UC MERCED IS UNIQUELY ABLE TO RAPIDLY TRANSFER ITS INNOVATIONS INTO COMPETITIVE ADVANTAGES.

This document describes more than 40 technologies invented at UC Merced in the fields of natural sciences, engineering and medicine.

UC Merced builds relationships with environment-friendly industries that complement its teaching, research and public service mission.

For more details, contact UC Merced’s Office of Research at ott@ucmerced.edu
The University of California, Merced, opened its doors in 2005 with an ambitious mission to become a premier, world-class university focused on teaching, research and public service in the heart of California's rapidly growing San Joaquin Valley. During a short time, we have grown into a community of more than 4,300 students and more than 130 faculty members with credentials from some of the world’s top-ranked universities.

As with all other University of California campuses, UC Merced has a strong dedication to research and scholarship. We are proud to report that, even in our brief period of existence, UC Merced’s talented researchers have produced dozens of inventions that have the potential to change people’s lives, industries and communities.

A byproduct of these research activities is intellectual property that can be copyrighted or patented. A vital element of our public service obligation to the people of California is to ensure that these research discoveries make the responsible transition from idea to application as products or services that benefit the community and our society.

This report represents a major milestone in the continuing progress of UC Merced. It is with great pride that we share with you the fruits of our faculty’s research. This document catalogues the inventions generated from January 2007 to July 2010 and acknowledges the faculty who developed these fruits. Fifty-five inventions have been processed during this brief time, tracking the progress of larger, more established campuses, especially when considering that a disproportionate percentage of our faculty are assistant professors who are early in their careers.

Our deepest admiration and appreciation go to the faculty, staff and students identified in this document. Many thanks to Jennifer Biancucci, Vincent Cook, Scott Hernandez-Jason, James Leonard, Brenda Ortiz, John Shih, Leslie Teixeira and Richard Miller for the production of this report.
The University of California, Merced is a research university built on the rich traditions of the world’s preeminent public university system. Located 45 minutes from Yosemite National Park, UC Merced features state-of-the-art laboratories, talented student researchers and world-class faculty lured by the startup culture of a new university.
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BACKGROUND

The rising incidence of infectious bacterial strains that are resistant to multiple broad-spectrum antibiotics poses serious complications to the treatment of infectious diseases.

Absent knowledge of a given infectious agent’s susceptibility to various antibiotics, physicians face the dilemma of prescribing an antibiotic that may prove to be ineffective or prescribing an antibiotic capable of treating the most resistant strains but that, if used unnecessarily, may accelerate the breeding of even more resistant strains.

In these circumstances, selection of the optimal antibiotic requires rapid profiling of a bacteria’s susceptibility to various antibiotics. However, current methods for assaying susceptibility of a purified bacterial culture, involving observations of the strain’s visible growth in antibiotic media, can take up to a full day. Thus, there is an urgent need for more rapid methods for assaying susceptibility that are suitable for use in clinical settings.

DESCRIPTION

Researchers at UC Merced have developed a calorimetric technique that reduces the time needed for determination of a microbe’s susceptibility from 16 to 24 hours to as little as 2.5 hours.

In situations where purified strains can be obtained quickly (especially blood-borne diseases), the entire process from taking a sample to making a diagnosis can be reduced to six hours. At a minimum, the UC Merced invention is likely to reduce the time required for diagnosing bacterial antibiotic susceptibility (typically three to four days at present for most diseases) by a full day.

The basis for this invention was the discovery that antibiotics can have an almost immediate measurable effect on the thermal output of a growing culture in a suitable system.

Using the protocols and thermal measurement techniques of this invention, the efficacy of an antibiotic relative to a control is readily apparent long before visible colonies could be observed. There is a dramatic and unambiguous difference in the thermal signatures of normal growth versus antibiotic inhibition of non-resistant strains.

The UC Merced researchers have demonstrated the utility of this invention not only with E. coli, but also with K. pneumoniae, A. baumanii and P. mirabilis, and have also shown that thermal signatures can be used to characterize the effects of different antibiotic dosages.

APPLICATIONS

The UC Merced susceptibility assay may become the preferred system for clinical determinations of microbial susceptibility to antibiotics and might also be found useful in research and public health laboratory settings when rapid assays are desired.

ADVANTAGES

As compared to existing disk diffusion tests and minimum inhibitory concentration tests, the UC Merced thermal test for antibiotic susceptibility offers:

• much more rapid results, often in as little as 2.5 to 4 hours,
• quantifiable data that is also useful for determining dosage effects, and
• simple protocols and devices that can be automated.

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Suppression of Hepatitis C Virus Replication
AN AFFORDABLE TREATMENT TECHNIQUE THAT MAY SUPPRESS THE ABILITY OF THE HEPATITIS C LIVER VIRUS TO REPLICATE ITSELF

BACKGROUND

Hepatitis C is an infectious disease of the liver that afflicts approximately 200 million people worldwide, including 4 million Americans. The standard treatment for hepatitis C virus (HCV) infection is a combination of pegylated interferon and ribavirin. This combination treatment is effective in only about 50% of the patients infected with HCV genotype 1 (which accounts for 80% of all HCV cases in the United States), about 75% of the patients infected with HCV genotypes 2 and 3, and about 65% of the patients infected with HCV genotype 4.

The problem of these low sustained cure rates is compounded by a lack of prophylactic vaccine. For those patients who do not respond to interferon/ribavirin therapy, there are currently no alternative treatments available for controlling the virus.

Moreover, interferon/ribavirin therapy is very expensive and often causes severe side effects, meaning that many patients are unable to afford or to complete the treatment. Thus, there is an urgent need for new hepatitis C therapies that are more effective across a broad spectrum of HCV genotypes and are less burdensome to patients in terms of cost and in terms of adverse secondary health consequences.

DESCRIPTION

Using an in vitro model of HCV replication, a researcher at UC Merced discovered that intracellular hydrogen peroxide (H$_2$O$_2$), in concentrations low enough to be non-cytotoxic, can rapidly suppress HCV replication by inducing calcium ion release within an infected cell. The UC Merced researcher has shown that various indirect methods for stimulating intracellular H$_2$O$_2$ production inhibit HCV replication independently of the HCV genotype, and are therefore attractive candidates for a novel hepatitis C therapy.

These candidates identified by the UC Merced researcher include an FDA-approved class of pharmaceuticals, an inexpensive enzyme currently used as an in vivo biosensor, and various small polycyclic organic molecules that inhibit synthesis of antioxidant compounds. Initial studies in a human hepatoma cell line indicate that elevated intracellular H$_2$O$_2$ levels are as effective as interferon in decreasing HCV RNA levels. The suppression can occur as early as 15–30 minutes. The effects of H$_2$O$_2$ on HCV are also comparable to those of interferon as well as interferon plus ribavirin (see Frese et al., Guo et al., and Tanabe et al.).

APPLICATIONS

The UC Merced treatment may suppress HCV replication in the liver, offering a viable and potentially superior alternative to existing interferon/ribavirin-based HCV therapies.

As compared to existing therapies, this invention is:

- readily available in several forms, including FDA-approved compounds,
- likely to be effective across HCV genotypes,
- more affordable,
- likely to act rapidly, and
- not subject to severe side effects of the interferons.

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Chemical Modulation of Hepatitis C Virus Mutation Rates

A PROTECTION MODE THAT HELPS INHIBIT VIRAL RESISTANCE TO ANTI-HEPATITIS C DRUGS OR VACCINES

BACKGROUND

RNA viruses such as the hepatitis C virus (HCV) often quickly develop strains that evade host immune responses and vaccines and develop resistance to antiviral drugs. While both immunity and the efficacy of many antiviral drugs depend heavily on the specific features of the viruses, the high mutation rates occurring in these viruses (associated with the error-prone viral replication) increases the variability of such features and therefore facilitates the rapid emergence of resistant viral strains. With approximately 200 million people worldwide infected by HCV, including 35,000 to 185,000 new cases each year and 10,000 to 20,000 fatalities each year in the United States, overcoming the obstacles to effective drug therapies due to HCV’s high mutation rates is a high priority. However, prior to this invention there has been no effective means for defeating new resistant strains other than to continually develop new drugs or to administer high concentrations of combinatorial drugs. There are no anti-HCV vaccines.

DESCRIPTION

A scientist at UC Merced has invented a novel anti-HCV therapeutic strategy that combines anti-viral agents with agents that suppress HCV mutagenesis. The scientist discovered that HCV mutagenesis depends on the presence of certain kinds of genotoxic agents that would amplify the error-prone nature of HCV’s RNA genome replication mechanism by damaging the viral RNA. As shown in figures 1 and 2 below, other chemical agents that block or neutralize such genotoxic agents can dramatically reduce RNA damage and the sequence heterogeneity of HCV RNA, indicating that these agents may thereby act as protective agents for preventing or slowing down the emergence of resistant HCV strains.

APPLICATIONS

The protective agents identified in this invention can be incorporated into existing and new anti-HCV therapies to inhibit the emergence of viral resistance to anti-HCV drugs or vaccines. This mode of protection might also inhibit the development of drug resistance by other RNA viruses.

ADVANTAGES

This invention is unique in its potential to slow down the development of drug resistance by RNA viruses; at present no other therapies employ this approach. Thus, this invention may offer a means for extending the useful life of both existing drugs and new drugs, and might even make anti-HCV vaccines feasible.

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BACKGROUND

For producing RNA viruses, applications such as drug screening or basic research require immortalized tissue cultures that enable efficient production of fully infectious viruses of a genotype of clinical interest and are easy to use. In the case of hepatitis C virus (HCV), however, existing tissue culture systems yield incompletely replicated viruses (which do not infect cells in vitro), work only transiently, or are not robust enough and otherwise yield viruses with less prevalent HCV genotypes such as genotype 2. Thus, there is a need for a continuous or semi-continuous HCV production system that overcomes these limitations with the generation of a fully infectious HCV of genotype 1.

DESCRIPTION

Researchers at UC Merced have stably transfected immortalized human cells with a CG1b construct that can release infectious HCV of genotype 1b into the cell culture media. The researchers demonstrated the infectivity of this media using Huh7 and Huh7.5 cells (figure 1).

APPLICATIONS

The UC Merced tissue culture system may find widespread use in numerous research and drug discovery applications where efficient and continuous production of completely replicated, fully infectious HCV is required.

ADVANTAGES

The UC Merced tissue culture system, along with the JFH1 system, are the only continuous tissue culture systems that can efficiently generate HCV that can infect Huh and other cells in vitro. Unlike JFH1, this invention can replicate HCV genotype 1b, which is more prevalent and of greater clinical interest than the HCV genotype 2 produced by JFH1.

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BACKGROUND

Relatively large surface areas and great sensitivity to environmental conditions make carbon nanotubes (CNTs) very promising candidates for sensing elements.

However, all existing CNT sensing methods based on electronic or acoustic techniques require complicated nanotube architectures involving multiple fabrication steps. Such complexity can increase the probability of material defects and often requires CNTs of very high purity. Such problems have blocked the commercialization of CNT sensor systems.

DESCRIPTION

A researcher at UC Merced has invented a molecular sensing system based on the optical properties of CNTs. Starting with CNTs suspended on a thin film substrate, one can process the suspended CNTs according to this invention to render CNT optical properties highly sensitive to the presence of biomolecules or other molecules of interest.

APPLICATIONS

This invention is generally useful for molecular sensing applications, particularly sensors for biomolecules. Given the thin film substrate used in the UC Merced CNT sensor system, it could be easily integrated into devices such as labs-on-chips.

ADVANTAGES

UC Merced CNT molecular sensors:

• are ultrasensitive,
• can be integrated into labs-on-chips,
• use a simple architecture with facile manufacturability,
• are more tolerant of CNT synthesis imperfections, and
• can employ any type of CNT with a diameter <2.0 mm.
Efficient Syntheses of Tetraketone Steroid Precursors

A LOW-COST WAY TO ENCOURAGE PRODUCTION OF MOLECULES THAT SPEED THE RECOVERY OF BURN VICTIMS, IMPROVE THE QUALITY OF LIFE IN AIDS PATIENTS AND FIGHT BREAST CANCER

BACKGROUND

Steroids constitute an important class of pharmaceuticals, including compounds for treating andropause and menopause, for speeding the recovery in burn victims, for helping improve the quality of life in AIDS patients, for fighting breast cancer and for staving off osteoporosis.

At the heart of steroid molecules are steranes, which consist of four fused rings of carbon atoms (three cyclohexane rings and one cyclopentane ring). There are also newer classes of important pharmaceuticals based on steroid-like scaffolds. In practical commercial-scale syntheses of steroids and other sterane-based compounds, it is desirable to start with single tetraketone rings, which can then be converted into fused bicyclic ketones, which in turn can be used as precursors of steroids.

The key to lowering the cost of such synthetic pathways is to lower the cost of the tetraketone reactants and to provide for stereoselective conversions of these tetraketones into fused bicyclic ketones. Such tetraketones would also lower the cost of synthesizing novel variants of the basic steroid structure.

DESCRIPTION

A UC Merced researcher has invented an efficient one-step synthesis of cyclopentane and cyclohexane tetraketones using low-cost reactants. These tetraketones in turn are suitable for facile stereoselective syntheses of fused bicyclic precursors of steroids and other sterane-based compounds using a simple amino acid catalyst and a low-cost solvent.

APPLICATIONS

The UC Merced tetraketones can be cyclized stereoselectively for use as reactants in the practical syntheses of steroids and other sterane-based bio-active molecules, especially in situations where costs and stereoselectivity are major concerns, as is the case with steroid pharmaceuticals and other sterane-based pharmaceuticals.

ADVANTAGES

The UC Merced tetraketones offer an additional synthetic handle as compared to conventional precursors of fused bicyclic structures, notably in enabling facile stereoselective cyclization. The syntheses of these tetraketones use low-cost reactants, offering a yield of approximately 90%. Also, these tetraketones offer an avenue into synthetic motifs of greater variability than has existed previously.

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Affinity Purification Scheme for PC-PLC
A PURIFICATION METHOD FOR A NEW CLASS OF POTENTIAL ANTI-INFLAMMATORY DRUGS

BACKGROUND
Phosphatidylcholine-specific phospholipase-C (PC-PLC) is an important enzyme in a number of signal transduction pathways, including pathways involving inflammation and apoptosis. It is thought that PC-PLC inhibitors might serve as a new class of anti-inflammatory compounds.

At present, only one inhibitor (D609) with poor specificity is known, so it would be highly desirable to fully characterize the structure of the PC-PLC protein so that novel, more efficacious inhibitors can be designed. However, purified PC-PLC protein has not been isolated yet nor its corresponding gene identified, so PC-PLC’s structure is unknown.

DESCRIPTION
Researchers at UC Merced have invented an affinity purification scheme for PC-PLC.

Starting with a particular modification of D609, it should be possible to isolate PC-PLC and determine its sequence, which can then enable one using standard techniques to construct a genetic sequence to produce a purified form of PC-PLC that is suitable for detailed determination of its structure and for the design and testing of inhibitors.

APPLICATIONS
The UC Merced affinity purification scheme may facilitate the design and testing of a novel class of anti-inflammatory candidate pharmaceutical compounds.

ADVANTAGES
So far, PC-PLC has only been crudely characterized in terms of its molecular weight. This invention is the first process with a reasonable prospect of going beyond this to enable full characterization of PC-PLC, which in turn is necessary for generating candidate PC-PLC inhibitors via a structural design strategy.
Background

Compounds for inhibiting viral entry into cells offer a promising component of microbiocidal creams or gels for prevention of HIV infections. The basis for such HIV entry inhibition is to block one or more of the interactions between HIV envelope glycoproteins (the gp120 cap and gp41 stem proteins) and surface proteins on the target immune system cells (the CD4 co-receptor and a chemokine receptor, usually CCR5 or CXCR4) that are necessary for HIV’s attachment and fusion to the target cell.

The protein Griffithsin and its derivatives are known to be a potent anti-HIV agents that function in this manner, binding to the sugar groups on the surface of gp120 and gp41. Griffithsin can also be cheaply produced in large quantities, and is therefore a strong candidate for use in microbiocidal formulations.

Notwithstanding Griffithsin’s advantages, it still suffers from some problems that also plague other potential HIV entry inhibitors, namely the greatly elevated concentrations required for efficacy in vivo and the potential for HIV mutations to create resistance to Griffithsin-based prophylactic compounds.

Description

A researcher at UC Merced has invented a family of Griffithsin analogs, involving a cross-linkage of Griffithsin to other peptide sequences that add an additional prophylactic function to the protein. Not only do these bifunctional Griffithsin analogs bind the sugar groups of HIV envelope glycoproteins, they also bind certain amino acid sequences of gp41 and/or gp120. These analogs have been shown in cell fusion assays and in single round virus assays to be highly effective in blocking HIV infection.

Applications

The UC Merced Griffithsin analogs are strong candidates for use as a component in microbiocidal creams and gels for preventing sexually-transmitted HIV infections.

Advantages

By binding at least two glycoprotein sites, the UC Merced Griffithsin analogs are even better than Griffithsin alone in blocking HIV entry (with a potential to lower the concentration required for microbiocidal formulations), and are less likely to be vulnerable to the development of drug resistance than Griffithsin alone.
BACKGROUND

Embryonic stem cells are used for producing a number of cell types in vitro, including endothelial cells, vascular progenitor cells and hematopoietic cells. However, the derivation of these cell types from stem cell progenitors and their ongoing maintenance often requires the use of serum-containing cell culture media, which can lead to batch variations and to contamination of the cells by unknown animal proteins or by other exogenous materials such as cytokines.

DESCRIPTION

UC Merced researchers have invented a serum-free culture medium formulation for the differentiation and maintenance of vascular mammalian vascular genes, designated “LDSk.” With the addition of a few specific growth factors and other compounds to a basal medium, LDSk provides chemically well-defined culture conditions for the directed differentiation of vascular progenitor and endothelial cells that also eliminates batch variation and unknown exogenous factors that plague serum-containing cultures. As shown in the flow cytometry graphs below (figure 1), LDSk consistently induces differentiation of human embryonic stem cells into endothelial cells.

APPLICATIONS

LDSk may become the preferred culture medium for growing and maintaining cell types derived from mammalian (including human) stem cells, most notably vascular progenitor cells and endothelial cells.

ADVANTAGES

The UCM LDSk medium:

- is not prone to the batch variation characteristic of serum-containing culture media;
- does not contaminate cell cultures with unknown cytokines or other exogenous compounds; and
- is suitable for deriving endothelial and mesodermal cell types from human embryonic stem cells.

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FIGURE 1: Relative staining frequencies of human embryonic stem cells grown in LDSk. These show that the cells are expressing the mesodermal marker Flk-1; the endothelial markers VE-cadherin, Flt-1, and Tie-1; and a marker specific for arterial endothelial cells, Ephrin B-2. All markers are significantly elevated relative to the negative controls in these samples, demonstrating LDSk’s induction of cell differentiation.
Neuron Regeneration Using Embryonic Stem Cells

An Innovative Process to Facilitate the Growth of Stem Cells That Have the Potential to Cure Neurological Disorders

**BACKGROUND**

Neural stem cells offer great potential for treatment of neurodegenerative disorders such as Alzheimer's disease, Parkinson's disease and Huntington's disease; for treatment of neural dysfunctions such as dementia and epilepsy; and for repairing debilitating neural injuries such as brain traumas, spinal cord traumas and strokes. However, adult stem cells for certain types of neural tissues are not available in sufficient quantities for commercial purposes. Embryonic stem cells may overcome this limitation, but growing neural cell types from them has been hampered by the difficulty in obtaining homogenous cell populations, in obtaining the glial cell subtype, and in obtaining a suitable culture media.

Moreover, the full regeneration of neuron tissue requires the correct geometric orientation of neural cells, not just the growth and differentiation of stem cells into the required neural cell types. On a normal culture surface, a neuron cell grown in vitro will extend its axons in all directions, thereby failing to replicate the parallel, cell-to-cell orientation of axons found in vivo. At present, there are no simple and economical methods available for growing, differentiating and correctly orienting embryonic stem cells to regenerate functional neurons.

**DESCRIPTION**

A scientist at UC Merced has invented a growth media supplement and a device for aligning cell growth, both of which facilitate quick, reliable, high-yield production of neurons from embryonic stem cells.

The growth media supplement, consisting of a few simple and inexpensive compounds that are added to standard growth media, facilitates a much more rapid and reliable differentiation of stem cells into neural cell types than is currently available. The alignment device consists of a thermoplastic sheet with a specially-modified surface that acts as a substrate for orienting the cells, so that neurons will form in parallel on the surface during the process of stem cell differentiation.

The growth media supplement, consisting of a few simple and inexpensive compounds that are added to standard growth media, facilitates a much more rapid and reliable differentiation of stem cells into neural cell types than is currently available. The alignment device consists of a thermoplastic sheet with a specially modified surface that acts as a substrate for orienting the cells so that neurons will form in parallel on the surface during the process of stem cell differentiation.

**APPLICATIONS**

These UC Merced inventions could be commercially significant for enabling the manufacture of neuronal lineages useful for treating various neurological disorders and diseases, for repairing brain and spinal cord injuries, and for related medical research.

**ADVANTAGES**

These inventions eliminate the need for the slow, labor-intensive methods currently used for growing and differentiating embryonic stem cells to produce neuronal lineages. The growth media supplement reduces the time needed for the differentiation process from two to three weeks to just a few days. The alignment device is the first practical technology for regenerating neurons from stem cells in vitro that feature the correct in vivo orientation.

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BACKGROUND

Since 1988, the Food and Drug Administration has required that the enantiomeric composition of all drugs be known, making stereoselective reactions essential for the pharmaceuticals industry.

However, the reactions used to establish chirality at one or more stereocenters often are not sufficiently stereoselective to warrant asymmetric synthesis, thus necessitating the addition of costly stereoisomer resolution steps. Chiral pool resolution strategies have two significant limitations that are responsible for the growing popularity of stereoselective syntheses:

Isolation of a desired stereoisomer from the chiral pool imposes severe limitations on reaction yield; and resolution steps often entail the use of environmentally damaging solvents, which increases costs associated with waste disposal.

A significant body of research has shown that it is often possible to increase stereoselectivity in asymmetric reactions using high pressure and thus bypass or minimize costly purification steps; however, high pressure apparatus is infeasible for syntheses on the kilogram scale and above.

APPLICATIONS

This invention is generally useful for amplifying stereoselective reactions in pharmaceutical syntheses, including reductions, allylations, hydroaminations, hydroformylations, cyclizations and cycloadditions.

Other syntheses requiring enantiomeric specificity, such as for producing specialty reagents and agricultural compounds, might also employ this invention.

ADVANTAGES

The apparatus required for the UC Merced method for increasing stereoselectivity:

• is inexpensive and commonly available,
• has a high throughput, and
• can be applied to a wide variety of stereoselective reactions.

DESCRIPTION

Researchers at UC Merced have discovered an alternative physical method for increasing the stereoselectivity of reactions without the problems associated with methods involving a high-pressure apparatus.

Like methods using high static pressures, the UC Merced method enhances stereoselectivity by favoring the transition state with the more negative volume of activation. So far, initial tests of the method with Alpine Borane reductions of various benzaldehydes and ynones have shown great promise, with excellent (>95%) selectivity being achieved after a few hours.
BACKGROUND

Lasers used in conjunction with optical parametric oscillators (OPOs) are the state of the art for generating ultrafast wavelength-agile light pulses.

This agility property means that OPOs can greatly extend the range of wavelengths that a laser can generate and enables one to continuously change the wavelength of each laser pulse, making laser + OPO light outputs uniquely suited to a wide variety of industrial and scientific research applications.

Fiber-based optical parametric oscillators (FOPOs) are promising as a cost-effective alternative to currently-deployed OPO technologies, but are limited in most designs by their restricted wavelength tunability and pulse duration flexibility.

More advanced types of FOPOs, featuring four-wave mixing mediated by non-linear non-linearities in the glass, are able to overcome these shortcomings and achieve a useful level of wavelength agility, but they in turn have problems with low power outputs and narrow bandwidths.

DESCRIPTION

A UC Merced researcher has discovered that a simple modification of a particular parameter in FOPO fiber design leads to previously unexpected results.

Taking advantage of this insight, the researcher has designed advanced FOPOs capable of providing an output pulse energy >100 pJ with a bandwidth >100 Hz while preserving full wavelength agility.

The invention is compatible with different types of oscillator mechanisms, including mirror pairs and ring feedback loops, and with fibers incorporating photonic crystal fiber materials or other microstructure fiber materials.

APPLICATIONS

This invention may be the preferred approach for many OPO-based laser applications. OPOs are used in such fields as:

- spectroscopy, particularly for resolving fast chemical or biological reactions,
- pump-probe measurements of semiconductor properties,
- multi-photon excitations to induce fluorescence or photochemical reactions,
- micromachining/microfabrication, and
- imaging of biomaterials at wavelengths of increased transparency.

ADVANTAGES

The UC Merced FOPOs offer greater power and bandwidth over other advanced FOPO designs while retaining their wavelength agility.
DESCRIPTION

UC Merced researchers have synthesized novel enantiomeric chiral alcohols, derivatives of a phenyl isobutanol. These compounds feature a conformationally restrictive methyl group on the phenyl group adjacent to the alcohol functionality.

APPLICATIONS

The UC Merced chiral alcohols are potential candidates for chiral auxiliaries, chiral ligands and alcohol precursors to other types of ligands, such as thiols or amines.

ADVANTAGES

The conformational restrictiveness of these compounds are highly advantageous for applications involving use as a chiral auxiliary or ligand, and could be beneficial in sterically occluding undesired reactions. The synthesis of these compounds involves a one-step procedure with enantiomeric yields >99%.
BACKGROUND

For computational tasks involving cognitive functions such as perception, classification, memory and attention, the massively parallel circuitry and dynamic interconnection of nodes characteristic of neural networks have distinct advantages over conventional computer circuits. Accordingly, there is great commercial interest in developing nanoscale chips that simulate neural network computation, devices known as “liquid state machines” (LSMs).

One key requirement for LSMs is to mimic the processing of a signal (in neurons taking the form of a transmembrane voltage spike, or “action potential”) at the interconnections between neurons (the synapses), which triggers an action potential spike in the adjacent neuron(s) while potentially giving rise to physical changes in the synaptic connections, thus dynamically altering signal processing over time.

DESCRIPTION

A UC Merced researcher has invented a mathematical model of LSM memory and computation suitable for simple implementations in conventional computer hardware and software. The UC Merced LSM model also goes beyond a simple biological analogy in its treatment of spike potentials, permitting signals that serve to stabilize network dynamics in an optimal state. Thus, this invention can be used to create a new class of LSMs that self-tune to attain critical branching, while retaining all the desired functionality of ordinary neural computation.

APPLICATIONS

This invention offers for the first time clear-cut dynamical rules for the design of LSM circuit architectures, greatly enhancing the feasibility of nanoscale LSM chips for next-generation computing.

ADVANTAGES

In contrast to existing LSMs that require ad hoc tuning, LSM implementations of the UC Merced model can self-tune, achieving the full informational and computational potential of critically branched networks without manual adjustment of LSM parameters.
BACKGROUND
Stochastic methods have been broadly applied for operational risk management in the industry of forecasting trends. The method can generate prediction for any time-dependent quantity (stock market, weather data, solar and wind power production, etc.). However, the conventional models that use divided differences and even integer differentials of input variable are not effective in the situation that incomplete or limited history data are accessible. It's desirable to be able to capture the non-local stochastic nature of the input variable and the important history effects, to predict better results for any nonlinear or complex trend.

DESCRIPTION
A researcher at UC Merced introduced a novel concept that extending the restricted definition of variable order operator to any order and an effective numerical method that using generalized order differentiation and integration of input variables to forecast trends.

The methodology consists of selecting appropriate input variables, applying generalized differintegral operators to these variables and using different streams of functional behavior as inputs for an artificial neural network (or any other stochastic method) to predict future trends. It has been successfully implemented to enhance the forecasting with real data of solar irradiance.

APPLICATIONS
The novel UC Merced invention can be used to forecast any nonlinear or complex trend. Applications include (but are not limited to):

- solar and wind forecasting,
- weather forecasting, and
- stock market forecasting.

ADVANTAGES
The methodology offers substantially better forecasting models and allows more accurate prediction of complex trends, particularly when data input is incomplete or limited.
Inexpensive Nanoparticle-Based Expectorant

A nanoparticle that could make for an economical, effective alternative to current over-the-counter decongestants

BACKGROUND

Expectorants are a class of medications that help dissolve thick mucus and thus relieve respiratory congestion. Widely-used expectorants such as guaifenesin, currently found in many popular over-the-counter formulations like Robitussin® and Mucinex®, can have problems with drug interactions or with side effects such as allergic reactions, nausea and vomiting. The challenge in creating viable competitors to existing expectorant compounds, however, is that they must also be economical to manufacture and easy to deliver to the respiratory system as well as have fewer side effects.

DESCRIPTION

Researchers at UC Merced have found that an inexpensive, easily produced nanoparticle can act as an expectorant without any additional drugs, chemicals, or enzymes. The UC Merced nanoparticle acts as a mucolytic agent, chelating the Ca++ ions that are crucial for cross-linking mucin proteins. The resulting chelates are repulsed from the glycans linked to mucin peptides, thereby promoting the dispersion of the chelated calcium and thus facilitating a more rapid breakdown of the mucin network. The researchers showed that in vitro mucin aggregates, gelated to approximately 7 µm diameter particles, could be broken down to particles less than 1 µm diameter in less than an hour using a 10 mg/L concentration of the UC Merced nanoparticles.

APPLICATIONS

Expectorant medications based on the UC Merced nanoparticles are attractive candidates for use in over-the-counter cough formulations and for the treatment of thick, viscous mucus associated with devastating respiratory diseases such as asthma, bronchitis, cystic fibrosis and chronic obstructive pulmonary disease.

ADVANTAGES

The UC Merced nanoparticles have a very promising commercial potential, as they are:

- economical to manufacture;
- easy to deliver via nasal sprays or inhalers;
- relatively inert compounds that are not likely to produce serious side effects;
- amenable to localized delivery, as nanoparticles of varying sizes can penetrate at different depths within the bronchial tree; and
- open to further chemical modification as needed for enhancing efficacy or for minimizing cellular cytotoxicity.
The introduction of foreign DNA or RNA into cells is a process of fundamental importance to modern genetics and biotechnology. There are many techniques for facilitating passage of nucleic acids through cell membranes, including viral transduction, transfection via chemical (such as cationic polymers and liposomes) or physical (such as electroporation) permeabilization of membranes, and transfection via mechanical penetration of membranes (such as microinjection and gene guns).

However, these techniques are constrained by serious tradeoffs, especially when dealing with cells that are relatively more fragile or less numerous, as is often the case with mammalian cell cultures. Generally speaking, the techniques that do the least harm to the cells while maintaining reasonable transfection efficiencies are also the most difficult techniques to use.

Gentler transfection techniques require time-consuming procedures such as conjugation reactions, nucleic acid encapsulation, or nanoparticle functionalization. Also, they require relatively expensive reagents that are often prone to being dissociated or digested without special storage and handling.

Thus, there is a need for new techniques that are more rapid and easier to use, while avoiding the damage to cells typically encountered with viral transduction and brute-force permeabilization techniques.

Researchers at UC Merced have discovered that unfunctionalized metal oxide nanoparticles, when mixed with nucleic acids in a suitable serum-free media, can transfect cells in a rapid, economical manner. For example, when using titanium dioxide (TiO₂) nanoparticles in this procedure, one can transfect Chinese Hamster Ovary cells with efficiencies of ~0.5%–3.0% in less than 24 hours. Similar efficiencies have been obtained using this technique to transfect mouse embryonic stem cells and to transform E. coli cells. The preparation of the nanoparticle/nucleic acid solution and the cells is exceedingly simple and direct, so that very little labor is involved in setting up this transfection reaction. Since the nanoparticles are not chemically bound to the nucleic acids or any other compound, they are effective as permeabilizing agents without subsequently interfering with nucleic acids within transfected cells.

This invention is generally applicable to introducing any kind of foreign nucleic acid into any kind of cell, though the benefits of this technique are particularly evident in transfection of cells that are relatively fragile and less numerous, especially mammalian cells. It could therefore achieve a significant market share for transfection reagents.

As compared to existing techniques for transfection and transduction, the UC Merced transfection technique:

• avoids severe cytotoxicity and phenotype alterations in transfected cells while maintaining high transfection efficiencies,
• employs nanoparticles that are stable at room temperatures and relatively easy and inexpensive to make, and
• is rapid and easy to do, requiring relatively little labor.

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BACKGROUND

Currently available contraceptives such as hormone-containing pills, intrauterine devices and barrier devices (e.g., condoms, sponges and cervical caps; often used in conjunction with spermicidal compounds) have a number of serious shortcomings — they can be expensive, invasive, prone to adverse side effects (including hormonal disregulation and secondary infections) or unreliable — so ongoing development of new contraceptive methods remains an area of great interest.

A potentially less problematic alternative for preventing fertilization involves alteration of mucus found in the reproductive tract (cervical mucus). Since hydration and proper dispersal of cervical mucus plays an important role in sperm mobility, one could restrict sperm movement by inducing excessive aggregation of the mucus. An agent that thickens cervical mucus sufficiently might achieve contraception by forming an insurmountable barrier to sperm movement.

DESCRIPTION

Researchers at UC Merced have invented a novel class of contraceptives based on nanoparticles that induce cervical mucus thickening. While the cross-linking of mucin polymer strands is normally limited by the amount of Ca++ and Mg++ ions present, the UC Merced contraceptive nanoparticles directly potentiate much greater mucin cross-linking without introducing any additional drugs, chemical irritants or enzymes.

APPLICATIONS

The UC Merced nanoparticles or their derivatives are attractive candidates as components in contraceptive formulations intended for use immediately prior to sexual activity. Such formulations might be applied in the form of an ointment, gel or spray, or they might be used along with spermicides in conjunction with barrier devices.

ADVANTAGES

The UC Merced nanoparticle contraceptives are:

- economical to manufacture;
- easy to deliver via topical formulations;
- fast-acting, allowing application immediately prior to sexual activity; and
- relatively inert compounds that are not invasive nor likely to produce severe side effects.

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BACKGROUND

Technological advancement demands new types of transducer materials that can efficiently sense and convert force and energy form one type to another for signal processing and modulation, switching and actuation, sensing and energy harvesting. It is also desirable to have transducer materials that mimic cylindrical outer hair cells and retinal cells and able to detect and convert signals instantly and reliably with exceptionally high coupling efficiency at reduced size. Nanocomposite materials could provide the necessary advantages, but are difficulty to be synthesized with controlled morphology and interface characteristics.

The rod-coil copolymer systems have attracted widespread interest in both fundamental understanding of the thermodynamics that control nanoscale self-assembly in polymers, as well as technological implication associated with the unique characteristics of the novel designed systems. With inception of the responsive polymer system designed by the inventors, for the first time, there are opportunities to design materials without the compromises typically found in conventional composites. The rationally synthesized nanomaterials can be processed in a thin film format, which provides a platform for technology innovation.

DESCRIPTION

A researcher at UC Merced has developed novel responsive polymers that comprise a hard segment that deforms upon light stimulation and a soft segment that deforms upon thermal stimulation, and nanomaterial-polymer composite comprising the novel responsive polymers.

The UC Merced invention can be applied for polymeric transducer materials and sensor systems. This polymer system and its associated composite 1D nanomaterials can be processed into hybrid thin film and directly incorporated into MEM-based device platforms.

APPLICATIONS

This invention relates to the field of transducer materials, which are used for sensing, amplifying and converting light and heat into macroscopically detectable forms for signal processing, modulation and energy conversion.

The broad application areas range from energy saving, energy harvesting, aerospace, automotive and electronics to biotechnology.

ADVANTAGES

The UC Merced polymer system and its 1D nanohybrid thin films have:

• greatly increased number of cycle times;
• faster response and recovery times;
• significant enhanced sensitivity (temperature and light) with amplified responses; and
• covalent linkage with nanoscale functional moieties to create hybrid nanomaterial systems with new functionalities and properties hitherto unattainable.
BACKGROUND

Lithium-Ion Batteries (LIBs) have been commonly applied in consumer electronics, especially for portable electronics. LIBs have unique properties such as low energy-to-weight ratios and slow loss of charge when not in use, etc., thus there is a growing demand for their use in national defense, electrical vehicles and medical devices. LIB technology has been actively pursued by researchers to improve the performance in energy density, durability, cost and safety.

Despite enormous potential, the use of LIBs is still limited by the lack of complementary cathode material with high discharge and charge rates. The promising use of lightweight polymer gels has been explored, due to their unique network structure and properties such as allowing more transition metal incorporation to achieve higher percentages electroactive sites, and providing shorter diffusion distance for Li+ ions to electroactive sites to facilitate Li+ ions’ attachment and detachment during charging and discharging.

DESCRIPTION

A researcher at UC Merced has developed a new type of cathode material to be used for LIBs. The material is composed of multi-walled carbon nanotubes covalently bound with a polymer gel matrix, in which redox centers are embedded.

The new cathode material is lighter with higher content of cathode material. It may potentially provide more than 300mAh/g energy density based on the theoretical calculation. The polymer gel like structures allows facile Li+ ion insertion/extraction, yielding higher power density. Multi-walled carbon nanotubes enhance electron transport, thus improving energy conversion efficiency. No lattice morphing occurs during charging and discharging cycles. As a result, cycle life is expected to be improved.

APPLICATIONS

The broad potential applications include:

- PORTABLE DEVICES: wireless communication devices, portable computers, cameras, portable power drills, saws and vacuum cleaners;
- ELECTRICAL TRACTION: hybrid and electric vehicles and provide backup for wind and solar energy; and
- MEDICAL DEVICES: longer-lasting and smaller batteries for powering implantable devices such as defibrillators and implantable hearing assist devices; and the new breed of nerve micro stimulators.

ADVANTAGES

The UC Merced innovative polymer-carbon nanotube gel for LIB cathode materials simultaneously provides:

- high energy density;
- high power rate;
- enhanced life cycle; and
- flexible cathode material.
The generation of electricity from sunlight is currently not cost-effective in many situations because of the inherent limitations of photovoltaic (PV) cells and typical lighting conditions. The production of commonly-used silicon PV cells demands expensive semiconductor fabrication methods and consumption of limited high-grade silicon feedstocks. Newer thin-film cell technologies, while using cheaper fabrication methods, consume even scarcer exotic materials. Moreover, at typical sunlight intensities, PV cells are relatively inefficient, requiring large panels for a given peak power output.

To reduce costs, it is desirable to increase PV cell efficiencies while minimizing the use of costly materials and fabrication techniques. One promising way to accomplish this is with concentrator PV (CPV) systems, where an inexpensive optical element (usually made of glass) covering a large sun-lit area is used to greatly concentrate the light onto a small PV cell. Higher light intensities enable higher efficiencies in converting sunlight to electricity while greatly reducing the size of the PV cell required. One important limitation of CPV, however, is the need to keep the concentrator surface aligned with the sun. For CPV to become cost-competitive with conventional PV technology, CPV designs must become less stringent in their alignment requirements (i.e. higher acceptance angles).

A researcher at UC Merced has invented a CPV design that features much wider acceptance angles than in other CPV systems while maintaining a high level of efficiency, a high concentration factor and more uniform illumination. The UC Merced researchers had previously developed CPV systems featuring glass sheets functioning in a Cassegrain reflective or a Fresnel lens configuration, and a non-imaging secondary element at the focal point that even distributes the concentrated light over a small PV cell. In their new CPV invention, the secondary element was replaced with an element that has a reflective inner surface.

This new type of secondary element uses specular reflections and (optionally) total internal reflections to achieve more uniform illumination of the small PV cell at wide acceptance angles. As with their previous designs, this CPV can be used with both silicon PV cells and with multi-junction PV cells.

This invention may become a preferred design for CPV systems, helping make CPV more competitive as compared to fixed panel arrays for solar electricity generation.

This novel Fresnel lens concentrator design offers a number of potential benefits over previous concentrator technologies, including:

- simple design with few parts,
- relatively low material costs,
- high optical efficiency,
- high angular tolerance to ameliorate tracking requirements,
- uniform light distribution over photovoltaic cells, and
- suitability for use with advanced cell technologies.

As compared to their previous Fresnel lens concentrator design, this invention, with its novel secondary element, offers more uniform illumination at wide acceptance angles.

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BACKGROUND

Generating electricity from sunlight is currently not cost-effective in many situations because of the inherent limitations of photovoltaic (PV) cells and typical lighting conditions. The production of commonly-used silicon PV cells demands expensive semiconductor fabrication methods and consumption of limited high-grade silicon feedstocks.

Newer thin-film cell technologies, while using cheaper fabrication methods, consume even scarcer exotic materials. Moreover, at typical sunlight intensities, PV cells are relatively inefficient, requiring large panels for a given peak power output.

To reduce costs, it is desirable to increase PV cell efficiencies while minimizing the use of costly materials and fabrication techniques. One promising way to accomplish this is with concentrator PV (CPV) systems, where an inexpensive optical element (usually made of glass) covering a large sun-lit area is used to greatly concentrate the light onto a small PV cell.

Higher light intensities enable higher efficiencies in converting sunlight to electricity while greatly reducing the size of the PV cell required. One important limitation of CPV, however, is the need to keep the concentrator surface aligned with the sun. For CPV to become cost-competitive with conventional PV technology, CPV designs must become less stringent in their alignment requirements (i.e. higher acceptance angles).

DESCRIPTION

Researchers at the University of California, Merced have invented a CPV design that features much wider acceptance angles than in other CPV systems while maintaining a high level of efficiency and a high concentration factor.

The UC Merced researchers had previously developed CPV systems featuring glass sheets with two reflective surfaces in a Cassegrain configuration and a non-imaging secondary element at the focal point that even distributes the concentrated light over a small PV cell.

In their new CPV invention, the UC Merced researchers retained the benefits of having the non-imaging secondary element but improved on their older CPV design by changing the primary optics into a Fresnel lens configuration and by incorporating an additional design element for better regulating the PV cell environment. This Fresnel lens CPV can be used with both silicon PV cells and with multi-junction PV cells.

APPLICATIONS

This invention may become a preferred design for CPV systems, helping make CPV more competitive as compared to fixed panel arrays for solar electricity generation.

ADVANTAGES

This novel Fresnel lens concentrator design offers a number of potential benefits over previous concentrator technologies, including:

- simple design with few parts,
- relatively low material costs,
- high optical efficiency,
- high angular tolerance to ameliorate tracking requirements,
- uniform light distribution over photovoltaic cells, and
- suitability for use with advanced cell technologies.
BACKGROUND

The generation of electricity from sunlight is currently not cost-effective in many situations because of the inherent limitations of photovoltaic (PV) cells and typical lighting conditions. To reduce costs, it is desirable to increase PV cell efficiencies while minimizing the use of costly materials and fabrication techniques.

One promising way to accomplish this is with concentrator PV (CPV) systems, where an inexpensive optical element (usually made of glass) covering a large sun-lit area is used to greatly concentrate the light onto a small PV cell. Higher light intensities enable higher efficiencies in converting sunlight to electricity while greatly reducing the size of the PV cell required. Optimization of solar concentrator design depends on maximizing light concentration and optical efficiency while enabling facile alignment of the system with the sun.

DESCRIPTION

A UC Merced researcher has invented a CPV design that features higher light concentrations than in other CPV systems coupled with high efficiency and a generous acceptance angle for easy solar tracking. In this CPV design, a glass element with two aspherical surfaces (a small portion of one surface being metallized) achieves high light concentrations by refracting the incident light and generating a pair of internal reflections. The emergent light beam yields an aplanatic image focused on a PV cell mounted on one of the surfaces.

APPLICATIONS

This invention may become a preferred design for CPV systems, helping make CPV become more competitive as compared to fixed panel arrays for solar electricity generation. The concentrator optical element might also be used in reverse to provide a highly collimated light beam from light emitting diodes.

ADVANTAGES

This UC Merced solar concentrator design offers a number of potential benefits over previous concentrator technologies, including:

• higher light concentration (1,200x),
• high optical efficiency (81% on axis),
• large acceptance angle (±3° at 90% intensity),
• compact size (~20:1 ratio of optical element thickness to PV cell width).

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BACKGROUND

The high cost of photovoltaic (PV) cells poses a serious obstacle to cost-effective generation of solar electricity. To reduce costs, it is desirable to increase PV cell efficiencies while minimizing the use of costly materials and fabrication techniques.

One promising way to accomplish this is with concentrator PV (CPV) systems, where an inexpensive optical element (usually made of glass) covering a large sun-lit area is used to greatly concentrate the light onto a small PV cell. Higher light intensities enable higher efficiencies in converting sunlight to electricity while greatly reducing the size of the PV cell required.

This has been a difficult goal to attain, however, since conversion efficiency and other key cost factors in CPV design are governed by multiple variables, including the degree of light concentration, the efficiency of light transmission to the PV cell, the acceptance angle of the primary optical element, and the compactness of the optical elements. To achieve such gains in conversion efficiency, there is a pressing need for novel design methods that meet the unique optical requirements of solar concentrators.

DESCRIPTION

A researcher at UC Merced has developed a general method for designing optical systems incorporating reflective and/or refractive elements that uniformly illuminate an exit aperture, which in turn can be a suitable location for a PV cell or for an entry aperture of an additional non-imaging concentrator.

Since the sun is an extended light source that might be slightly off-axis, there are stringent requirements for the design of the reflective and refractive elements, specifically to homogenize light to achieve Köhler illumination of the exit aperture.

The UC Merced researcher has specified a general mathematical representation of these requirements that can be used to optimize a wide variety of CPV designs.

APPLICATIONS

This CPV design method is of general application in this field, including commonly-used configurations of optical elements such as Cassegrain and Fresnel designs. It has already been used as the basis for a number of other recent UC Merced CPV inventions, including a CPV that is in commercial production.

ADVANTAGES

Because of the importance of optimizing multiple parameters in practical CPV systems, design methods of this type are indispensable for realizing the full potential of CPV for reducing the costs of generating solar electricity.
The generation of electricity from sunlight is currently not cost-effective in many situations because of the inherent limitations of photovoltaic (PV) cells and typical lighting conditions. To reduce costs, it is desirable to increase PV cell efficiencies while minimizing the use of costly materials and fabrication techniques. One promising way to accomplish this is to raise light intensities at the PV cell surface with concentrator PV (CPV) systems, where an inexpensive optical element covering a large sun-lit area is used to greatly concentrate the light onto a small PV cell.

However, a critical problem with many CPV systems is the expense of mounting and moving a CPV array to track the sun. Fixed concentrator arrays do not concentrate light as effectively as tracking arrays, thereby dissipating much of the efficiency gains associated with using concentrators in conjunction with PV cells.

A UC Merced researcher has invented a fixed CPV system that can achieve higher light concentrations and therefore greater PV efficiency than existing fixed concentrator designs.

The UC Merced fixed CPV system is similar to conventional trough-shaped reflector concentrators but features an unusual geometric arrangement of PV cells that significantly increases the average light intensity at the PV cell surface.

Overall, there is a five-fold concentration of light and ten-fold increase in power output relative to fixed PV panels without any concentrator, and a large enough acceptance angle (65 degrees east/west and 15 degrees north/south) that only rough seasonal adjustments of the concentrator are required. Because it relies on reflective elements, the optical efficiency of this CPV system is on the order of 90%, substantially better than many tracking CPV systems.

The UC Merced fixed CPV system may become a preferred design for CPV systems, helping make fixed CPVs more competitive relative to fixed non-concentrator PV arrays and relative to tracking CPV arrays.

This invention eliminates the need for costly tracking systems while achieving a useful increase in light concentration for increasing PV efficiencies and high optical efficiencies.
BACKGROUND

One of the major design goals in tracking solar concentrators is to capture light from a source that is extended in angular extent (the sun subtending approximately half a degree) and perhaps slightly off-axis (a few degrees being typical in solar concentrators intended for concentrator photovoltaic applications) and deliver it to an exit aperture such that the exit aperture is uniformly illuminated by the source (Köhler illumination).

It is also desirable to reduce the volume and mass of the concentrator relative to its surface area, meaning that the light-concentrating optical elements should be as thin as possible.

DESCRIPTION

A UC Merced researcher has developed a novel solar concentrator design involving two layers in the optical element, where the first layer employs a Fresnel-like arrangement of parabolic air gaps to reflect the incident light beam to a greater angle from the central axis as it passes to the second layer (effectively trapping the light within the second layer), while the second layer employs a series of internal reflections within the layer to concentrate the light at a central exit aperture. The two layers can be constructed as a single piece of any transparent material, such as glass or acrylic.

APPLICATIONS

The principal use for non-imaging concentrators is for generating electricity from photovoltaic cells at higher light concentrations (and thus smaller and less costly cells) than is the case without concentrators.

ADVANTAGES

This solar concentrator design combines light trapping and total internal reflection for light concentration with radial symmetry and skew invariance of the light pathways so that a highly concentrated, uniform illumination of the central exit aperture is achieved. The separation of light trapping and light concentration in two separate layers offers greater control over critical solar concentrator design parameters than other designs.

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Evacuated-tube solar collectors, in conjunction with non-tracking, non-imaging parabolic concentrators, can heat working fluids to 200°C at efficiencies near 50%, providing a relatively economical means for capturing and transferring solar energy for use in cooling, heating and power generation applications.

However, the transfer of heat from the solar energy-absorbing element to the working fluid within such collectors poses a significant challenge to the feasibility of these systems. It is a critical limitation of existing evacuated-tube collector designs because of trade-offs between resistance to heat transfer, cost and safety.

A scientist at UC Merced has recently invented an improved evacuated-tube solar collector design that incorporates mini-channels for circulating the working fluid in the absorber element.

While mini-channel technology helps overcome the limitation described above, a serious engineering problem remains in optimizing the coupling between the absorber mini-channels and the connecting manifolds. These manifolds, which enable the flow of the working fluid to and from the mini-channels, must connect to pipes that are much larger and possibly a very different shape than the mini-channels. At present, inlet-outlet manifolds that are suitable for this application are not commercially available.

Inlet-Outlet Manifolds For Mini-Channel Evacuated-Tube Solar Collectors

A UC Merced scientist has invented several manifold designs for mini-channel-based absorbers, including absorbers containing flat-plate and semi-circular arrays of mini-channels. Variations of these manifold designs include manifolds with separate inlet and outlet sections, and also featuring an end cap where the fluids from different mini-channels can mix and flow back to the manifold through a separate tube or a shallow slit on the surface of a mini-channel-containing pipe. The manifold can also assume several different forms, including drums or semi-circular tube arrays.

APPLICATIONS
The UC Merced input-output manifolds are necessary for implementing evacuated tube solar collector designs based on mini-channels, which could help realize the great potential of mini-channels for making such solar collectors commercially feasible.

ADVANTAGES
At present, this invention is the only technology that addresses the specific need for enabling the flow of working fluids into and out of mini-channels in solar collector absorber elements.

Figure 21. Evacuated tube solar collector assembly (not to scale).

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**BACKGROUND**

A key limit on the light-to-electricity conversion efficiency of existing photovoltaic (PV) materials is the fixed band gap energy needed to create electron/hole pairs.

Sufficiently energetic photons will waste whatever excess they have over the band gap level, while less energetic photons will not be converted at all. Crystal lattice vibrations (as in silicon PVs) can also squander the energy available in photons.

Carbon nanotubes (CNTs) are a promising alternative as a PV material. CNTs with different diameters and chiralities offer a plethora of bandgap energies that can cover a very wide range of light energies, thus significantly boosting the production of electron/hole pairs from incident sunlight.

One can optimize CNTs to match the solar spectrum, enhancing optical absorption and reducing carrier scattering. However, a remaining obstacle to realizing high efficiencies in CNT PVs is that interactions between thin film CNTs and substrate materials give rise to nonradiative recombination with low fill factors, resulting in low energy conversion efficiency.

**DESCRIPTION**

A UC Merced researcher has invented a three-dimensional CNT PV membrane that increases the fill factor of the CNT membrane via increased thickness without creating a problem with electronic screening. The CNT membranes of this invention eliminate nonradiative recombination, so that the potential of CNTs as a charge generation material can be fully realized.

**APPLICATIONS**

The UC Merced CNT membrane may become widely employed as a solar photovoltaic material.

**ADVANTAGES**

*The UC Merced CNT PV membrane offers a number of cost advantages, as it:*

- is an inexpensive, non-toxic material with great thermal and chemical stability,
- can be fabricated using conventional semiconductor fabrication technologies, and
- does not require materials like indium tin oxide.

*It also offers a number of advantages in terms of increasing PV conversion efficiency, as it:*

- is a direct bandgap material with a broad range of bandgaps,
- eliminates the nonradiative recombination typical of CNT thin film PVs, and
- offers graded photo absorption.
The combined effects of climate change, increasing energy consumption, and higher fuel prices are challenging universities and industry to develop more efficient ways to produce power, heating and cooling for commercial and residential applications. The utilization of renewable energy sources is receiving considerable attention as a non-resource-depleting approach that reduces the emissions of pollutants and greenhouse gases to the atmosphere.

In this respect, solar thermal systems provide the capability of generating heat, electric power, and/or cooling in a sustainable way and for a variety of applications due to the relatively large range of temperatures that different collector configurations can provide.

A UC Merced researcher has invented a combined thermodynamic cycle for simultaneous refrigeration, water heating and power generation using CO2 as a working fluid. This cycle employs multiple heat exchangers and loops for the working fluid (including a transcritical refrigeration loop), so that systems employing this cycle offer a number of important gains in efficiency and utility over existing systems. It can also accept heat inputs from other sources to generate even more power and hot water.

The proposed system achieves a 15% improvement in coefficient of performance (COP) with respect to a standard air conditioning system operating under the same conditions. The power/hot water generating loop can operate at much higher temperatures depending on the availability and quality of the additional heat. Energy obtained from solar collectors or from waste heat can be readily utilized for this purpose.

Systems incorporating the UC Merced combined cycle would be particularly useful in settings where refrigeration (e.g., air conditioning), water heating, and power generation are simultaneously required.

The advantages of the UC Merced combined cycle include:

- higher efficiency as compared to separate heating, cooling and power generation system, particularly with its higher COP for the transcritical refrigeration loop at ambient temperatures,
- production of power and hot water using energy from the refrigeration cycle that is wasted otherwise,
- production of power and hot water from other waste heat or renewable energy sources, and
- usage of an environmentally-friendly working fluid.

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Efficient Solar Concentrator With A Low-Cost Tracking Mechanism

AN EASIER WAY TO TRACK THE SUN'S MOVEMENTS TO USE SOLAR ENERGY TO HEAT GAS OR OTHER FLUIDS

BACKGROUND

Solar concentrators used for heating a working gas or fluid have serious trade-offs in terms of the concentration factor attainable (high light concentrations being desirable for achieving high temperatures and, in power generation applications, high thermodynamic efficiencies) versus the cost of mounting and moving relatively large reflective or refractive surfaces and their associated light-absorbing elements in order to track the sun’s movements across the sky.

DESCRIPTION

A UC Merced researcher has invented a new type of solar concentrator that enables one to greatly reduce the cost of the tracking mechanism while employing a reflective surface with a very large area in relation to the size of the light-absorbing element.

In this new UC Merced concentrator, only the light-absorbing element needs to be moved in order to track the sun, while the reflective surface remains fixed. The geometry of the concentrator design guarantees that high efficiencies can be maintained.

Moreover, the reflective surface can be formed using simple inflated balloon-type structures, further reducing the cost of the concentrator. Low-cost technologies can also be used for the light-absorbing element.

APPLICATIONS

This UC Merced solar concentrator may find widespread use in any application where a working gas or fluid needs to be heated by the sun, particularly in applications where high efficiencies and/or high temperatures are desirable.

ADVANTAGES

At present, this invention is the only technology that addresses the specific need for enabling the flow of working fluids into and out of mini-channels in solar collector absorber elements.

This solar concentrator design enables higher temperatures and efficiencies as compared to fixed concentrators, while greatly reducing the cost of the tracking mechanism by keeping the reflective surface in a fixed configuration. Also, this design permits the use of low-cost fabrication techniques for both the reflector and the absorber components.

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BACKGROUND

Evacuated-tube solar collectors, in conjunction with non-tracking, non-imaging parabolic concentrators, can heat working fluids to 200°C at efficiencies near 50%, providing a relatively economical means for capturing and transferring solar energy for use in cooling, heating and power generation applications.

However, the transfer of heat from the solar energy-absorbing element to the working fluid within such collectors poses a significant challenge to the feasibility of these systems.

It is a critical limitation of existing evacuated-tube collector designs because of trade-offs between resistance to heat transfer, cost and safety.

DESCRIPTION

A researcher at UC Merced has invented a new class of evacuated tube solar collectors that incorporate mini-channel technology.

Previously, mini-channel heat exchangers have been employed successfully in air conditioning and electronics cooling applications to achieve high performance and compact designs. The new UC Merced invention uses them to increase the amount of heat transferred from an evacuated-tube solar collector’s energy-absorbing element to the working fluid. Based on numerical simulations, efficiency gains of nearly 5% can be obtained at inlet temperatures of ~180°C can be achieved using the mini-channel solar collectors.

APPLICATIONS

This invention may become a preferred design for evacuated-tube solar collectors, heating working fluids in non-tracking arrays to provide energy for heating, for solar cooling or for power generation via organic Rankine cycles (ORCs).

ADVANTAGES

This mini-channel solar collector has the potential to significantly increase heat transfer efficiency in compact evacuated-tube systems without compromising safety (unlike Dewar-based collector designs where glass tube breakage is possible) or adding to fabrication costs (unlike collector designs that require multiple glass-to-metal seals or more substantial condensers).

Mini-channel technology has already been proven to be cost effective in other heat transfer applications.
BACKGROUND

Solar concentrators are relatively compact optical components that concentrate sunlight to heat a working fluid or to generate electricity from photovoltaic cells at higher efficiencies than is possible from unconcentrated sunlight. In the case working fluids, higher efficiencies are due to the higher working temperatures realized. For photovoltaic applications, concentrators can greatly economize on the use of expensive photovoltaic cell materials.

A common solar concentrator design employs a refractive material that admits light on one surface and a combination of internal reflections to concentrate and focus the light on a small spot on another surface using a Cassegrain-type optical pathway. The efficiency of such a system is limited, however, by unavoidable optical aberrations — minimizing such aberrations with an aplanatic concentrator design is necessary for achieving the thermodynamic limits of concentrator efficiency. Dielectric layers or other special materials facilitate the most compact concentrator designs, but conventional design methods (based on rotations of 2-dimensional mathematical solutions for correcting optical aberrations) are very difficult to calculate and implement due to the complex shapes of the resulting surfaces and the requirements of compact designs.

DESCRIPTION

Researchers at UC Merced have invented an aplanatic concentrator design with surface geometries arranged according to a novel three-dimensional mathematical solution for minimizing aberrations. The UC Merced design can reach the thermodynamic limits of efficiency with reasonably wide acceptance angles (about 2° or greater) and high concentration levels (greater than 1,000).

APPLICATIONS

This invention may find use in any application requiring a highly efficient light concentration, especially in applications involving solar energy.

ADVANTAGES

These UC Merced aplanatic concentrator designs are relatively easy to calculate and implement as compared to other high efficiency concentrator designs and can be made exceptionally compact due to the three-dimensional mathematical optimization used.

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BACKGROUND

For many solar energy applications, it is desirable to increase the light flux incident upon a light absorbing element such as a photovoltaic (PV) cell or a tube used for heating a working fluid. The use of a light-concentrating collector can be a significant factor in lowering overall system costs, particularly by increasing the energy conversion efficiency of the light absorbing element and by decreasing the size of the light absorbing element (a particularly important cost consideration for expensive PV cells). However, concentrators also have a serious drawback – excessive heating of a light-absorbing element can cause serious decreases in light conversion efficiency. In a typical PV cell, for example, each 1°C increase in temperature reduces its light-to-electricity conversion efficiency by ~0.5%. Thus, a significant ongoing challenge in solar collector design is to optimize the overall thermodynamic efficiency of the system, not merely to facilitate high light concentrations on the light absorbing surfaces.

DESCRIPTION

A researcher at UC Merced has invented a new method for designing thermodynamically efficient solar concentrators. Unlike previous design methods that merely maximize light concentration at the absorber surface, this invention also takes into account the emission of radiation from the absorber surface back to the sky. By minimizing the reflection of infrared radiation back to a concentrator PV cell, for example, one can reduce PV cell temperature and therefore achieve significant gains in light conversion efficiency.

APPLICATIONS

The UC Merced solar collector design method is likely to be used in any solar collector application where radiation from the light-absorbing surface is important, as is the case in concentrator PV systems.

ADVANTAGES

This solar collector design method is the first to optimize the overall thermodynamic efficiency of the light absorbing element of a solar collector, enabling greater collection and conversion of light to useful forms of energy than is possible with other design methods.
### BACKGROUND

Solar thermal concentrators are used by concentrating solar radiation and converting it to high-temperature steam or gas to drive a turbine or motor engine for power generation. A wide range of concentrating technologies have been developed. However, it remains a challenge and in demand to optimize the overall thermodynamically efficient solar thermal systems in achieving the engineering optimum.

Evacuated solar thermal tubes are widely used as solar collectors and come in a variety forms. An innovative design methodology based on the combination of optimal nonimaging optics and heat transfer techniques produces a remarkable effective nontracking solar collector for high temperature. It promises to be well applied in balancing the competing engineering constrains in constructing the collector.

### APPLICATIONS

A researcher at UC Merced has revealed the methodology that provides a pathway for the designers to make rational and optimal design choices of the reflector and absorber configuration in an evacuated solar thermal tube.

By incorporating the new concentrating principle and improving the reflector technology, the researcher also developed a prototype solar collector, which is a cost-effective, single-ended tube with a metal cylindrical absorber inside an evacuated glass envelope. The innovative collector has thermal performance of about 50% efficiency at 200°C, and angular performance of 32 degree acceptance, perfectly adequate for a non tracking east-west solar collector for high-temperature application.

### ADVANTAGES

The thermodynamically efficient solar thermal collector combines the features of being:

- non-tracking;
- high-temperature; and
- low-cost.

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Luminescent solar energy concentrators can concentrate both diffuse and direct solar radiation and require no tracking system. These characteristics have advantages for providing the devices and techniques to improve the efficiency of solar power systems. However, for the technology to become economically viable in the marketplace and cost-competitive with the conventional forms of solar energy systems, the overall power generation efficiency of the system needs to be increased.

Previous works demonstrated the application of luminescence to concentration of solar radiation by applying optical waveguide technology, which guides the frequency-shifted light via total internal reflection (TIR) to an energy transducer that comprises a photovoltaic cell. The typical conversion efficiencies achieved have been in the 3% to 5% range. The present invention discloses an improved apparatus design that significantly increases the overall conversion efficiency of the system.

A luminescent solar energy concentrator comprises an apparatus, which includes an optical waveguide containing quantum dot material or other suitable luminescent materials that respond to incident light by emitting frequency-shifted light. Researchers at UC Merced improved the waveguide by further employing a highly efficient diffusely-reflecting bottom layer in conjunction with a narrow-band reflecting top layer to the wave-guide. The innovation significantly raises the overall energy conversion efficiency range of the system by factors of two to three.

The UC Merced invention has application in converting solar energy to electricity, and for light sensing and other sensor-related technologies.

The low conversion efficiency of previous luminescent concentrator technologies has been a barrier to their practical implementation. The current improvement increases the efficiency by factors of two to three, thus bringing the technology into the range of economic viability.
Effective optical imaging design is critical for concentrating photovoltaic and concentrating solar thermal energy systems. One of the design goals is to produce high solar flux and a desirable uniform irradiance on the photovoltaic cell, which further convert lights into electrical output effectively.

A previous solution was to use kaleidoscopic prism. However, the kaleidoscopic glass mixer is bulky, the material is expensive for mass production, and the mounting is difficult. A promising new solution based on combining aplanatic optics with Köhler illumination has been invented.

Researchers at UC Merced have improved the optical system design based on principle of combining aplanatic optics with Köhler illumination. The new type of solar concentrator effectively produces a desirable uniform irradiance on the solar cell by placing a Köhler lens near the focal plane of the aplanatic system. This is different from the previous design by the group, where the Köhler element was integrated into a two-reflector aplanatic system.

The improved UC Merced design of solar concentrator is applicable to concentrating photovoltaic systems and is particularly suitable for concentrating photovoltaic systems with multi-junction solar cells.

The design with a Köhler homogenizer for aplanatic solar concentrators offers advantages including:

- uniform irradiance distribution;
- small and simple lens element; and
- no need to glue the cell.
BACKGROUND

The optical concentrators for solar energy generation are applied in both concentrating photovoltaic (CPV) and concentrating solar thermal (CST) technologies. The high-level concentrators move to track the sun across the sky in order to maximize the amount of sunlight that hits the solar cell; the low-level concentrators are stationary with fixed direction but use prisms and magnifying lenses to maximize the solar collection. Since it adds costs and complexity to apply a tracker, the stationary solar concentrator is always attractive, especially when high concentration is not critical. The maximum concentration for the stationary solar concentrators has been actively explored.

The theoretical maximum concentration for the hollow concentrators (consists of medium with refractive index $n=1$) were found typically between one to two times depending on hours of sunlight collection. By filling the hollow concentrator with dielectric medium (with refractive index $n=1$), the concentration limit can be increased. However, it remains a question how high the concentration can be for a practical dielectric design. In the real world application, there are practical constraints on possible optical designs, including but not limited to geometry shape, size and weight.

DESCRIPTION

Researchers at UC Merced gave the theoretical limits concentration allowed by non-imaging optics for the stationary solar concentrators. Different from previous analysis commonly performed in real space, the new method is carried out in direction cosine space on a polar plane.

The inventors demonstrated the design principles for maximizing the concentration using several real, practical examples. These examples include a hollow CPC trough, a dielectric CPC trough and a 3D dielectric stationary solar concentrator which is designed with practical considerations and concentrates sunlight four times, eight hours per day, year round.

APPLICATIONS

The UC Merced method has application in photovoltaic and other solar energy collection and conversion systems.

ADVANTAGES

The disclosed practical 4X concentrator approaches the theoretical concentration limit for a stationary solar concentrator.

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One significant aspect of UC Merced’s public service mission is to ensure that the results of its research are made available for public use and benefit.

This “technology transfer” is accomplished in many ways through educating students, publishing results of research and ensuring that inventions are developed into useful products in the commercial marketplace for public use.

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