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Synthesis, Characterization, and Integrating Biological Functions for Enhanced Applications"

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Abstract: -

The only source of natural light in the "Solar System" is the Sun. Solar energy is clean and environmentally friendly since it is a renewable resource. In addition, solar energy is available all year round. Many electrical appliances use, run, and operate on solar energy. If utilized, this energy might prove to be a more effective energy source. To improve the use of solar energy and storage of the energy, new methods, concepts, and discoveries have been presented to the globe. This article examines the synthesis of a nanocomposite of Vanadium oxide (V_2O_5) and Titanium dioxide (TiO_2), as well as its characterization. Additionally, Nanocomposite coating for solar cells is being developed. These NCs have undergone rigorous testing and have proven to be more heat resistant, scratch resistant, water resistant, and capable of removing dust buildup on cell surfaces. These nanoparticles boost the solar power production and aid in trapping solar heat at the necessary rate. NP's are also proven to be antimicrobial in nature

Introduction: -

Highly selective absorber coatings of solar thermal collectors, ensuring high conversion efficiencies, lead to increased stagnation temperatures and also the overheating of the collector. In general, selective solar absorbers have a high absorptance. To effectively prevent overheating, the efficiency of solar collectors should decrease once a maximum allowed temperature is reached. Thermochromic Vanadium dioxide (V2O5) is undergoing a reversible, first order semiconductor-to-metal (SMT) phase transition at approximately 325-360 K or 51.85-91.85 ℃, over which the electrical and the optical properties in the near and mid-infrared spectral region change significantly. TiO2 NPs enhance the charge conduction and harvest more light. The electron transport of zero dimensional TiO_2 nanoparticles is no better than that of higher-dimensional TiO_2 nanostructures. TiO2 NPs have been employed because of their easy synthesis property, cost effectivity, less toxicity and availability.

The aim of this work is to develop highly selective solar absorber coating with an integrated overheating protection function as well as a nanocomposite with an effective function to increase the efficiency of the solar cell. The absorber should have a high selectivity- high solar absorptance (αsol) and low thermal emittance (εth)- in normal operating temperature ranges and a bad selectivity at high temperatures – high thermal emittance (εth) and low solar absorptance (αsol), where collector overheating is a challenge. This switch of selectivity is to be achieved by the combination of phase change thermochromic films into the absorber multilayers. The effective reduction of the collector stagnation temperature is determined by the durability of the novel coatings.

Keywords: -

Nanoparticles, solar cells, Titanium di-oxide (TiO_2) and Vanadium di-oxide (V_2O_5), solar power yield, Antimicrobial activity.

Materials and Methods-

Synthesis of V2O5 Nanoparticles: -

Green synthesis of Vanadium dioxide (V2O5) nanoparticles exploiting seed extract from Butea monosperma,

Combustion is used to create vanadium oxide nanoparticles because it is a straight forward process and produces a high-quality product in a short period of time.

The seeds are added to a beaker filled with distilled water after being ground into a fine powder using a mixer grinder. 90 ml of monospermic seed containing extract is mixed in 15 g of Ammonium metavanadate (NH4VO3) and the mixture is then sonicated for roughly 30 minutes. The mixture-containing solution is then poured into the crucibles and heated to 500

°C in the muffle furnace for 8 hours to produce the foam-like extract. These materials are ground up into a small particle structure using a mortar and pestle, and then they are heated to 520 °C for calcinations to produce fine Vanadium di-oxide (V2O5) nanoparticles.

Synthesis of TiO2 Nanoparticles: -

Titanium tetraisopropoxide (TTIP) is hydrolysed in clean water under ultrasonic radiation using the sonochemical technique to create highly photoactive Titanium dioxide (TiO_2) nanoparticles.

Sonochemistry is a result of acoustic cavitation, which is the development, expansion, and burst of bubbles inside a liquid medium. Cavitational collapse generates heat (5000 K) and high pressures (1000 atm).

Result and Discussion: -

<u>Characterization of V_2O_5-</u>

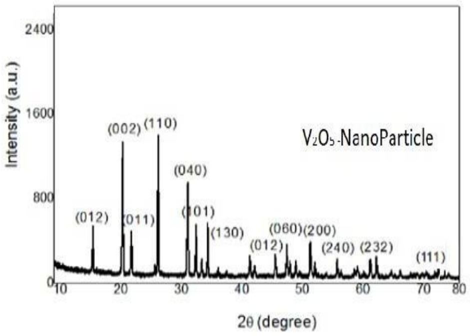
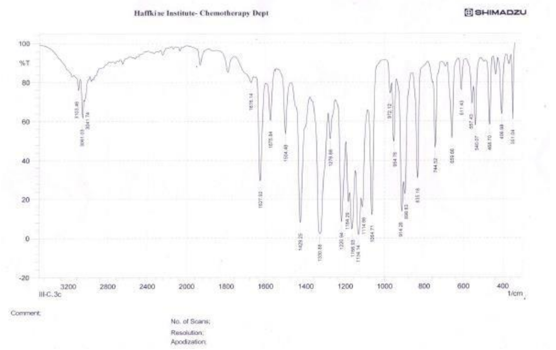
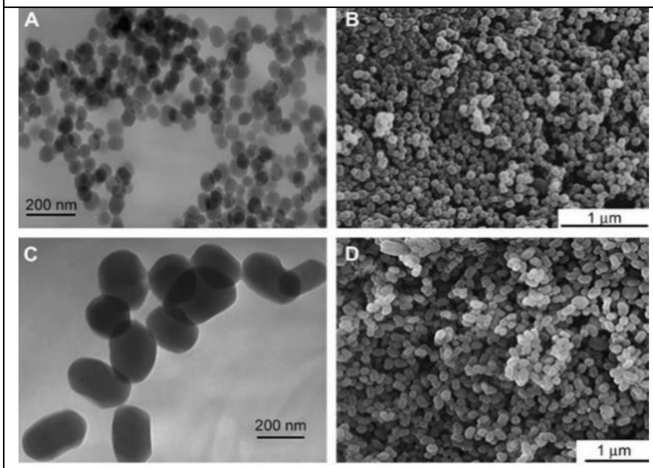
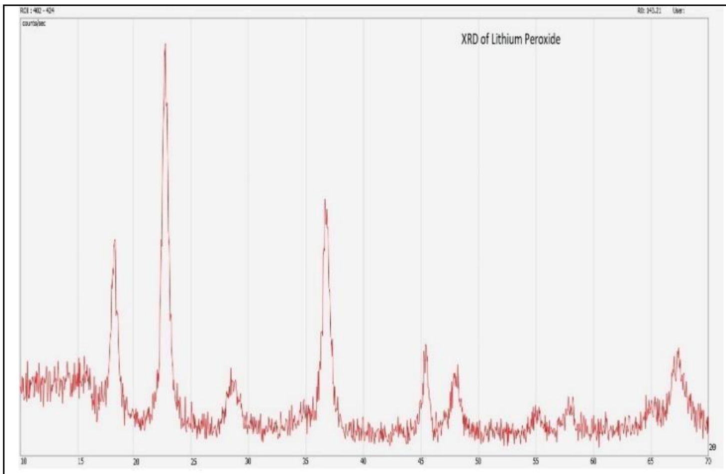


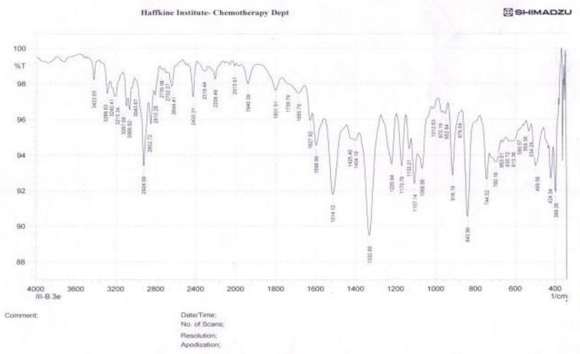
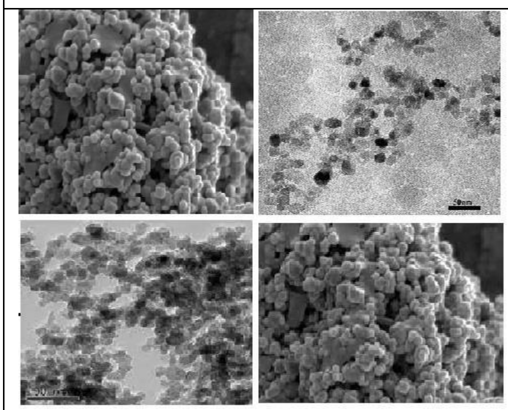
Figure:1a - XRD pattern indicating the peaks for <u>V_2O_5</u> NPs.

The results from the structural analysis of the synthesized nanoparticles obtained from the XRD- The image indicates strong diffraction peaks at (0 1 2) (0 0 2) (0 1 1) (1 1 0) (0 4 0) (1 0 1) (1 3 0) The observed strong peaks at two locations from the results at (0 0 1) and (1 1 0) indicate the absence of any organic impurities [18, 19]. The other small narrow and intense peaks denote the synthesized nanoparticles (NPs) are highly crystalline, which contributes to the increased sensitivity of the pressure sensor.

 Figure:1b - FTIR Spectrum indicating the output results for V_2O_5 NPs.	The FTIR spectrum is depicted in the Figure1b. It is used to obtain the infrared transmission spectrum, chemical bonds and the functional group of the vanadium oxide nanoparticles, they were analysed in the range of 400-4000 cm-1 wave number The peaks observed from the results indicate three
	characteristic vibration modes. The one at 1064.81 denotes V=O vanadyl stretching mode, 540.07 denotes V-O-V symmetric stretching, 1627.28 denotes V-O-V asymmetric stretching around the bonding structure
 Figure:1c SEM images of V_2O_5 NPs.	

Characterization of Titanium di-oxide (TiO_2): -

 Figure: -2a XRD pattern indicating the peaks for TiO_2 NPs.	The results from the structural analysis of the synthesized nanoparticles (NPs) obtained from the XRD- The image indicates strong diffraction peaks at (0 1 1) (0 1 2) (0 0 1) (0 1 0) (0 2 0) (1 2 0) (1 3 0). The observed strong peaks at two locations from the results at (0 0 1) and (1 1 0) indicate the absence of any organic impurities [18, 19]. The other small narrow and intense peaks denote the synthesized nanoparticles are highly crystalline, which

	contributes to the increased sensitivity of the pressure sensor.
 Figure:2b - FTIR Spectrum indicating the output results for TiO_2 NPs.	The FTIR spectrum is depicted in the Figure 2b. It is used to obtain the infrared transmission spectrum, chemical bonds and the functional group of the vanadium oxide nanoparticles. They were analysed in the range of 400-4000 cm-1 wave number. The peaks observed from the results indicate three characteristic vibrational modes. The one at 1121.60 denotes Titanium di-oxide (TiO_2).
	SEM image of TiO_2.

Result and Discussion

Characterization of V_2O_5

The results from the structural analysis of the synthesized nanoparticles obtained from the XRD- The image indicates strong diffraction peaks at (0 1 2) (0 0 2) (0 1 1) (1 1 0) (0 4 0) (1 0 1) (1 3 0) The observed strong peaks at two locations from the results at (0 0 1) and (1 1 0) indicate the absence of any organic impurities [18, 19]. The other small narrow and intense peaks denote the synthesized nanoparticles are highly crystalline, which contributes to the increased sensitivity of the pressure sensor. The FTIR spectrum is depicted in the Figure 2b. It is used to obtain the infrared transmission spectrum, chemical bonds and the functional group of the vanadium oxide nanoparticles, they were analyzed in the range of 400-4000 cm-1 wave number The peaks observed from the results indicate three characteristic vibration modes. The one at 1064.81 denotes V=O vanadyl stretching mode, 540.07 denotes V-O-V symmetric stretching, 1627.28 denotes V-O-V asymmetric stretching around the bonding structure

The efficiency is the criterion that is most frequently used to evaluate how well one solar cell performs in comparison to another. Efficiency is defined as the ratio of solar cell energy output to solar energy input. The efficiency depends on the spectrum, intensity, and solar cell temperature of the incident light in addition to how well the solar cell performs itself. To evaluate the performance of different devices, it is necessary to precisely regulate the conditions in which efficiency is assessed. At a temperature of 25°C and at AM 1.5 circumstances, terrestrial solar cells are measured.

Table No. 1 Application of Nanocomposite

Solar cell	Volt/ohm	µA	mA	A
Solar cell without nanocomposite	0.103 Volts per ohm	103,000.0	103.6	0.1036
Solar cell with Nanocomposite	0.120 volt/ohm	120,000.0	120.0	0.120

Biological Activity

The study evaluated the antimicrobial properties of benzothiazole derivatives through in vitro screening against a range of bacteria and fungi. The focus was on determining the minimal inhibitory concentrations (MIC) required to halt the growth of the microorganisms. Additionally, when MIC values fell below 100 µg/mL, further investigation included determining the minimal bactericidal concentrations (MBCs) and minimal fungicidal concentrations (MFCs). The findings, presented in Table II, were compared with established standards such as Ampicillin, Trimethoprim, and Miconazole to assess the efficacy of the benzothiazole derivatives as potential antimicrobial agents.

Table no II:- Microbial Activity of Synthesized Compounds

Sr. No	Sample	Anti-Microbial Activity						
		Bacterial Stain					Fungal Stain	
		E.coli	S.typhi	P.aeroginosa	Kleb Pneumoniae	Vibrio Hlorae	C. albican	A. niger
1	V_2O_5	200	200	200	200	50	100	100
2	TiO_2	200	200	200	100	200	100	100
3	Nano Composite	100	100	100	100	50	100	200

1. Ampicillin (MIC-0.04 □g/ml) used as standard against S. aureus, E.coli,P.aeroginosa
2. Trimethoprim (MIC 0.01 μg/ml) used as standard against S. typhi, K.pneumonia
3. Miconazole (MIC 6.25 μg/ml) as standard against C. albicans and A. niger.

Table no III:- Anti Oxidant and Anti Inflammatory activity of Synthesized Compounds

Sr. No	Sample	Anti-Oxidant	Anti-Inflammatory
		$IC_{50}\pm SD$	$IC_{50}\pm SD$
1	V_2O_5	58.23+2.364	35.23+2.364
2	TiO_2	72.72+2.364	85.23+2.060
3	Nano Composite	36.02+2.364	32.23+2.364

1. Standard Anti-Oxidant Butyrate hydrogen Toluene

2. Standard Anti-Inflammatory Sodium Dichlofenac.

Conclusion: -

From above table it is clear that nanocomposite increases efficiency. The nanocomposite synthesized in the earlier stages with the help of natural materials and chemicals manufactured, obtained from the extract of the plant seeds proved to be an excellent novel source of nanoparticle synthesis and was further employed in the application of increasing the efficiency of the solar cell. Synthesized compound were screened for anti-microbial activity by tube dilution method. The compound was tested on Bacterial stains E. coli, S. typhi, P. aeroginosa, Kleb Pneumoniae, Vibrio chlorae, Fungal Stains C. Albicans, A.niger. Each test compound was tested against each strain. The activity was then monitored for 24-48 hours and the data is presented in the Table II. A comparative study of the 3 compounds synthesized reveals the following information: the compounds showed mild to moderate anti-microbial activity.

Compound 1 and 3 has shown the maximum activity among electron donating substitution forVibrio chlorae (50µg/ml) but the compound 2 has not shown activity for bacterial or fungal stains. In Radical scavenging activity done by DPPH method, standard drug BHT shows IC_{50} at 8.25µg/mL All Synthesized compounds compared with standard, we observed that, compound 3 shows remarkable activity at 36µg/mL while others shows moderate activity. In Anti-inflammatory activity done by Human Red Blood Cell (HRBC) membrane stabilization method, standard drug shows IC50 at 11.70µg/mL ,Compound 3 shows IC50 32.13 µg/mL

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