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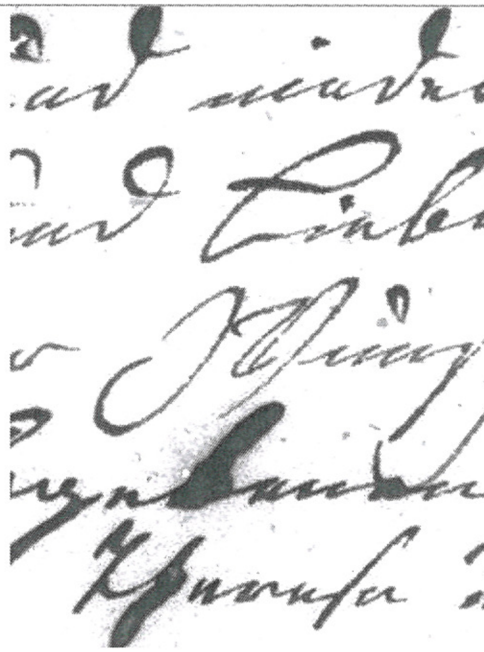
Article 1

New method to identify inks could help preserve historical documents

Date: June 18, 2014

Source: American Chemical Society

The inks on historical documents can hold many secrets. Its ingredients can help trace trade routes and help understand a work's historical significance. And knowing how the ink breaks down can help cultural heritage scientists preserve valuable treasures. In a study published in the Journal of the American Chemical Society, researchers report the development of a new, non-destructive method that can identify many types of inks on various papers and other surfaces.



A better way to analyze inks could help preserve treasured historical documents.

Credit: ACS

Richard Van Duyne, Nilam Shah and colleagues explain that the challenge for analyzing inks on historical documents is that there's often very little of it to study. Another complication is that plant- or insect-based inks, as well as some synthetic ones, are composed of organic molecules, which break down easily when exposed to light. Current methods are not very specific or sensitive or can leave a residue on a document. To address these issues, the research team set out to develop a different way to analyze and identify historical inks.

They used the novel method, called tip-enhanced Raman spectroscopy (TERS), to analyze indigo and iron gall inks on freshly dyed rice papers. They also studied ink on a letter written in the 19th century. "This proof-of-concept work confirms the analytical potential of TERS as a new spectroscopic tool for cultural heritage applications that can identify organic colorants in artworks with high sensitivity, high spatial resolution, and minimal invasiveness," say the researchers.

The authors acknowledge funding from the Andrew W. Mellon Foundation, the Grainger Foundation and the National Science Foundation.

Story Source:

The above story is based on materials provided by **American Chemical Society**. *Note: Materials may be edited for content and length.*

Journal Reference:

1. Dmitry Kurouski, Stephanie Zaleski, Francesca Casadio, Richard P. Van Duyne, Nilam C. Shah. **Tip-Enhanced Raman Spectroscopy (TERS) forin SituIdentification of Indigo and Iron Gall Ink on Paper**. *Journal of the American Chemical*

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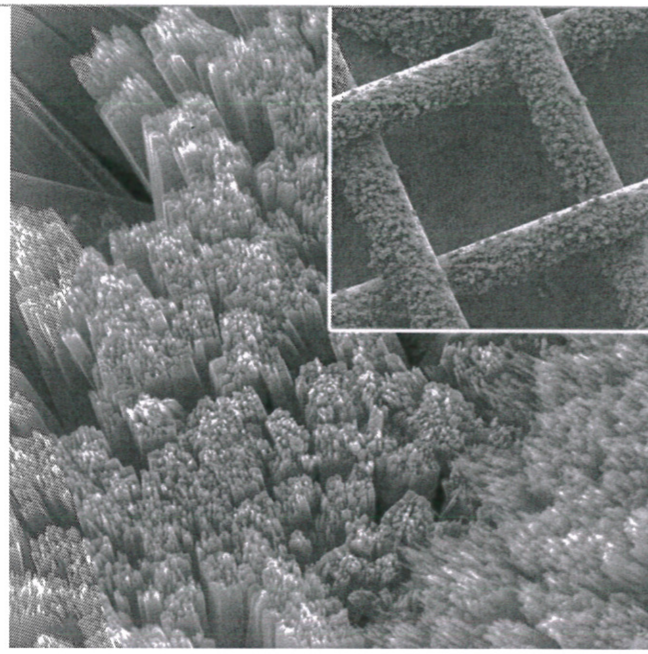
Article 2

Batteries included: A solar cell that stores its own power

Date: October 3, 2014

Source: Ohio State University

Is it a solar cell? Or a rechargeable battery? Actually, the patent-pending device invented at The Ohio State University is both: the world's first solar battery.



Researchers at The Ohio State University have invented a solar battery -- a combination solar cell and battery -- which recharges itself using ... [show more]

Credit: Yiying Wu, The Ohio State University

In the October 3, 2014 issue of the journal *Nature Communications*, the researchers report that they've succeeded in combining a battery and a solar cell into one hybrid device.

Key to the innovation is a mesh solar panel, which allows air to enter the battery, and a special process for transferring electrons between the solar panel and the battery electrode. Inside the device, light and oxygen enable different parts of the chemical reactions that charge the battery.

The university will license the solar battery to industry, where Yiying Wu, professor of chemistry and biochemistry at Ohio State, says it will help tame the costs of renewable energy.

"The state of the art is to use a solar panel to capture the light, and then use a cheap battery to store the energy," Wu said. "We've integrated both functions into one device. Any time you can do that, you reduce cost."

He and his students believe that their device brings down costs by 25 percent.

The invention also solves a longstanding problem in solar energy efficiency, by eliminating the loss of electricity that normally occurs when electrons have to travel between a solar cell and an external battery. Typically, only 80 percent of electrons emerging from a solar cell make it into a battery.

With this new design, light is converted to electrons inside the battery, so nearly 100 percent of the electrons are saved.

The design takes some cues from a battery previously developed by Wu and doctoral student Xiaodi Ren. They invented a high-efficiency air-powered battery that discharges by chemically reacting potassium with oxygen. The design won the $100,000 clean energy prize from the U.S. Department of Energy in 2014, and the researchers formed a technology spinoff called KAir Energy Systems, LLC to develop it.

"Basically, it's a breathing battery," Wu said. "It breathes in air when it discharges, and breathes out when it charges."

For this new study, the researchers wanted to combine a solar panel with a battery similar to the KAir. The challenge was that solar cells are normally made of solid semiconductor panels, which would block air from entering the battery.

Doctoral student Mingzhe Yu designed a permeable mesh solar panel from titanium gauze, a flexible fabric upon which he grew vertical rods of titanium dioxide like blades of grass. Air passes freely through the gauze while the rods capture sunlight.

Normally, connecting a solar cell to a battery would require the use of four electrodes, the researchers explained. Their hybrid design uses only three.

The mesh solar panel forms the first electrode. Beneath, the researchers placed a thin sheet of porous carbon (the second electrode) and a lithium plate (the third electrode). Between the electrodes, they sandwiched layers of electrolyte to carry electrons back and forth.

Here's how the solar battery works: during charging, light hits the mesh solar panel and creates electrons. Inside the battery, electrons are involved in the chemical decomposition of lithium peroxide into lithium ions and oxygen. The oxygen is released into the air, and the lithium ions are stored in the battery as lithium metal after capturing the electrons.

When the battery discharges, it chemically consumes oxygen from the air to re-form the lithium peroxide.

An iodide additive in the electrolyte acts as a "shuttle" that carries electrons, and transports them between the battery electrode and the mesh solar panel. The use of the additive represents a distinct approach on improving the battery performance and efficiency, the team said.

The mesh belongs to a class of devices called dye-sensitized solar cells, because the researchers used a red dye to tune the wavelength of light it captures.

In tests, they charged and discharged the battery repeatedly, while doctoral student Lu Ma used X-ray photoelectron spectroscopy to analyze how well the electrode materials survived -- an indication of battery life.

First they used a ruthenium compound as the red dye, but since the dye was consumed in the light capture, the battery ran out of dye after eight hours of charging and discharging -- too short a lifetime. So they turned to a dark red semiconductor that wouldn't be consumed: hematite, or iron oxide -- more commonly called rust.

Coating the mesh with rust enabled the battery to charge from sunlight while retaining its red color. Based on early tests, Wu and his team think that the solar battery's lifetime will be comparable to rechargeable batteries already on the market.

The U.S. Department of Energy funds this project, which will continue as the researchers explore ways to enhance the solar battery's performance with new materials.

Story Source:

The above story is based on materials provided by **Ohio State University**. The original article was written by Pam Frost Gorder. *Note: Materials may be edited for content and length.*

Journal Reference:

1. Mingzhe Yu, Xiaodi Ren, Lu Ma, Yiying Wu. **Integrating a redox-coupled dye-sensitized photoelectrode into a lithium–oxygen battery for photoassisted charging**. *Nature Communications*, 2014; 5: 5111 DOI: 10.1038/ncomms6111

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Article 3

How salt causes buildings to crumble

Date: September 11, 2014

Source: ETH Zurich

Salt is a big problem for buildings in Havana's old town, which lies by the sea.

Credit: Julio Llopiz / ETH Zurich

Salt crystals are often responsible when buildings start to show signs of ageing. Researchers from the Institute for Building Materials have studied salt damage in greater depth and can now predict weathering processes more accurately.

Historic stone buildings are tourist magnets. The Jordanian rock city of Petra, the medieval town of Rhodes in the Aegean Sea and the sandstone temples at Luxor, Egypt, for example, attract hundreds of thousands of visitors each year. These cultural assets all have one thing in common: they suffer from weathering caused by salts. These crystallise inside the porous building materials and generate enough force for the stone to break or crumble. The same problem also occurs in concrete buildings in this country. Researchers at the Institute for Building Materials at ETH Zurich and at Princeton University have now conducted an experiment to test the effect of salts under controlled conditions. They are hoping the results will help conservators and restorers of cultural assets to predict the weathering process of buildings.

Salt can enter building materials in a variety of ways, explains Francesco Caruso, a post-doctoral researcher in the group of Robert Flatt, Professor of Building Materials. Cement, for example, a component of concrete, always contains gypsum (calcium sulfate) and alkali sulfates, both of which are salts. Building materials can also be infiltrated by salt from the environment, such as through mineralised ground water close to the surface, which permeates porous building materials through capillary force, or via the atmospheric pollutant sulfur dioxide, which reacts with the calcium carbonate in limestone to form gypsum.

Damage can also be caused by de-icing salt and seawater spray that accumulates on the surface of buildings. "If these salts are dissolved by rain, the saline liquid can enter the building material through pores and cracks," explains Caruso. The salts crystallise as the liquid dries out and evaporates, causing parts of the stonework to crumble away.

Temperature differences lead to salt accumulation

For their laboratory experiment, the ETH researchers used sodium sulfate, the most destructive salt known and which exists in two forms: anhydrous and hydrated. In several cycles, the researchers placed limestone cubes with a side length of two centimetres into a sodium sulfate salt bath, allowing the salt solution to permeate the pores of the limestone. They then dried the stones at high temperature before placing them in the salt bath again at a lower temperature for the next cycle. During the drying phases, the salt crystallised in the stone's pores in anhydrous form. In the salt bath phases, the salt solution permeated the pores again and the crystallised salt turned back into a liquid solution.

With this controlled cyclical process, the scientists managed to accumulate a large amount of salt within the stone and create a supersaturated salt solution with respect to the hydrated form. A supersaturated salt solution is a liquid in which, because of special circumstances, more salt is dissolved than would be possible under normal circumstances.

Important findings for restorers

The experiment showed that the greater the supersaturation, the greater the salt's destructive potential. Temperature also played a role: in cycles in which the temperature never fell below 25°C, it took an average of four cycles before damage occurred. When the temperature dropped to 3°C, one cycle was enough. "Although these wet and dry cycles play a part, supersaturation is the most important factor," explains chemist Caruso.

For a building, this means that if environmental conditions are such that a salt solution repeatedly infiltrates porous stone and the fluid can then evaporate again (e.g. due to strong sunlight or wind), the salt in the building material can become supersaturated. "In these cases, it doesn't take a lot of salt to inflict considerable damage," says ETH professor Flatt. However, higher amounts of salt are needed in more moderate environmental conditions.

With this controlled experiment, the researchers have been able to describe the phenomena of salt damage in detailed physico-chemical and mechanical terms for the first time. "We have shown that damage caused by salt can be predicted, at least under controlled conditions," says Flatt. He believes the experiments may help conservation scientists decide how much salt needs to be removed from a building to avoid damage or -- if the salt cannot be removed -- to predict when a building might be damaged.

Michelangelo's frescos and geothermal drilling

This damage caused by salt is not seen only on historic buildings. It is also a problem for wall paintings, such as Michelangelo's frescos inside the Sistine Chapel in the Vatican, says Caruso. These can be damaged by salt efflorescence in the stonework or the paint layers or in between.

The problem is also visible on a large scale in erosion processes and during geothermal drilling. "Salt damage forms entire rock landscapes," says Caruso. In 2007, geothermal drilling in the old town of Stauffen, Germany, raised the ground by up to 26 centimetres in places, causing cracks to appear in rows of houses. It was later discovered that due to the underground drilling, groundwater had entered a layer containing calcium sulfate in anhydrous form, which reacted with the water to form gypsum. The supersaturation of this gypsum generated enough pressure to lift the ground.

The researchers at ETH are now planning to use their findings in a project in Havana's old town, where salt is a major issue. The special render used in restoration work crumbles away from building façades after just a few years, and the aim of the research project is to discover the exact cause. The scientists involved in this research at ETH Zurich and Princeton University are also hoping to find ways to reduce salt damage, such as by changing the pores of building materials on a molecular scale.

Story Source:

The above story is based on materials provided by **ETH Zurich**. *Note: Materials may be edited for content and length.*

Journal Reference:

1. Robert J. Flatt, Francesco Caruso, Asel Maria Aguilar Sanchez, George W. Scherer. **Chemo-mechanics of salt damage in stone**. *Nature Communications*, 2014; 5: 4823 DOI: 10.1038/ncomms5823

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Article4

A 'Star Wars' laser bullet -- this is what it really looks like

Date: October 22, 2014

Source: Institute of Physical Chemistry of the Polish Academy of Sciences

Action-packed science-fiction movies often feature colourful laser bolts. But what would a real laser missile look like during flight, if we could only make it out? How would it illuminate its surroundings? The answers lie in a film made at the Laser Centre of the Institute of Physical Chemistry of the Polish Academy of Sciences in cooperation with the Faculty of Physics at the University of Warsaw.

A light pulse fired from a 10 TW laser, dispersing into water vapor. The blue glow is laser light. The source of the other colors is mainly plasma fiber (filament) arising as a result of ionized matter, located in the air in the path of the light pulse. The laser with parametric amplifier NOPCPA was designed and constructed at the Laser Centre of the Institute of Physical Chemistry of the Polish Academy of Sciences and the Faculty of Physics at the University of Warsaw.

Credit: IPC PAS

Tests of a new compact high-power laser have given researchers at the Laser Centre of the Institute of Physical Chemistry of the Polish Academy of Sciences and the Faculty of Physics, University of Warsaw (IPC PAS and FUW) the opportunity to film the passage of an ultrashort laser pulse through the air. The film shows the journey of a light projectile at an extremely slow rate, similar to that watched on cinema screens by science-fiction aficionados.

"If you wanted to film a single light impulse to move as slowly on film as in our recording, you would have to use a camera operating at a speed of a billion frames per second," says Dr. Yuriy Stepanenko, leading the team responsible for the construction of the laser.

Cameras recording billions of frames per second in one sequence do not exist. In order to film the travelling laser pulse, researchers from the Laser Centre of IPC PAS and FUW used an earlier known trick. A suitably adapted camera was synchronised with a laser generating laser pulses at a rate of approx. 10 shots per second. It was done in such a way that with every subsequent pulse the camera recorded an image minimally delayed than previous one.

"In fact, a different laser pulse can be seen in every frame of our film," explains Dr. Paweł Wnuk, (LC of IPC PAS and FUW) and adds: "Luckily, the physics always stays the same. So, on the film one can observe all the effects associated with the movement of the laser pulse in space, in particular, the changes in ambient light depending on the position of the pulse and the formation of flares on the walls when the light passes through the dispersing cloud of condensed water vapour."

The laser pulse, lasting a dozen or so femtoseconds (millionths of a billionth of a second), was generated by a laser constructed at the Laser Centre of IPC PAS and FUW. It was so powerful that it almost immediately ionised the atoms it encountered. As a result, a plasma fibre -- filament -- was formed alongside the pulse. By appropriately selecting the operating parameters of the laser, to permit a balance of the complex interactions between the pulse's electromagnetic field and the plasma filament, the laser light beam did not disperse in the air, conversely, it underwent self-focusing. This meant that the pulse could effectively move a much greater distance than low-power pulses, whilst maintaining its original parameters.

"It is worth noting that although the light we are shooting from the laser is in the near infrared range, a laser beam like this travelling through the air changes colour to white. This happens since the interaction of the pulse with the plasma generates light of many different wavelengths. Received simultaneously, these waves give the impression of white," adds Dr. Stepanenko.

The ability of the light pulses from the new laser to penetrate the atmosphere over long distances is a feature that the Warsaw researchers made use of when demonstrating LIDAR, a device that can be used for the remote testing of atmospheric pollution. The fact that the pulses generate white light during passage is an important advantage in this context. Light at different wavelengths interacting with the atoms and molecules in the air is able to provide a far greater wealth of information. This means that LIDAR constructed using the new laser will be able to detect a larger number of elements and compounds polluting the atmosphere.

Photos and films of the ballistic laser pulse and plasma filaments were shot during testing of the compact laser generating femtosecond pulses with a power of over 10 terawatts, constructed at the Laser Centre of IPC PAS and FUW. The innovative device uses the direct transfer of energy from the pump laser beam to the reinforced beam. Due to the effects of nonlinear optics the light is amplified hundreds of millions of times on a distance of just a few centimetres with over 30% efficiency, which is outstanding among devices of this class. The multi-pass optical parametric amplifier NOPCPA (Noncollinear Optical Parametric Chirped Pulse Amplifier) used in the laser was designed in-house and Prof. Czesław Radzewicz and his team have been developing it in the Laser Centre of IPC and FUW since 2005.

Story Source:

The above story is based on materials provided by **Institute of Physical Chemistry of the Polish Academy of Sciences**. *Note: Materials may be edited for content and length.*

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