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"Synthesis,Characterization and Surface Morphology of Conducting Polymer with Nanocomposite Used for wide range of Applications"

[1]Ms. Dipali Nagnath Hodade
[1]PHD Student, ***Dr. APJ Abdul Kalam University,Indore,MP, India***
Department of Physics
Indore,India
dipalihodade2@gmail.com

[2]Dr. Mohan N Giriya
Dr. APJ Abdul Kalam University,Indore,MP, India
Department of Physics
Indore,India

Abstract— Polyaniline was utilized for the very first time in a search for cadmium sulphate in an aqueous solution. The search was conducted for the very first time. The present investigation is the pioneering effort to produce a polyaniline-CdS nano-composite through the application of a method known as in-situ oxidative polymerization**.** Synthesis and study of conducting polymers' physical characteristics are keys. Polyaniline is conductive. X-ray diffraction (XRD) showed that the matrix contains pure nano CdS particles. This work prepares nanostructured polyaniline (PANI) using four sol-gel methods. Morphology of PANI samples was determined by X-ray diffraction was used to characterize PANI molecular structure (XRD). The results of the characterization of the prepared PANI show that the morphology, chemical composition, crystallinity, conductivity, and surface area were significantly altered as a result of the atypical techniques that were used in its synthesis. This was confirmed by the results of the characterization. This paper examines recent advances in polyaniline conducting polymer production and characteristics. Synthesis of polyaniline using traditional and grafted methods has been reviewed. By this high-accuracy development process, structure and properties are directly related. Structure-modified polyaniline can be used in the future. Observations showed that PANI/CdS nanocomposites have higher DC conductivity than PANI. By oxidizing aniline with cadmium sulfate 3.5 pH, conducting polyaniline nanocomposites with CdS nanoparticles were produced in situ. CdS-nanoparticles affect polyaniline's electrical conductivity. The homogeneous intercalation of CdS nanoparticles leads in a cooperative phenomenon between polyaniline and the nanoparticles, increasing the electrical conductivity of polyaniline nano-composite compared to pure polyaniline**.**

Keywords*:* PANI/CdS nano-composite material, Sol-gel, XRD, ZNS, Polyaniline, Polymer, Nano particle

INTRODUCTION

Cadmium Sulphide and Polyaniline films were produced using vacuum evaporation. Single-layer and multilayer films were grown and characterized. In this study, multilayer CdS/Polyaniline thin films are X-ray diffracted.

Sol-gel plus chemical oxidation produces conducting polyaniline (PANI). Screen-printed cadmium sulphide on polyaniline pellet PANI/CdS nano-composite material was produced utilizing $FeCl_3$ as an oxidant.

Sulphide semiconductors are one of the most-studied thin-film semiconductors, and many deposition processes have been used to make solar cells. Cadmium sulphide films produced by vacuum evaporation are utilized as oxygen sensors.
In polymerization of aniline monomer in the presence of dispersed CdS quantum dots and multi-walled carbon nanotubes has produced polyaniline/carbon nanotube/CdS quantum dot composites with improved optical and electrical characteristics.

Polyaniline (PANI) has a simple synthetic technique, strong environmental and thermal stability, a vast conductivity range, and good optical, electrochemical, and chemical properties, making it a model structure for advanced study and the basis for a new class of innovative materials/composites.

We created a PANI/CdS composite with homogeneous CdS dispersion. In-situ polymerization of aniline in multi-walled CdS yielded PANI/CdS quantum dots.
Polymerization at the water-toluene interface forms a transparent, free-standing layer. Plasma pretreatment and in-situ polymerization make polyaniline composites conductive.
Spin-coated polyaniline–CdS nanocomposites' sensing properties

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PROPOSED SYSTEM

XRD validates PANI/CdS' crystal structure. SEM and XRD demonstrate composites' changed crystallinity. CdS crystallites develop and impregnate PANI's granular pillar-like structure. The composite absorbs bluer than CdS. PANI's C=C bond alters infrared wave numbers.

PANI switches between base and salt states quickly. PANI has good reduction and oxidation properties, electrical conductivity, a simple manufacturing method, and environmental stability. PANI was oxidatively polymerized from aniline monomers. Different approaches were utilized as PANI research progressed.

- Polymerization using electrochemistry.
- Polymerization by chemicals.
- Polymerization in the vapor phase (VPP).
- Polymerization that was started by photochemistry.
- Polymerization facilitated by enzymes.
- Electron acceptor-based polymerization

Material & Techniques

Research Methodology

Materials used: aniline, chloroform, Sulphuric acid, ammonium persulphate, cadmium nitrate, methanol, zinc chloride, and titanium tetra Isopropoxide. All chemicals were analytical and used as stated.

PANI/CdS-PANI/ZnS-PANI/TiO2-PANI Nano Composite Synthesis

PANI was made by oxidizing aniline in H2SO4 with APS. The solution transformed from pale to blue-green and dark green when ammonium persulphate was added, showing rapid aniline polymerization into polyaniline. Low temperatures were used to delay polymerization and generate nanoparticles. PANI and its nanocomposites were made using these steps:

Polyaniline Preparation

In 100 mL chloroform, 0.2 M aniline (2.462 M) was made. Another APS (0.05 M) solution (1 M) was made in 100 mL H2SO4 and combined with the original solution to polymerize overnight at 4–5 °C.

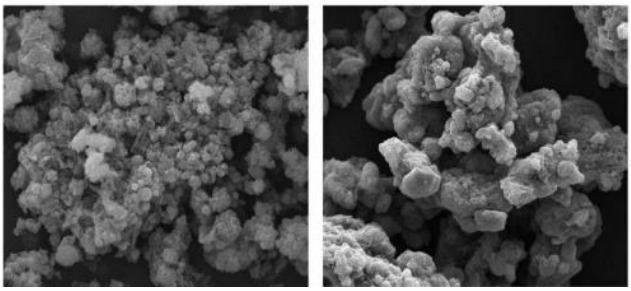

Figure1.1: Pure PANI SEM picture

CdS-PANI Nanocomposite Preparation

PC was produced by in situ polymerizing PANI in CdS nanoparticles utilizing a single pot chemical precipitation technique. With vigorous stirring, a 100 mL Cd (NO3)2 (0.085 M) aqueous solution was combined with 50 mL methanol (24.44 M). A 100 mL aniline (0.2 M) solution in chloroform (2.462 M) was added and agitated for 60 min. The process took 1 min in H2S with vigorous stirring, then 2 h. A 0.05 M APS solution was made in 100 mL H2SO4 (1 M) in another jar. This solution was gradually added to the previous one and polymerized overnight at 4–5 °C. The result was dark green.

CdS-ZnS-PANI Nanocomposite Preparation

Dropping 50 mL methanol (24.44 M) into 100 mL aqueous ZnCl2 (0.15 M) while stirring. The hue changed to milky white after 1 min of stirring in H_2S and 2 h of other stirring. A magnetic stirrer added 100 mL aqueous Cd (NO3)2 (0.085 M) dropwise to 50 mL methanol (24.44 M) in a separate beaker. The operation was repeated for 2 h after 1 min of stirring in H2S. The solution went from clear to bright yellow. The two solutions were vigorously stirred for 2 h. The solution was yellow. Next, 100 mL aniline (0.2 M) solution from chloroform (2.462 M) was stirred into this reaction mixture for 1 h. A 0.05 M APS solution was made in 100 mL H2SO4 (1 M) in another jar. This solution was gradually added to the previous one and polymerized overnight at 4–5 °C. The result was dark green.

CdS-TiO2-PANI Nanocomposite Preparation

In a typical synthesis, 100 mL aqueous Cd (NO3)2 (0.085 M) was added dropwise with continuous stirring, followed by 50 mL methanol (24.44 M) for 1 min in H2S with a magnetic stirrer, and then the same for 2 h. The solution turned yellow from clear. Next, 3.53 mL TTIP (Titanium Tetra Isopropoxide) (0.1 M) was dropwise added to this solution (20 drops per minute) and stirred for 2 h. The solution turned pale yellow. Next, 100 mL aniline (0.2 M) solution from chloroform (2.462 M) was added to this reaction mixture and agitated for 1 h. A 0.05 M APS solution was made in 100 mL H2SO4 (1 M) in another jar. This solution was gradually added to the previous one and polymerized overnight at 4–5 °C. The result was dark green. All precipitates were repeatedly cleaned with water and acetone before air-drying.

Characterization Methods

Element analysis was performed using energy-dispersive X-ray spectroscopy (EDS, JEOL, JSM6510LV, Tokyo, Japan) and Fourier Transform Infrared Spectroscopy (Spectrum 2, PerkinElmer, Waltham, MA, USA). JEOL JEM2100 and JSM6510LV scanning and transmission electron microscopy characterize surface morphology. Powder X-ray diffraction (Miniflex-TM II Benchtop, Rigaku Co-operation, Tokyo, Japan) examined structural characteristics. Thermal Gravimetric Analysis determined thermal characteristics. Shimadzu UV-1601 (Waltham, MA, USA) UV-Visible Spectroscopy determined optical characteristics.

Polyaniline synthesis

Polyaniline was made through oxidative polymerization. In a beaker, 0.2M (0.8 g) aniline, 2 M HCl, and distilled water were mixed. Beaker in (0-8) oC ice bath. The glass substrate was dipped.

Ammonium peroxydisulfate was dissolved in 2 M HCl and purified water. Drop by drop, ammonium peroxydisulfate was added to aniline while stirring.

The mixture turns from light blue to blue green to greenish black during polymerization. Color denotes emeraldine salt polyaniline. We kept this overnight. Filtered and rinsed with HCl and distilled water to eliminate contaminants. The residue and substrate were dried at 80°C for 4 hours.

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Polyaniline, a conducting polymer, has several uses. This conducting polymer is likely produced in rings and nitrogen-substituted derivatives. Each derivative has two oxidation states, which are created using different dopants and non-redox, chemical, or electrochemical oxidation. The technological potential of these materials depends on their cost-effectiveness, stability, and ease of synthesis and processing.

Cadmium-sulfide synthesis

80 ml distilled water dissolved 6.396 mg cadmium acetate and 3.648 g thiourea. Drop by drop, thiourea solution was added to the cadmium acetate solution while stirring. After 3.5 h, nanoparticles precipitate and the solution turns yellow. The solution sat overnight without stirring. Bottom-stabilizing CdS nanoparticles; filtered and rinsed with distilled water to remove contaminants; precipitate and substrate were dried at 70°C for 4 hours.

Nanocomposite PANI–CdS

In oxidative polymerization, PANI-CdS nanocomposites were made with 10, 20, 30, 40, and 50% CdS nanoparticles. 0.97 g aniline in 94.3 ml distilled water with 2 M HCl. The solution was stirred in (0–8)^{0}C ice bath. 4.2 g ammonium peroxy-disulfate was dissolved in 94.3 ml 2 M HCl in distilled water. Drop by drop, ammonium peroxydisulfate solution was added to aniline solution. The solution was agitated for 12h after adding 10, 20, 30, 40, and 50% CdS. Two times with HCl and distilled water, the precipitate was filtered. Precipitate and substrate were dried at 80^{0}C for 4 hours.

This study analyzes iodine's effect on polymer/inorganic nanocomposites. I2@PANI is redox-coated iodine nanoparticles on PANI nano-fibers. CdS nanoparticles increase I2@PANI–CdS photocurrent (as electron acceptors). I2's penetration into porous semiconductor sheets, quick charge transfer, and slow photoelectron recombination all help. Nano-CdS may have more charge carriers. I2@PANI–CdS nanocomposites boost photocurrent.
XRD confirms a PANI/CdS composite's crystalline structure. SEM and XRD show the composites' altered form and crystallinity. Transmission electron microscopy shows CdS crystallites growing and impregnating PANI's granular pillar-like structure. The composite's absorption edge is blue-shifted compared to CdS. PANI's C14C bond strengthens, causing a shift in infrared wave numbers.

Summary

The first in-situ oxidative polymerization of polyaniline-CdS nanocomposite was performed.

This study used hybrid POT-CSA-CdSe-TEA nanoparticles. Studying electricity, structure, and morphology. XRD hybrids are cubic like CdSe nanoparticles. Semiconducting hybrids conduct 0.1 S.cm-2.
This paper polymerizes ultrasonic-irradiated cadmium sulphide. USI makes organic-polymer composites. PANI/CdS. This USI creates particles. Concentration controls PANI/CdS particle size. USI is not chemically made like PANI/CdS. USI splits PANI/CdS. USI strengthens composite. CdS PANI blocks micro-fibre polymerization. Discover USI and XRD-verified PANI/CdS. Both materials retained crystal structures but lost XRD crystallinity after USI. TEM and SEM confirm XRD.

PANI and CdS-QDs nanocomposites were examined for optics, electronics, morphology, and structure. CdS-PANI nanocomposites precipitate QDs and polyaniline. The UV eV spectroscopy examined PANI, CdS-PANI nanocomposites, and CdS quantum dots. Quantum dots modify PANI's band gap. PANI and nanocomposites showed 1-D charge transport in DC conductivity measurements. CdS-PANI DC conductivity rises with CdS and temperature. AC conductivity of CdS-PANI nanocomposites depends on temperature, frequency, and CdS content.

This study creates CdS-based PANI nanocomposites with APS as an oxidant. Chemical structure, morphology, and electrical properties are studied. Nanoparticle form and content are determined by TEM. Fore Probe measures CdS composite conductivity. Calculating activation energy with polyaniline and various CdS nanocomposite weights.

Green bio-catalytic polymerization. More than chemicals and recyclable enzymes are made. Under mild conditions, this process is selective, catalytic, efficient, low-energy, etc. It uses enzymes and organic solvents.

Others require superfluous steps, whereas enzyme-catalyzed polymers are well-structured. Process and dissolve with templates. Polyelectrolyte templates foster para coupling and counterion doping. This study analyses new polyaniline conducting polymer synthesis and properties. Traditional, ultrasonic, Fenton, and grafting polyaniline synthesis methods are addressed. Highly accurate evolution links structure and characteristics.

Potential of structure-modified polyaniline.
Optoelectronics, morphology, and PIn/CdS nanocomposite structure are reported. FT-IR and XRD found CdS in PIn. TEM and FESEM examined synthesized samples. Nanocomposite PIn/CdS 2.15 eV optical band gap; PL spectra electron-hole mobility. The J-V characteristics of PIn/CdS nanocomposite Ohmic conductance were examined. Each statistic shows optoelectronic PIn/applicability CdSs.

In PANI nanocomposites, CdSe cubic constants are 6.24 and 5.44. PANI sphere. PANI-CdSe nanocomposite EDAX-validated. Ohmic P-N diodes. Better PANI/CdSe nanocomposite DC conductivity. The material can build gas sensors, protective devices, P-N junction diodes, and electronics with 150 [A (cm)-2] short circuit current.

PVA had CdS nanoparticles. PVA/CdS nanocomposite films examined CdS nanoparticles' effects on PVA. We examine mechanical and structural properties. FTIR peaks show C-H, CO, COC, and COS stretching; XRD shows 100% nano-CdS. SEM pictures of PVA/CdS nanocomposite showed nanoparticle agglomeration. We measure thermal characteristics with DSC.

Many electroactive polymers use. Conductive polymer PANI is easy to make. PANI LEDs light. Low-cost PANI solar cells. PANI solar cells are affordable and efficient. PANI gas and glucose sensors are popular. Increase energy efficiency with supercapacitors. Super capacitors use PANI's cost, conductivity, and redox. Medicine needs new tech. Neuroprotective brain probes improve neurology.

Video and probable PANI/CdS analysis in situ. XRD, FTIR, and SEM evaluated structure, shape, crystallinity, composition, and molecular interaction. Based on AC frequency, nanocomposite CdS enhances conductivity, dielectric, and impedance. Percolation changes PANI/CdS.
P3 composite dielectric is low. CdS nanoparticles impact electric composites. Conductive hybrid polymers store energy.

Biosensor matrix clad. Cross-linked glucose oxidase. Certified nanocomposite by XRD/FE-SEM. Sensor nanocomposite matrix was optically imaged. A glucose sensor. Biomolecules stick to fibre optic sensors with PANI-CdS.

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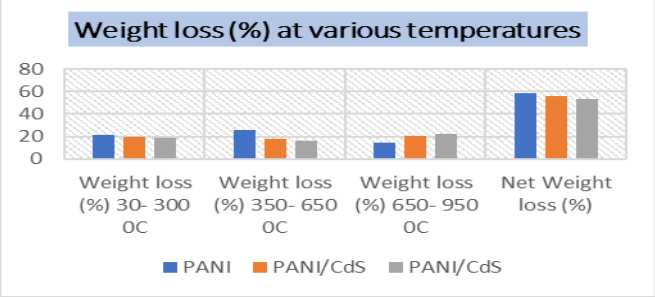
Sol–gel nano-CdS. Polyaniline was oxidised aniline. 20-30-40-50% CdS PANI-CdS nanocomposites. X-ray diffraction peaks are 21.5o, 25.7o, and 28.1o for emerald salt polyani Peaks at 26.69 and 47.47 suggest hexagonal and cubic CdS. PANI crystallites are 7.95 and 12.09 nm. Polyaniline CdS-FTIR. AFM discovers PANI CdS.

On-site aniline monomer CNT polymerization increased CdS quantum dots' optical and electrical characteristics. CdS dots' first-, second-, and third-order phonons. Excitons and quantum dots carry charge in PANI/CNT/CdS (2 wt.%) combinations. Optoelectronics

Weight loss (%) at various temperatures for the as-prepared materials

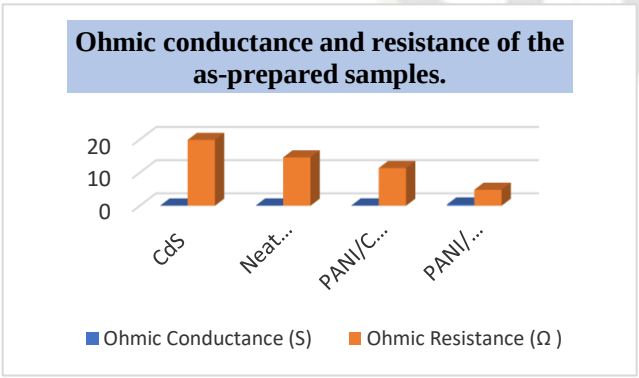
Specimen	Weight loss (%) 30- 300 ^{0}C	Weight loss (%) 350- 650 ^{0}C	Weight loss (%) 650- 950 ^{0}C	Net Weight loss (%)
PANI	21.41	25.56	14.09	58.96
PANI/CdS	19.71	18.05	20.68	55.62
PANI/CdS	18.95	16.61	22.31	52.98

The technique was utilised in order to investigate the surface morphology of the materials that were synthesized in their natural state. These materials included pristine PANI, graphene oxide, CdS nanoparticles, and their nanohybrids.



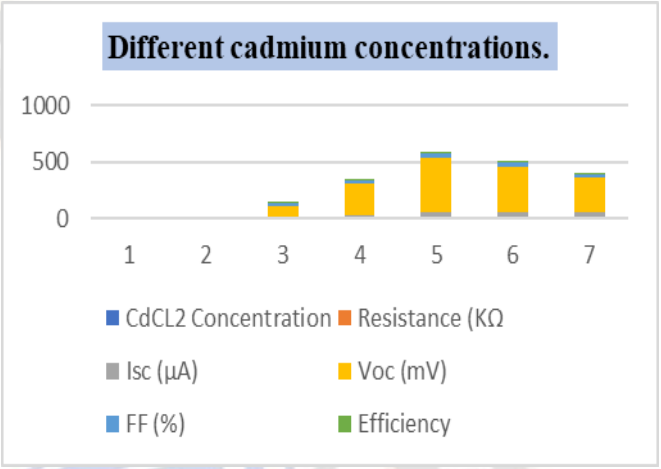
Ohmic conductance and resistance of the as-prepared samples

Sample	Ohmic Conductance (S)	Ohmic Resistance (Ω)
CdS	0.078	19.85
Neat PANI	0.089	14.59
PANI/CdS	0.101	11.37
PANI/Gradient/Cds	0.392	04.82



Summary of the parameters extracted from the devices with different cadmium concentrations.

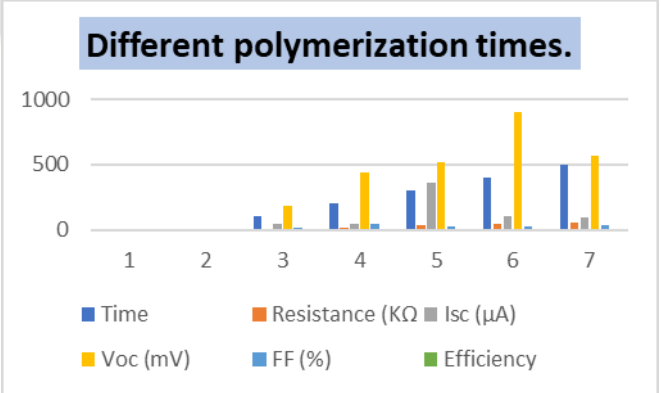
$CdCL_2$ Concentration	Resistance (KΩ	Isc (μA)	Voc (mV)	FF (%)	Efficiency
3.8	4.1	8.9	91	35	0.0389
7	7.9	11	278	32	0.01156
8.9	11.5	38	478	39	0.1098
12	4.6	38	395	49	0.425
14.9	5.8	43	294	37	0.783



The photovoltaic characteristics that were acquired by adjusting the polymerization time, the concentration of cadmium, and the concentration of dopant.
The output current (Isc) also increased as the concentration of CdS increased, which may be owing to an increase in defects and, as a result, an increase in light absorption and photon conversion.

Summary of the parameters extracted from the devices with different polymerization times.

Time	Resistance (KΩ	Isc (μA)	Voc (mV)	FF (%)	Efficiency
100	7.8	40	180	16	0.0986
200	11	45	440	40	0.086
300	39	365	520	29	0.78
400	41	105	899	30	0.64
500	52	98	564	35	0.15



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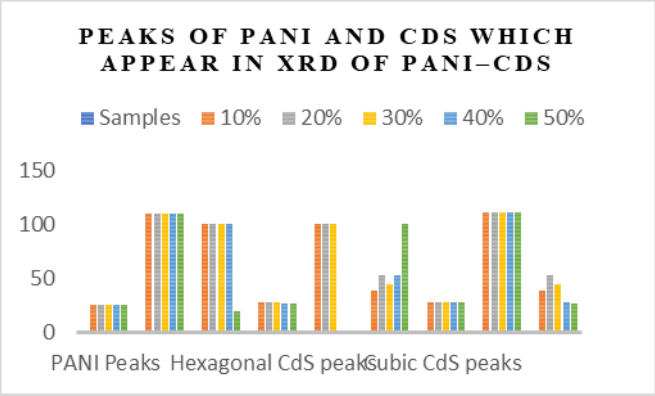
Nanoparticles provide a high interfacial surface for charge separation and reduced recombination, whilst polyaniline can be modified to have certain electrical characteristics and a band gap that can be tailored to the specifications of the device.

Through the use of photo-electrochemical research, this composite has demonstrated the potential to be utilised in photovoltaic applications. An IPCE value of 11.2% was obtained by photocurrent studies, which revealed a high photon conversion efficiency when exposed to light environments. There will be an improvement in device response if effective solutions for matrix alignment are developed.

The strongest peaks of PANI and CdS which appear in XRD of PANI–CdS (10–50 wt.%) composites.

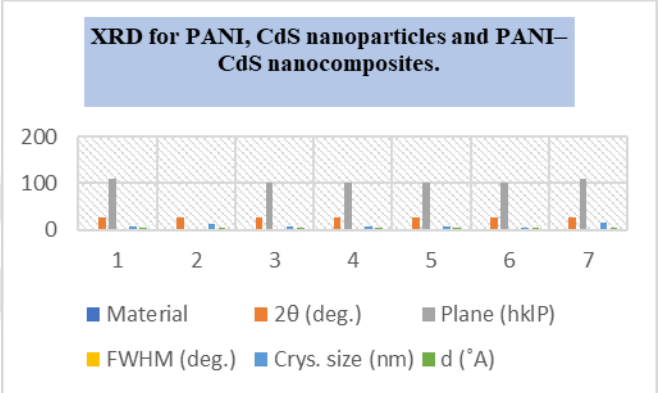
	PANI Peaks				Hexagonal CdS peaks				Cubic CdS peaks		
Samples	2θ deg.	hkl	I/I_0		2θ deg.	hkl	I/I_0		2θ deg.	hkl	I/I_0
10%	25.7	110	100		28.1	101	39		28.1	111	39
20%	25.5	110	100		28.1	101	53		28.1	111	53
30%	25.4	110	100		27.8	101	44		27.8	111	44
40%	25.7	110	100		26.8	002	53		28	111	28
50%	25	110	19		26.6	002	100		27.9	111	27



The XRD pattern of PANI– CdS (10–50 wt.%) composites show interconnected PANI and CdS peaks. From this pattern, CdS peaks are lower intensity than PANI peaks, but in the sample with 50% CdS, hexagonal and cubic CdS peaks are clearly visible and PANI peak intensity decreases due to CdS concentration, which forms an interlocking structure between CdS nanoparticles and PANI matrix. Table 1 shows the brightest PANI and CdS peaks in PANI–CdS (10–50 wt.%) composite XRD.

XRD for PANI, CdS nanoparticles and PANI–CdS nanocomposites

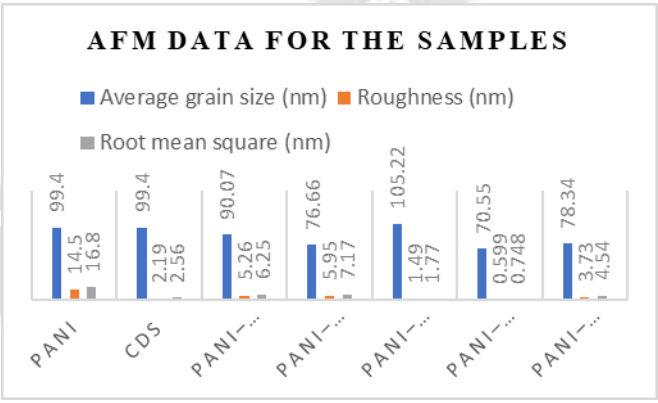
Material	2θ (deg.)	Plane (hklP)	FWHM (deg.)	Crys. size (nm)	d (Å)
PANI	25.75	110	1.05	7.95	3.45
CdS	26.69	002	0.925	12.09	3.33
10%	25.72	100	1.25	6.64	3.46
20%	25.54	100	1.158	7.01	3.48
30%	25.45	100	1.176	6.84	3.49
40%	25.75	100	1.885	4.42	3.45
50%	25.05	110	0.50	15.90	3.55



Illustrates the variation in the diffraction angle of CdS in PANI-CdS composites as a function of CdS concentration, relative to the standard diffraction angle of CdS. The shifting of the CdS peaks in this diagram indicates the existence of tension within the lattice.

AFM data for the samples.

Sample	Average grain size (nm)	Roughness (nm)	Root mean square (nm)
PANI	99.40	14.5	16.8
CdS	99.40	2.19	2.56
PANI–CdS (10%)	90.07	5.26	6.25
PANI–CdS (20%)	76.66	5.95	7.17
PANI–CdS (30%)	105.22	1.49	1.77
PANI–CdS (40%)	70.55	0.599	0.748
PANI–CdS (50%)	78.34	3.73	4.54



Kinetic parameters for PANI and nanocomposites

Polymer composites	Ea (KJ/mole)	Δ S (J/K)	G (KJ/mole)	Ts (K)
PANI	9.5	43.16	24.4	786
PANI-CdS 5%	11.94	43.08	48.34	845

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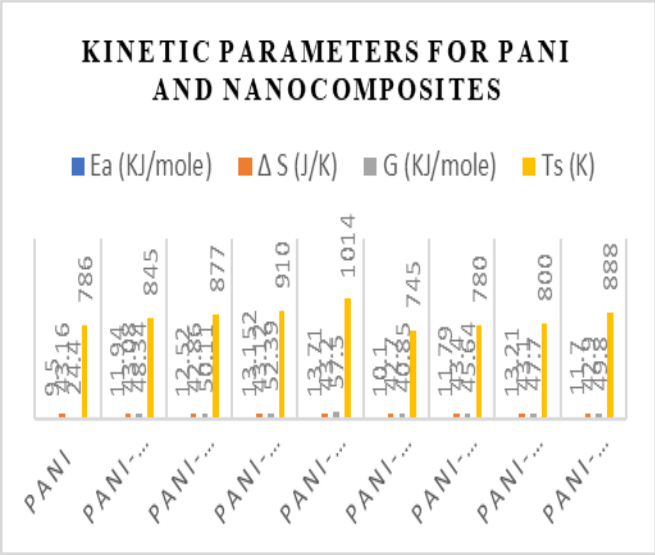
PANI-CdS 10%	12.52	42.86	50.11	877
PANI-CdS 15%	13.152	43.12	52.39	910
PANI-CdS 20%	13.71	43.20	57.5	1014
PANI-ZnS 5%	10.1	42.7	40.85	745
PANI-ZnS 10%	11.79	43.4	45.64	780
PANI-ZnS 15%	13.21	43.1	47.70	800
PANI-ZnS 20%	11.7	42.9	49.8	888



CONCLUSION

The inhibitory zone that is produced by cotton that has been treated with polyaniline is as thin as it is physically possible for that zone to be. The antibacterial activity of PANI can be explained in a number of different ways, including the protonation of cadmium sulfide-containing polymer groups, the physical interaction that takes place between the microbial cell and the polymer as a result of the chain structure of PANI, as well as a number of other possibilities. PANI has been shown to inhibit the growth of a wide variety of bacteria.

Simple techniques of synthesis were employed for PANI and CdS nanoparticles, respectively, in order to explore the structural and surface properties of PANI, CdS nanoparticles, and PANI-CdS nanocomposites. This was done in order to better understand the relationship between the three materials. PANI and CdS nanoparticles were the first ones to be manufactured. In the X-ray diffraction pattern of PANI-CdS nanocomposites, it was observed that the peaks of PANI and CdS occurred together at the same spot. This was a significant finding. This turned out to be a very important discovery. This shows that they are connected, and the fact that PANI and CdS have separate crystallite shapes produces stress in the nanocomposites because of the difference in the structures of the crystallites. Consequently, this suggests that they are connected. This is because the nanocomposites are composed of both of these materials, which explains why this is the case.

The synthesis of PANI/CdS is one that can be repeated and carried out on a far bigger scale than it was previously possible. A polymer composite will form on the surface of the PANI if it is allowed to come into contact with CdS. The combination of these two compounds brings about this effect, which is a consequence of their interaction. During the course of the inquiry, EDS and XRD were utilized, which ultimately resulted in the discovery that the PANI composite contains cadmium sulfide as one of its component parts. The interaction between PANI and CdS has been shown to be both genuine and functional by utilizing a number of various vibrational patterns. This has been shown to be the case. After going through the process of composite synthesis with PANI, the CdS crystals ended up taking the shape of a hexagon when the process was finished. This observation refers to the production of PANI/CdS composites, as it is possible to make out clusters of CdS that have collected in PANI fibers. You can locate the images that were taken by the TEM in this location.

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