate agents at a silica surface associate chemically by a free silanol group. Coccyxylane silicate influences typically exist in the usual formula $(RO)_3$ Si-R*, where R is ethyl or methyl groups, while R* is a carbon n-propyl chain comprising final functional groups such as halogen, amine, sulfur, or any combination.

Adjusted Silica utilizing a cellulite factor is one of the best options for incorporating simple variations using a fixed pendant chain. Through this process, one of the main benefits of freezing functional groups on Silica is to render the organic functional group immune to the removal of the surface through organic solvent or different liquids [42]. Through exposure to immersive centres, it also offers strong thermal and aqueous stability. There are two methods for immobilizing agents at Siles. The first approach is to react with the ligand complex to the silylating agents, and then freeze the resulting ligand in a heterogeneous reaction with the pre-formed Silica as in Fig. (6a). the second technique is to handle post-polysiloxane as (Fig. 6b) with the complex group. Hundreds of scholars have researched the two approaches thoroughly. It has been noted that these two approaches recorded long preparation times and the use of hazardous chemicals contributing to inadequate preparation strategies, as mentioned in the following [43] [47].

Materials and methods

Raw materials

All chemicals applied were AR grade or of high purity used directly without further purification, which includes sodium hydroxide (99%), 3-(chloropropyl) triethoxysilane (95%), and nitric acid (95%). The rice husk (RH) was collected from a rice mill in Al Warka city, Iraqi.

Amorphous Silica Extracted from Rice Husk

Washing of Water/Leaching Acid

A substantial amount of rice husk was taken and added into 1000 ml of HNO_3, placed in the magnetic stirrer plastic bottle at room temp for 24 hours [37]. Washing has been used to extract tiny quantities of minerals from the rice husk. The shell was washed vigorously and carefully using HNO_3 before washing reached a pH of 7. It was then dried for 6 hours in an oven at (90-100°C) [38 -39].

Rice Husk Pyrolysis

Pyrolysis of the rice husk is performed in a muffle furnace. A substantial amount of acid-washed rice husk was placed in a crucible and put at a temperature of 800°C in a muffle furnace for 6 hours. The sample was then allowed to cool down after shutting off the furnace [38]. The sample is extracted after cooling, known as HNO_3 acid-washed rice husk, as displayed in Figure 6.

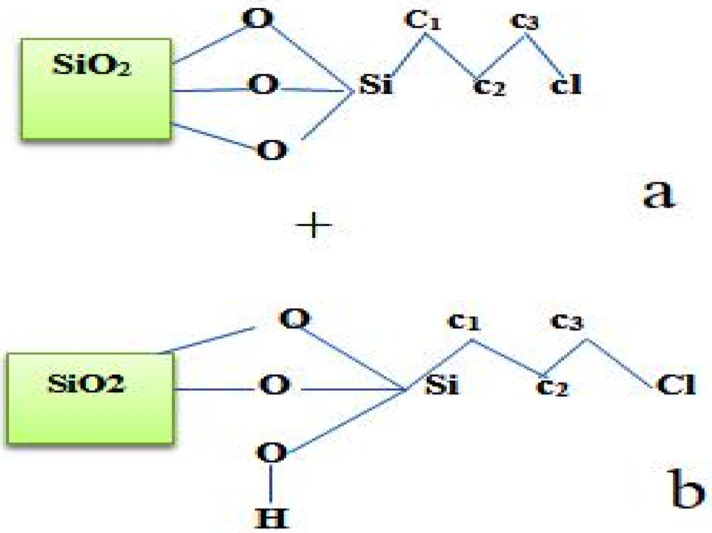

Fig.6. Simple reaction sequences and potential structures for RHACCl as proposed by FTIR. (A) Three siloxane bonds to silica, (b) two Siloxane links to silica [37][40].

Extraction of Amorphous Rice Husk Ash Silica

Separation

4.5 g of rice husk ash is taken and added to 350 ml, 1M of NaOH solution and heated up for (1-2) hours on a magnetic stirrer cum heating plate with continuous stirring at 25°C, which yields a dark-brown alternative. The solution is then treated with a filter paper followed by refrigeration. Figure 7 illustrates this process, which yields a smooth and glassy filtrate.

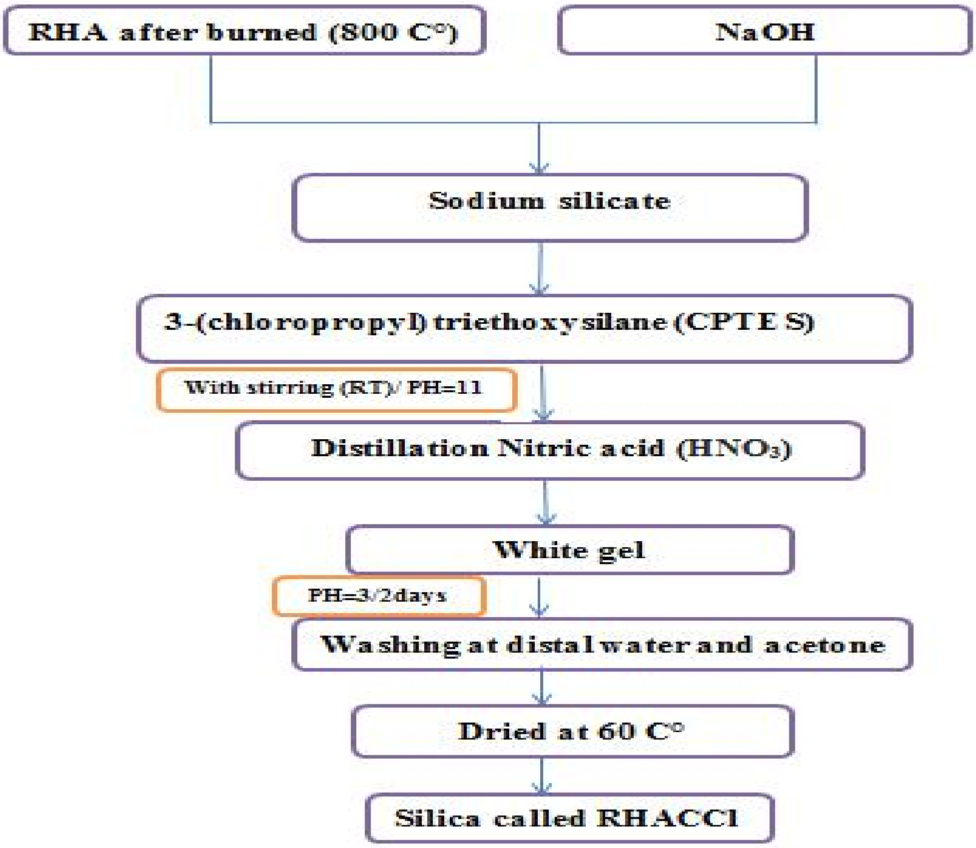

Fig .7. Synthesis of PANI/ RHACCl (SiO_2) Nanocompsite.

Synthesis (Polyaniline) Rice Husk Ash (Silica) Nanocompsite (PANI /RHACCl) NCs

In this paper, we developed an efficient method for the synthesis of conductive PANI/RHCCl (SiO_2) Nanocomposite. The suggested method has great potential in the commercialization of technology, which could be easily applied in industries. The proposed method is secure, effective, and able to achieve superior results in comparison with the state of art methods. The PANI/SiO_2 Nanocomposite are successfully prepared by oxidative polymerization of polyaniline in the presence of SiO_2 Nanoparticles. The PANI/RHACCl (SiO_2) Nanocomposite are synthesized in chemical oxidative polymerization method of aniline in the presence of silica Nanoparticles preparation (polyaniline (PANI) / (RHACCl (SiO_2) NCs) with great interest because of the large surface area that allows the rapid distribution of particles in the structure. There are several ways to prepare compounds of Nanocomposite for various conductive polymers with silica. The synthesis of Polyaniline /Silica (PANI/SiO_2) was carried out by adding of PANI to RHACCl in toluene and triethylamine (Et_3N). The Et3N is used as a deprotonating agent to increase the efficiency of the reaction and also to trap the HCl released during the reaction. The reaction mixture is refluxed at 120˚C in an oil bath for 48 hours. The solid phase was then filtered and washed with HCl acidic distilled water followed by ordinary purified water. The solid sample was then dried at 120˚C for 48 hours. Finally, it was ground to produce fine powder, labelled as RHACCl.

Fabrication Methods and application of polyaniline – silica Nanocomposite

The following table summarizes several methods of preparations and various advantages, as displayed in Tables 4 and 5. The summarized information focuses on the technique of fabrication that includes chemical polymerization, in-situ oxidation polymerization, emulsion polymerization and the sol-gel method. The sizes of PANI- SiO_2 Nanocomposite are also summarized, which indicate the enhance properties of PANI- SiO_2 Nanocomposite such as enhanced mechanical properties, thermal stability and electric insulation or conductivity, optical clarity, and the surface hydrophobic. The supercapacitor properties of PANI-SiO_2 are one of the new research trends, where the different concentration of Nanoparticles can have drastic properties enhancement of PANI-SiO_2 Nanocomposite. Table 2.2 focuses on PANI-SiO_2 Nanocomposite application such as potential supercapacitor device.

Table 4: Silica types with its advantage, structure, polymer Nanocomposite and the techniques.

Silica types Nanocomposie	Advantage	Structure of the Nanoparticle	Polymer	Techniques	Refs
PANI/M-SiO_2	Improve PANI mechanical properties, increase its electrochemical capacitance, and reduce degradation during the charge–discharge process.	(23 nm)	PANI	chemical polymerization	[45]
Aniline- silica	Exhibit enhanced mechanical strength, thermal stability, thermal and electric insulation, optical clarity, and surface hydrophobic properties in comparison to Nanocomposite membranes	__________	Polyaniline	insitu oxidation polymerization	[25]
polymer/silica	Sorbents for cadmium	(30 nm)	polymer	emulsion polymerization	[46]
silica-polyaniline core-shell	Electrical conductivity and mechanical properties.	(240 nm) in diameter	PU/Polyaniline	_____________	[47]
Polyaniline -silica	Used as electro rheological fluids showing higher yield stress, higher polarizability and faster response to electric field compared	___________	Polyaniline	Chemical oxidative polymerization	[19]
MSNPs/PANI	Improves their properties and thermal stability	(3.3 nm) and (4.2 nm)	Polyaniline	Chemical oxidative polymerization	[48]
PANI.DBSA/SiO_2/CB	Results in hybrid particles with the smaller size and higher conductivity	(50–130 nm)	Polyaniline	Emulsion polymerization	[49]
PANI/SiO_2	Improve the mechanical, tribological, and electrical	__________	Polyaniline	Chemical oxidative polymerizations method	[4]
polymer/silica	Improve mechanical properties and thermal stability	______________	polymer	Insitupolymerization and the sol-gel process	[50]
Aniline-modified mesoporous silica (AMS)	Improve the mechanical, thermal, optical and barrier properties	(2–10 nm)	polyaniline	sol-gel	[25]
Polymer/Silica	Improve the mechanical, thermal, optical properties	less than 100 nm	Polymer	________	[51]
Silica/Polystyrene/	Approached semi conductive	__________	PS/PANI	sol-gel	[52]

Polyaniline	materials	____			
($PANI/SO_2$)	Improved cyclic stability	(50 nm) in diameter	Polyaniline	Polymerization	[53]
PANI/silica	High electrical conductivity	(12 nm)	Polyaniline	situ chemical oxidative polymerization	[54]
Silica/PANI	High electrical conductivity and large surface area	(from 18 to 130 nm)	Polyaniline	__________	[55]
phosphoric acid doped/PANI/silica	Improve thermal stability, dielectric properties, temperature dependent resistivity and electrical conduction	(20−30 nm)	polyaniline	Polymerization	[56]

Table 5: Some application of PANI-RHACCl (SiO_2) Nanocomposite.

NO	Polymers / silica Nanocomposite	Application	Reference
1	$PANI/SiO_2$	supercapacitor	[6][57][58]
2	SiO2/PANI	Uptake of metals.	[59]
3	$PANI/M\text{-}SiO_2$	Electrochemical	[60][50]
4	MSNPs/PANI	Pesticides	[61]
5	PANI/SiO2	Used as the adsorbent to remove EPs such as AMX	[62][61]
6	Polymer/silica	Biomedical(drug delivery)	[2]

Applications of Conducting Nanocomposite

Due for attention to their potential in boosting mechanical, electrical and conductivity properties, thus exhibiting different unique features, the silica/polymer Nanocomposite gained immense interest in modern industries. Such Nanocomposite are used in several other applications than plastics and rubber insulation, such as numerous resistive and hardened fire coatings, sensors, electrical devices, ultra-membranes, flammable materials, optical devices, electronics and optical packaging materials, photoresist materials, photoluminescent film, ultra-reverse-membranes, sensors, metal absorption compounds, etc. The different morphologies of these Nanocomposite display particular unique and enhanced properties compared to the normal Nanocomposite, hence providing many unexplored applications such as catalysis and coatings. Some of the technologies are discussed as follows.

Layers/Coatings

The hybrid coatings see the mix of polymer strength and inorganic content hardness. Compared with old coatings, they usually exhibit improved resistance and adhesive strength. When acrylates are reinforced with Nano-silica particles, they form Nanocomposite acrylate materials which exhibit superior scratch and wear & tear resistance. These coatings have a range of uses on structures, such as wood, fibres, etc. Compared to Nanocomposite, they display increased rubbing resistance in comparison to silica nanoparticles. Since of these outstanding properties, these composites of Nanohybrids are applied coats for flooring. Formed of such polymer Nanocomposite, As these polymer Nanocomposite may be generated in various configurations, they are used in the creation of films that are random with better abrasion resistance due to inorganic Nanoparticles in the polymer[44][19].

Supercapacitors

Due to their high-power capacity, comparatively lower energy density, reversibility, long cycle life and low effects on the climate, supercapacitors have gained much publicity in these years. There are usually two different forms according to their function for load handling. The electrical double-layer capacitance (EDLC) type produces capacitance from the separation of charges at the electrode/electrolyte interface, whereas the second type pseudocapacitance produces capacitance from Quickly Faradaic reactions in the electrode content, Therefore, it is critical to use electrode materials with reasonable conductivity and broad specific surface areas in EDLCs, and excellent conductivity in pseudocapacitors with increased power and strong load-discharge kinetics[63-64][6].

Sensing Platforms

Silica-based PANI Nanocomposite is often used as sensing platforms due to a strong electrocatalytic operation, high specific surface area, outstanding stability and low-cost properties. Such composites are widely used for the analysis of DNA4-aminophenol, serotonin articulate, hydrogen peroxide and hydrazine, hydrogen (H_2), methane (CH_4), and ammonia (NH_3) ammonia sensing (NH_3) [65][6].

Electrochemical

The behaviour of PANI / inorganic Nanocomposite has often drawn growing interest nowadays. Due to interfacial interactions between inorganic Nanoparticles and PANI macromolecules, the properties of this Nanocomposite are somewhat distinct from PANI and the related inorganic Nanoparticles. By manipulating particle size, form, and distribution of Nanoparticles, their properties can be conveniently modified to the appropriate applications. Therefore, they have a number of possible uses in electrical Nanodevices. Several inorganic Nanoparticles have been used to produce conductive PANI Nanocomposite, such as CDs, SiO_2 Cu_2S, clay, Fe_2O_3, MnO_2, TiO_2, ZnO, ZrO_2, and carbon Nanotubes. Until now, most of these Nanocomposite based on polymer matrix have been developed utilizing chemical and electrochemical processes [66] [6].

Proton Exchange Membranes

The proton exchange membrane (PEM) makes use of the different solid-state fuel cells as essential components. The use of silica polymer Nanocomposite as PEM is studied continuously. Hybrid materials such as PEMs are produced when silica Nanoparticles are combined with sulfonated poly (phthalazinone ether ketone) with (1.23°) of sulfonation. The hybrid membranes show enhanced swelling effects, thermal stability and mechanical properties. Suppression of the membrane's methanol crossover activity enables it to be used in a cell test in a high methanol concentration environment, an optimal power density of 52.9 mW cm-2 with a current density of 264.6 mA cm-2. An open-cell potential of 0.6 V was seen with 5 nm silica Nanoparticles providing a specific efficiency boost relative to Nafion membranes, proton exchange membrane (PEM) [67-68] [6].

Conclusion

Nanostructures operating have held a leadership role in Nanotechnology, thanks to larger surface area it may be seen in specific applications. In the recent scenario, due to its mechanical and electrical properties, a class of conducting polymers is becoming common. Synthesis of polyaniline/Rice Husk Ash (silica) Nanocomposite (PANI / RHACCl (SiO_2)) NCs is performed through oxidative polymerization of aniline in the presence of specific RHACCl (SiO_2) ratios. The Nanocomposite obtained is defined through UV-Vis, FT-IR, XRD, TGA, FESEM and four-point research techniques. Results from the experiments have shown that PANI encapsulates SiO_2 Nanoparticles with a very powerful impact on Nanocomposite morphology. The polyaniline temperature for thermal decomposition in Nanocomposite is lower than that of pure PANI. The electrical conductivity of Nanocomposite has lower SiO_2 values than that of PANI pure. Combined with conductive polymers such as polyaniline, silica Nanocomposite can be used in different applications such as supercapacitor, pseudocapacitors, fabrics and coatings, metal absorption, chemical sensors, organic light encapsulation exchange protons, pervaporation membrane, biosensors, lightweight Nanoelectronic systems, and drug delivery.

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