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Effect of Silicon Oil with Nano Particles in Direct Absorption of Solar Thermal Collectors

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ABSTRACT

We discussed about various aspects of solar energy, including its growth due to technological advancements and government support. It explores the utilization of solar energy in different climatic conditions, techno-economic analyses for hydrogen production, and solar-assisted biomass conversion. The section on Solar Thermal Collectors highlights different collector types, their efficiencies, and environmental impacts. The Nano Platelets section delves into the use of graphene nanoplatelets in direct absorption solar collectors, their structure, stability, and potential applications. Additionally, the paragraph touches on the application of graphene in coatings, cement-based composites, and nanocomposites, showcasing their impact on thermal and electromagnetic properties. The discussion extends to silicon oil-based materials, detailing their use in engine bearing alloys, transformer insulation, and environmental considerations. The findings emphasize the multifunctional benefits of graphene and nanocomposites in enhancing various properties, making them promising for future energy solutions.

Keywords: Solar Energy, Solar Thermal Collectors, Thermal Nano Platelets, Silicon Oils.

INTRODUCTION

Solar energy has emerged as a pivotal solution to address the escalating energy demands, environmental concerns, and the need for sustainable alternatives. This paragraph delves into the multifaceted aspects of solar energy, encompassing its technological advancements, barriers, global implications, and diverse applications. From a macro perspective, it explores the United States' initiatives under the Solar America Initiative and emphasizes the phenomenal growth of solar energy globally, attributed to technological enhancements and supportive government policies. The paragraph also touches on the challenges posed by increasing energy requisition, climate issues, and the Sun's potential as an inexhaustible energy source. Furthermore, it ventures into specific solar-energy-based technologies, such as solar-assisted biomass utilization, hydrogen production in Morocco, and the application of solar energy in cold climatic conditions. The subsequent section narrows down to focus on solar thermal collectors, detailing their efficiency differences, environmental impacts, and various storage methods. Finally, the narrative transitions to a micro-scale exploration of solar energy, specifically examining the use of graphene nanoplatelets in direct absorption solar collectors. This study showcases the potential of nanofluids, layer-by-layer methods, and innovative coatings to enhance the efficiency of solar energy conversion. As we delve into various applications, including the use of graphene in cement-based composites, PVC nanocomposites, and direct absorption solar collectors, the paragraph unveils a promising avenue for future energy requirements.

Solar Thermal Collectors:

There are three types:

- "Flat-plate collectors"
- "Concentrating collectors"
- "Evacuated tube collectors"

Properties of Flat plate solar collectors:

- "Absorber plate"
- "Transparent Cover"
- "Insulation"
- "Casing"
- "Fluid Circulation system"
- "Collector Orientation"
- "Collector Efficiency"
- "Temperature Control"
- "Application"

Thermal Nano Platelets:

Types of platelets:

- "Graphene platelet"
- "Boron Nitride Platelet"
- "Transition Metal Dichalcogenide Platelet"

Properties of Graphene Nano Platelet:

- High Surface Area
- Excellent Thermal Conductivity
- Optical Transparency
- Electrical Conductivity
- Mechanical Strength

Solar Thermal Fluids:

- Types Of Fluids:
- "Air"

- “Water”
- “Propylene Glycol/ Water Mixtures”
- “Silicon Oil”
- “Thermal Oil”

Properties Of Silicon Oil:

- High Thermal Stability
- Low Flammability
- Chemical Inertness
- Low Surface Tension
- Dielectric Properties
- Low Viscosity
- Water Repellency
- Biocompatibility

SOLAR ENERGY

The nontechnical barriers to solar energy use, drawing on recent literature to help identify key barriers that must be addressed as part of the technology acceptance efforts under the U.S. Department of Energy (DOE) Solar America Initiative. (1) Solar energy has experienced phenomenal growth in recent years due to both technological improvements resulting in cost reductions and government policies supportive of renewable energy development and utilization. (2) In a global era, continuous increment in energy requisition with its associated cost and relevant climate problems is causing accentuation in exploring more efficient ways to provide air conditioning in enclosed space without degradation of the environment. In hot and humid areas, a major part of conventionally produced electrical energy is consumed by air conditioning. Also in the rapidly growing world scarcity of clean water is dilemma as equal as green-house and ozone layer depletion. (3) The Sun is an inexhaustible source of energy capable of fulfilling all the energy needs of humankind. The energy from the sun can be converted into electricity or used directly. Electricity can be generated from solar energy either directly using photovoltaic (PV) cells or indirectly using concentrated solar power (CSP) technology. (4) a techno-economic analysis of the capacity of Morocco to produce hydrogen from solar energy has been conducted. For this reason, a Photovoltaic-electrolyze system was selected, and the electricity and hydrogen production were simulated for 76 sites scattered all over the country. (5) solar-energy-based technologies and research work conducted under cold climatic conditions. These conditions include mountainous, continental, cold oceanic and polar climates and in general, all climates where below Zero temperatures are common during the winter. (6) Utilization of solar energy for assisting the biomass conversion through thermochemical conversion process significantly improves the overall sustainability and process performance. This work reviews solar based technologies and their application to solar assisted biomass utilization and conversion technologies. (7) we propose a low-power maximum power point tracker (MPPT) circuit specifically designed for wireless sensor nodes (hence effective, flexible, low cost and power-aware), i.e., a power transferring circuit for optimally conveying solar energy into rechargeable batteries even in not optimal weather conditions. (8) For the case of a domestic water heating system, the saving, compared to a conventional system, is about 80% with electricity or Diesel backup and is about 75% with both electricity and Diesel backup. In the case of space heating and a hot water system the saving is about 40%. (9).

SOLAR THERMAL COLLECTORS

Evacuated-tube collectors are more efficient at higher temperature than flat plate collectors. (10) parabolic dish collectors focus solar energy onto a receiver to transfer fluid. (11) Nanoparticles are used to absorb concentrated sunlight and drive thermochemical reactions. (12) Hybrid PV-solar thermal collectors have shown increasing efficiency and reducing the need for building surface for installation. (13) The environmental impacts include resources consumption, air emission, water emission and potential environmental impacts such as global warming potential and ozone depleting potential. (14) Nanofluids have been used to enhance the performance of solar collectors. (15) The performance of silicon oil based MXene in CPVT system, showing an increase in thermal efficiency with addition of MXene nanoparticles. (16) Thermal energy can be stored through sensible heat, latent heat and thermochemical means using materials like water, ice phase-change materials and nanomaterials. (17) The addition of PCM inside the evacuated tube solar collectors aims to provide delayed heat and extend the operation of solar water heaters. (18)

Types of collectors with its conversion factor and thermal loss factor around a specific temperature

Difference (10)

Type of collector	Conversion factor	Thermal loss factor (kW/m^2 c)	Temperature(C)
Flat plate collector	0.66-0.83	2.9-5.3	20-80
Evacuated-plate collector	0.81-0.83	2.6-4.3	20-120
Reservoir collector	about 0.55	about 2.4	20-70
Evacuated-tube collector	0.62-0.84	0.7-2.0	50-120

Fig 1: Common base fluids used in heat transfer applications - most are transparent (12)

NANO PLATELETS

The world faces a challenge meeting future energy needs due to population growth and industry relying heavily on fossil fuels. To address this, research on renewable energies, especially solar power, is crucial. This study focuses on improving direct absorption solar collectors by using nanofluids, specifically graphene nanoplatelets in deionized water at different concentrations. The research examines the nanofluid's structure, stability, optical properties, and thermal conductivity. Results show that this nanofluid, with a strong absorption band between 250–300 nm, is recommended for use in direct absorption collectors, presenting a promising solution for future energy requirements. (19) In this study, they used a method called layer-by-layer to bring together graphene nanoplatelets. The graphene surface got changed by attaching poly (acrylic acid) and poly (acryl amide), creating a positive and negative charge. These oppositely charged nanoplatelets stuck together through electrostatic forces, forming multiple layers. Various tests like thermogravimetric analysis, Raman spectroscopy, and microscopy were done to show these changes. The study confirmed that this method works for making films with graphene, and UV-visible spectroscopy verified even growth across the film.(20) To make solar energy into heat, we studied special coatings at tiny levels, we did experiments to understand how these coatings act in rust conditions, modifying graphene pieces is crucial for putting them in coatings, Our modified products didn't mess up the coatings' looks, adding graphene bits really helps prevent rust a lot, Thinner coatings work just as well for anti-rust as thicker one, Our findings could help make cheap and reliable coatings for solar energy.(21) The research explores cement-based composites using graphene nano-platelets (GN) and hollow glass microspheres (HGM) to enhance their electromagnetic wave absorbing abilities, Results indicate an overall improvement in absorbing properties when GN and HGM are combined, showing a positive impact on the material's performance, The absorption peak and bandwidth below -5 dB exhibit an initial increase with the filling ratio of glass microspheres, reaching a maximum before decreasing. This suggests an optimal point for effective absorption, Multiple sharp peaks are observed, particularly at high frequencies, indicating the material's ability to efficiently absorb electromagnetic waves, Optimal absorbing properties are achieved when GN is at 0.2%, HGM is at 40% (vol/vol), and the thickness is 20 mm, resulting in an average reflectivity loss of -8.2 dB in the 2–18 GHz range with a bandwidth of 4.4 GHz below -5 db. The thickness of the sample significantly influences these absorbing properties, with an optimal range identified as 20–30 mm when 40% (vol/vol) HGM and 0.2% (wt/vol) GN are combined. (22) The study discusses the preparation of microcapsules for direct absorption solar collectors (DASC) using a combination of melamine-formaldehyde (MF) resin, octadecane core, and modified with reduced graphene oxide (rGO) and oleic acid-coated Fe_3O_4 magnetic nanoparticles (OA-MNs), The addition of rGO significantly improves the thermal conductivity of the magnetic phase change microcapsules (MPCMs) while having minimal impact on their phase change behaviour, The MF resin shell plays a crucial role as a protective barrier, enhancing the thermal stability of octadecane within the rGO-modified MPCMs, The rGO-modified MPCMs slurry exhibits superior optical absorption and thermal storage capacities compared to both MPCMs slurry and deionized water, thereby enhancing photo-thermal conversion performance, Under the influence of an external magnetic field, the rGO-modified MPCMs in the slurry demonstrate excellent controllability and recyclability, adding to their potential practical applications, The research suggests that the rGO-modified MPCMs slurry serves as a promising working fluid with broad application prospects for DASC, showcasing its potential impact on solar thermal utilization.(23) The research explores cement-based composites using graphene nano-platelets (GN) and hollow glass microspheres (HGM) to enhance their electromagnetic wave absorbing abilities, Results indicate an overall improvement in absorbing properties when GN and HGM are combined, showing a positive impact on the material's performance, The absorption peak and bandwidth below -5 dB exhibit an initial increase with the filling ratio of glass microspheres, reaching a maximum before decreasing. 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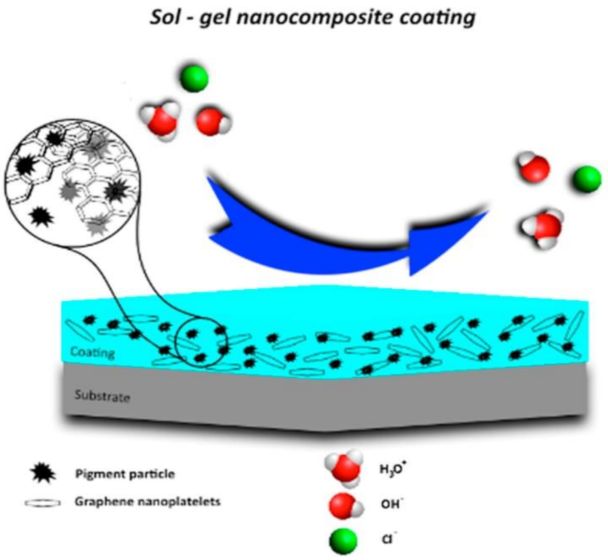
The thickness of the sample significantly influences these absorbing properties, with an optimal range identified as 20–30 mm when 40% (vol/vol) HGM and 0.2% (wt/vol) GN are combined.(24) Nanocomposites of graphene nano-platelets (GnPs) with varying ratios were incorporated into polyvinyl chloride (PVC) using a simple casting technique, DSC and TGA analyses revealed that PVC/GnPs with 0.5 wt% of GnPs exhibited the highest thermal stability among the nanocomposites, Increasing GnPs content led to improved thermal stability, with the residue increasing from 1.9% for pure PVC to 9.3% with the addition of 0.5 wt% of GnPs, Optical parameters such as penetration depth (δ), steepness parameter (S), and group velocity dispersion (GVD) decreased with higher GnPs content. Solar skin protection factor (SSPF) significantly improved in PVC/GnPs (2.5 wt%) compared to pure PVC, Optical oscillator strengths (f) increased substantially from 7.97 $(eV)^2$ for PVC to 90.8 $(eV)^2$ for PVC/GnPs (2.5 wt%). GnPs content affected various optical parameters, and the nanocomposite films' optical conductivity improved due to increased absorbance. DMA results indicated a 21% increase in storage modulus with 0.25 wt% of GnPs but a ~31% decrease with a higher GnPs ratio of 2.5 wt%. (25) This study explores using nano graphite platelets (NGPs) as fillers in cementitious composites, leveraging their unique hexagonal plane structure for enhanced mechanical, thermal, and electromagnetic properties. Results indicate that adding NGPs significantly alters these properties. At 5% NGP content, the composites show a 1.5-fold increase in hardness, a 71% reduction in abrasive loss, a 73% decrease in abrasion depth, a 77% rise in thermal conductivity, a 17.7% drop in specific heat, a 20% increase in damping ratio, and a 38% decrease in electromagnetic wave reflectivity compared to pure cementitious composites. This highlights the multifunctional benefits of NGPs in improving various aspects of cementitious composite performance. (26)



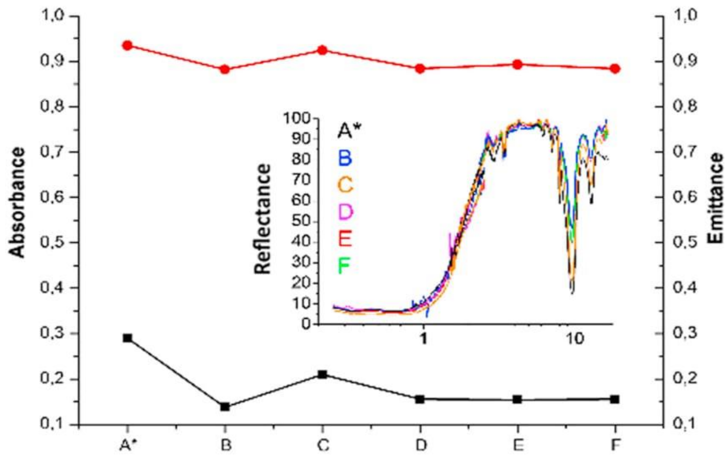
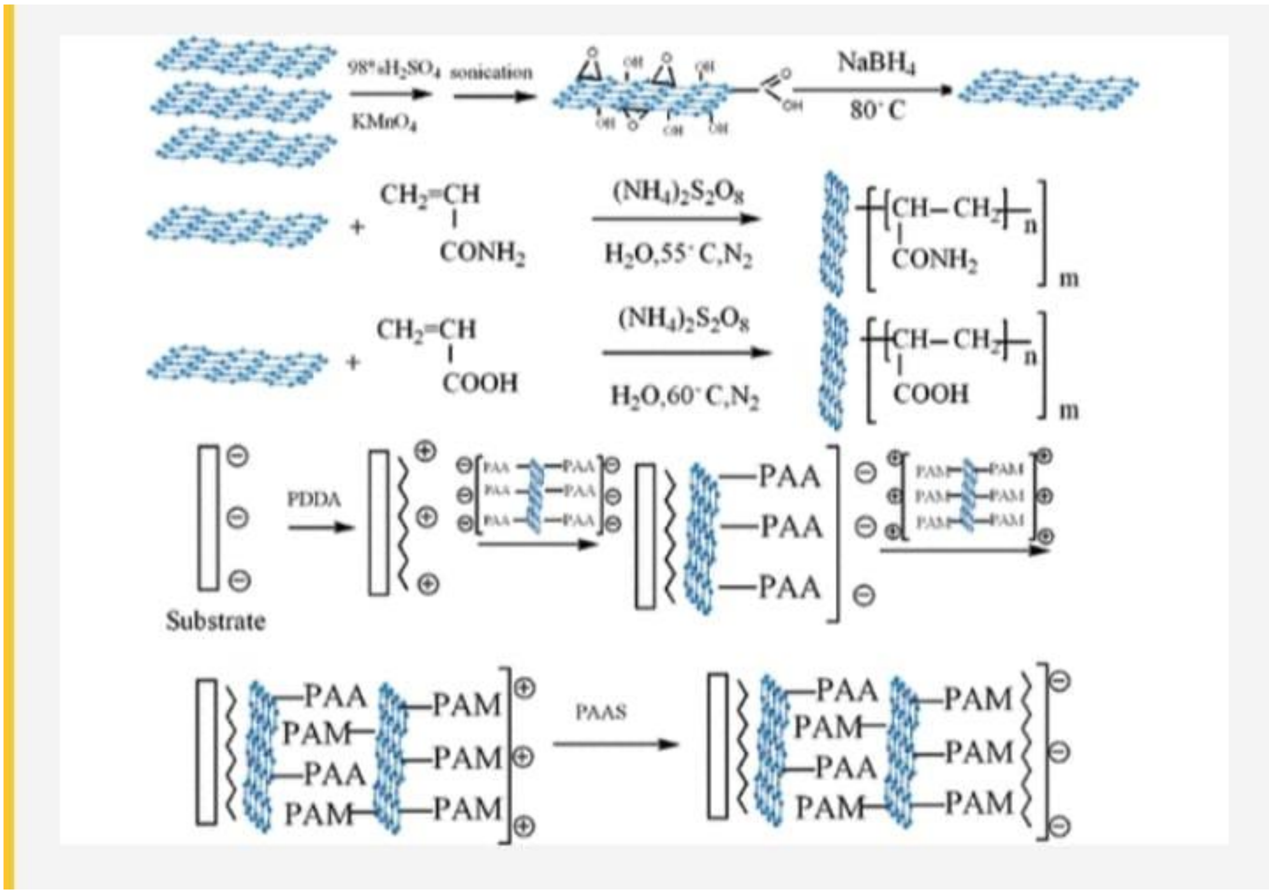


Fig 2 &3: in this, graphene nanoplatelets were self-assembled through the layer-by-layer (LBL) method. (20)



SILICON OIL

A new engine bearing alloy, Al Sn8 Si2. 5 Pb2 Cu0. 8 Cr0. 2, has been developed. Extensive experimentation has led to this composition, which shows excellent performance characteristics, particularly seizure resistance and wear resistance. (27) The optimization of power transformer insulation via the improvement of the characteristics of the most used insulating liquid, i.e., mineral oil. For that purpose, mixtures consisting of mineral oil and other insulating liquids (namely silicon and synthetic ester oils). (28) The presence of silicon in petroleum products is a major issue due to its poisoning effect on catalysts. The aim of this work is to combine silicon speciation and poisoning tests. Cyclic siloxanes were the main silicon species found in petroleum products. (29) The silicone oil-based fluids behave in a Newtonian manner in all the studied MWNT volume fractions and temperatures. The hexamethyldisilane added in silicone oil, in addition to decreasing the silicone oil viscosity, has little effect on the nanofluid rheological properties. (30) Low-drift agricultural formulations minimize fine droplets narrowing size distribution, Oil drops in a multiphase system facilitate liquid sheet breakup during atomization, Antifoam formulations (liquids, solids) help rupture of the thin films, Tested antifoam materials as good as current industry low-drift standards. (31) composition, physic-chemical properties, advantages, applications and practical use of individual vegetable oils as metal working fluid in environmental conscious machining to make the process environmentally friendly and less toxic for operators. (32) The aggregation behavior of silicone oil polymers exposed to Ar plasmas was investigated. A reptation aggregation related to the viscosity of silicone oil was found. The viscosity dependence $\eta \sim Lb$ on the reptation length L with b = 3.37 in the viscous coefficient range of 20 and 500 mm2 · s−1 was obtained. (33) Due to its lower energy consumption, higher mechanical properties and easier to control, magnetorheological (MR) fluid has been widely used in the engineering field, The friction and Wear behavior of Silicon oil-based Magnetorheological fluid with Solid lubricant. (34) In order to elucidate the tribological behavior of the Si3N4 ceramic used in automobile engine, a series of tests was carried out to measure the friction coefficient and wear resistance of Si3N4 during lubricated sliding against metals, the Si_3N_4 ceramic has excellent wear resistance, but also that the wear of the metal parts in contact with the Si3N4 ceramic decreased. (35)

CONCLUSION

The comprehensive exploration of solar energy in this paragraph highlights its pivotal role in addressing the escalating energy demands and environmental concerns. The Solar America Initiative in the United States and the global growth of solar energy underscore the importance of technological advancements and supportive government policies. Despite challenges posed by increasing energy requisition and climate issues, the Sun's inexhaustible potential remains a beacon for sustainable alternatives. From macro-level initiatives to micro-scale innovations, the diverse applications of solar energy, including solar thermal collectors and graphene nanoplatelets, reveal promising avenues for meeting future energy requirements. This multifaceted approach positions solar energy as a crucial solution for a sustainable and resilient energy future.

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We express our gratitude for the comprehensive exploration of solar energy, emphasizing its pivotal role in addressing escalating energy demands and environmental concerns. The acknowledgment extends to the Solar America Initiative in the United States and the global growth of solar energy, underscoring the significance of technological advancements and supportive government policies. Despite challenges posed by increasing energy requisition and climate issues, the Sun's inexhaustible potential remains a beacon for sustainable alternatives. Our appreciation extends to the efforts in both macro-level initiatives and micro-scale innovations, showcasing diverse applications such as solar thermal collectors and graphene nanoplatelets. These findings reveal promising avenues for meeting future energy requirements, positioning solar energy as a crucial solution for a sustainable and resilient energy future.

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