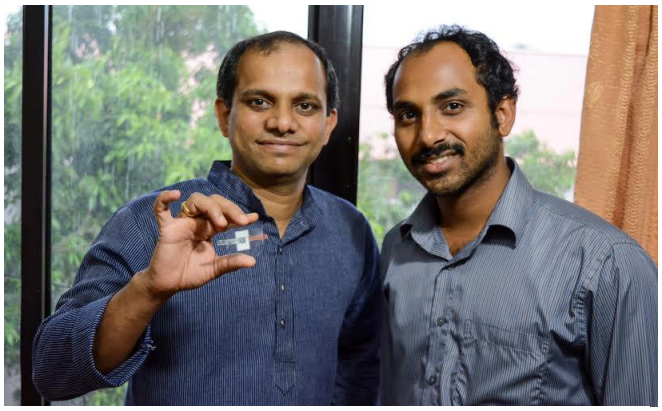
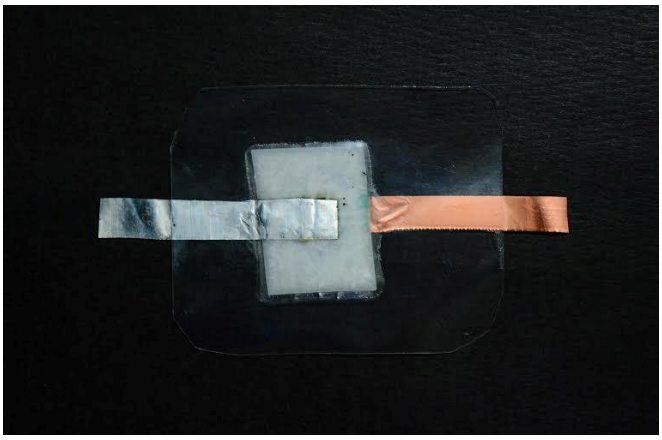
Scientists devised a capacitor from activated rice husk.

A team of scientists from Indian Institute of Science Education and Research (IISER) Thiruvanthapuram led by M M Shaijumon has devised a hybrid Li-ion capacitor, an energy storing device based on activated porous carbon derived from activated rice husk. The finding was published last month in the journal Electrochimica Acta. In an in interview with ISNS (Indian Science News Service), Shaijumon talks about the device in detail.



What is the device being developed ? What will be its broader utility?

We developed a Lithium ion capacitor in our laboratory at IISER Thiruvananthapuram. These are some sort of hybrid devices-capable of delivering energy and power intermediate between a normal rechargeable Lithium ion battery (one which is being used in most of the cell phones, laptops etc) and a super capacitor (typically with very high power density and low energy density- for e.g.., these are used for high power applications such as used to power emergency evacuation doors in AIRBUS 380 flights). These two energy storage devices are very important and comes with opposite features- For e.g..to compare their properties when used to power an automobile, batteries can store more charge and hence their energy density is very good. It means one could drive more miles. However, when powered by a super capacitor instead, it will have high power density (discharge very quickly) and very low energy density. This means that it can undertake powerful actions such as a quick acceleration to overtake, but can't run long. So what would you expect to do- combine the best features of these two devices into one - a hybrid device, which are typically known as hybrid Lithium ion capacitor (taken partly from both names). There have been lot of efforts in this direction recently and it shows quite promising in terms of the energy and power densities it deliver.



We have fabricated one such hybrid Lithium ion capacitor device. Here the novelty is that, one of the electrodes in the hybrid device (positive electrode) was made using porous carbon which was derived from Rice husk, an environmental waste. By cleaning and chemically activating this material under optimal conditions, one gets highly porous carbon powder. These materials with its high surface area, shows good properties and when combined with a standard battery electrode such as Lithium Titanate ($Li_4Ti_5O_{12}$) as negative electrode, we fabricated the hybrid device. We investigated in detail the performance of the device fabricated in our lab using several techniques and has demonstrated its applicability by powering an LED using the fabricated device. This was just a proof -of-concept device.

By making use of an environmentally benign and waste material, the advantages are many fold. The cost can drastically come down. These hybrid devices would find use in several important applications such as back-ups for power interruption in servers and other devices, supplementary power sources in medical equipments and even for powering plug-in hybrid vehicles.

What is the science behind the device?

One of the electrodes is a battery electrode wherein redox reaction happens and other electrode is a typical capacitor electrode, which exhibit a double layer capacitance.
The increasing demand on electrochemical energy storage systems for their widespread use in portable electronics, plug-in hybrid electric vehicles (PHEVs), electric vehicles (EV) and smart grids has pushed the researchers to explore newer mechanisms and directions for energy storage, outperforming the current technologies. To address the concerns over the trade off between power and energy densities of electrochemical energy storage in high energy Li-ion battery and high power supercapacitor, hybrid Li-ion capacitor that integrates the intercalation chemistry with physical adsorption has been recently explored as an attractive approach resulting in improved power and energy densities.
By suitably combining the chemistries of supercapacitors and rechargeable Lithium ion batteries, one could design such hybrid energy storage devices that could recharge in minutes and can also store much higher charge compared to the normal supercapacitors, which could also be cycled more than 25,000 times compared to few hundreds of cycles for a typical rechargeable battery.

Researchers have been looking into designing suitable electrode materials for achieving higher energy and power densities for the Lithium ion hybrid capacitor devices.

In our work, we fabricated one such hybrid energy storage device, wherein a typical battery electrode (Lithium titanium based oxide-$Li_4Ti_5O_{12}$) is combined with an activated porous carbon electrode (a capacitor electrode). The highlight here is that we used porous carbon with very high specific surface area (higher the surface area ï meaning large number if tiny pores- higher the amount of charge stored or capacity) and more importantly these were synthesised through an environmentally benign route - from rice husk, which is otherwise an environmental waste. These rice husks when activated through simple chemical activation route resuls in the formation of highly porous activated carbon with very high surface area, capable of storing large amount of charge in their microspores. This is the first report on using these rice husk derived porous carbon for fabricating efficient Lithium ion capacitor device and the obtained performance is superior to several recently reported hybrid devices.

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By when will be device be ready

What we have done now is to fabricate a lab scale prototype of the device and we demonstrated powering an LED using this device. To take it into commercial terms, we need to do several things, starting from optimisation of several parameters to further improve the energy and power densities so as to cater to large scale applications. Proper device fabrication that would improve the performance of the device.

Currently we are also engaged in making Sodium ion hybrid capacitors, as eventually we will need to depend on Sodium, since Lithium is getting depleted and availability is a big issue. On another note, it will be interesting to design completely foldable (flexible) hybrid energy storage devices. We are working in this direction and with some promising preliminary results, we have submitted a proposal for undertaking technology oriented applied research in this important area of energy storage.