Fundamentals of Solids

Article summary

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Introduction

Cellulose paper has been a major medium for displaying purposes for thousands of years. The focus of this article is to present recent progress in the
development of energy and electronics devices fabricated using wood fiber cellulose as the building block in conjunction with other nanomaterials.

Research on nanostructures of cellulose has increased dramatically due to the potential applications in electronics, biosensors, and energy storage devices. 1–4
Large-scale, energy-efficient production of nano-fibrillated cellulose (NFC) has recently become possible by employing various physical, chemical, and enzymatic pretreatment methods before the homogenization step.

Cellulose by itself is usually limited in functionalities. However, the three-dimensional (3D) hierarchical structures formed by cellulose fi bers at different length scales, combined with the ability to accommodate other functional materials, open up many opportunities for applications in electrical, electrochemical, and optical devices.

Cellulose-The Building Block

The cell wall of wood has a fascinating 3D hierarchical structure designed to maximize the stability and durability of the trees. At the molecular scale, the cellulose polymer molecules have a linear chain structure consisting of glucose repeating units with many hydroxyl groups. They pack into cellulose crystals with dimensions of a few A, which in turn are organized into nano-fibrils with a diameter of around 4 nm and a length over 1 µ m.

Energy storage with conductive paper

- Cellulose solution coating on vertically grown CNTs.
- Used as an electrode for super-capacitors and lithium-ion batteries.
- Meyer-rod coating of CNT ink.
- As an ultra-capacitor electrode with a specific capacitance of 200F/g

Conductive paper made from cellulose fibers and CNTs demonstrates excellent mechanical properties. In the case of CNT-coated photocopy paper, the sheet resistance increased only slightly (<5%) after the conductive paper was bent to a 2 mm radius 100 times. In contrast, conductive paper fabricated with a metal evaporation coating does not withstand bending very well, and the sheet resistance in this case increased by 50% after three bending cycles to a radius of 2 mm. The graphene cellulose paper was shown to withstand

Cellulose-The Building Block

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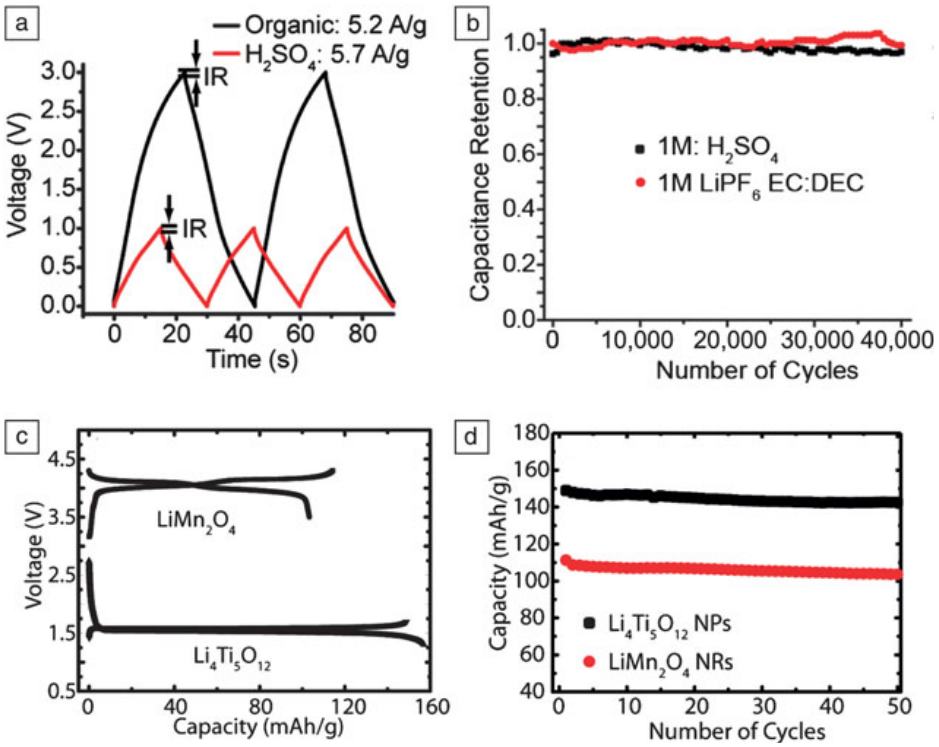
In this article, we examine the recent development of Nano-fibrillated cellulose and integration of other nano-materials leads to a wide range of applications.

The cell wall of wood has a fascinating 3D hierarchical structure designed to maximize the stability and durability of the trees.
The wood fi ber is made up of crystalline cellulose nanofi brils
(around 40 wt% of the wood), random amorphous hemicellulose (around 25 wt% of the wood), and organic “glue” lignin
(around 30 wt% of the wood) that cross-link different polysaccharide.

Nano-structured paper for flexible energy and electronic devices

high tensile stress up to 8.67 MPa.

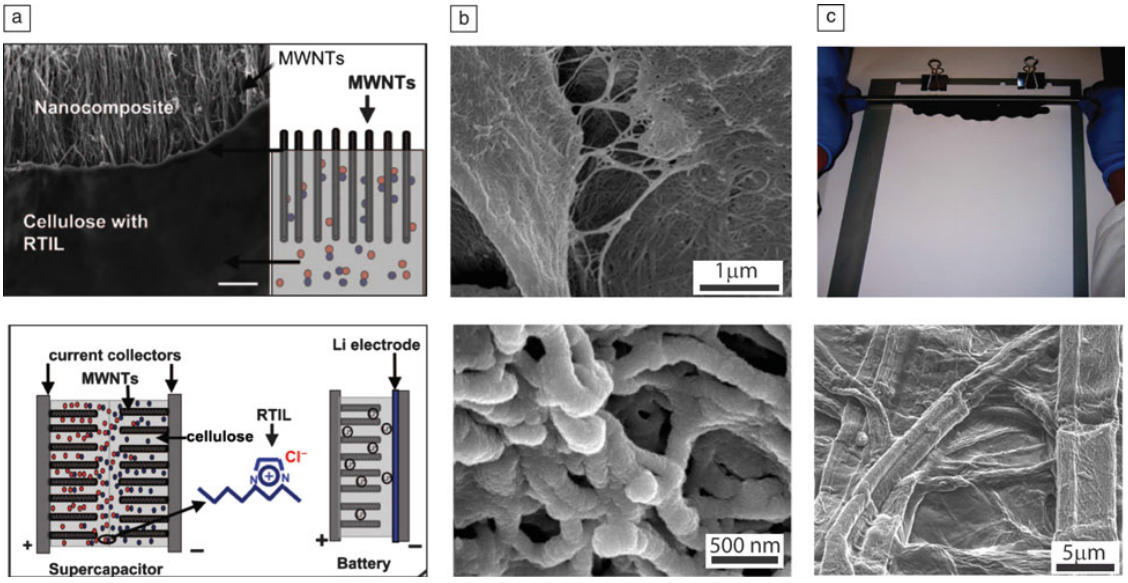


Properties

- Due to the hydrophilicity of cellulose fibers, conductive paper has been widely used as electrodes for ultra-capacitors with aqueous electrolytes.
- By using cellulose as a substrate for the carbon matrix, aqueous electrolyte can be readily absorbed into the electrode, providing intimate contact between the carbon electrode and electrolyte.
- The unique structure of conductive cellulose paper made from ionic liquid and allows the working electrode (CNTs) and separator (excess cellulose) to be combined in a single sheet of paper.
- Mixing CNTs directly with NFC allows for better tuning of the 3D structure of the composite.
- The optical transmittance of nanopaper can be tailored by varying the diameter of the NFC nanofi bers.
- Nanocellulose paper is generally as lightweight as regular paper but with a much higher Young's modulus.

Transparent nano-cellulose paper for electronic devices

- The use of nanocellulose paper as a “green” substrate for electronic and optoelectronic devices has attracted broad attention.
- Commercial paper has a relatively rough surface and weak mechanical properties, which can be problematic for electronic device fabrication.
- Electronic and optoelectronic devices based on transparent nanocellulose paper and printing techniques have been recently demonstrated.
- Integrated transparent sensors and 3D microfluidic devices, may also be fabricated on nanocellulose paper.



Conclusion

In this article, we have reviewed recent progress in the application of nanocellulose paper for flexible energy storage and electronic devices. Conductive paper made from cellulose fi bers of 20 μ m in diameter can function as a new type of current collector that enables high-performance paper ultracapacitors and Li-ion batteries. Another emerging area is the development of nanocellulose paper, which is made of nanofibrillated cellulose with diameters of around tens of nanometers. Such nanocellulose paper is highly transparent, smooth, and mechanically strong, allowing applications in a range of flexible energy and electronics devices.