GlobalResearch
Center for Research on Globalization

Hemp-Based Batteries Could Change the Way We Store Energy Forever

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Global Research, August 19, 2014
Prevent Disease 14 August 2014
Theme: Environment, Oil and Energy

As hemp makes a comeback in the U.S. after a decades-long ban on its cultivation, scientists are reporting that fibers from the plant can pack as much energy and power as graphene, long-touted as the model material for supercapacitors. They're presenting their research, which a Canadian start-up company is working on scaling up, at the 248th National Meeting & Exposition of the American Chemical Society (ACS), the world's largest scientific society.

Although hemp (*cannabis sativa*) and marijuana (*cannabis sativa var. indica*) come from a similar species of plant, they are very different and confusion has been caused by deliberate misinformation with far reaching effects on socioeconomics as well as on environmental matters.

Hemp is the most universally useful plant we have at our disposal. The history of mankind's use of hemp can be traced way back in time to between about 5000 – 7000 BC.

Industrial hemp and hemp seed could transform the economy of the world States in a positive and beneficial way, and therefore should be exploited to its full potential, especially relating to energy storage.

David Mitlin, Ph.D., explains that supercapacitors are energy storage devices that have huge potential to transform the way future electronics are powered. Unlike today's rechargeable batteries, which sip up energy over several hours, supercapacitors can charge and discharge within seconds. But they normally can't store nearly as much energy as batteries, an important property known as energy density. One approach researchers are taking to boost supercapacitors' energy density is to design better electrodes. Mitlin's team has figured out how to make them from certain hemp fibers — and they can hold as much energy as the current top contender: graphene.

"Our device's electrochemical performance is on par with or better than graphene-based devices," Mitlin says. "The key advantage is that our electrodes are made from biowaste using a simple process, and therefore, are much cheaper than graphene."

The race toward the ideal supercapacitor has largely focused on graphene — a strong, light material made of atom-thick layers of carbon, which when stacked, can be made into electrodes. Scientists are investigating how they can take advantage of graphene's unique properties to build better solar cells, water filtration systems, touch-screen technology, as well as batteries and supercapacitors. The problem is it's expensive.

Mitlin's group decided to see if they could make graphene-like carbons from hemp bast

fibers. The fibers come from the inner bark of the plant and often are discarded from Canada's fast-growing industries that use hemp for clothing, construction materials and other products. The U.S. could soon become another supplier of bast. It now allows limited cultivation of hemp, which unlike its close cousin, does not induce highs.

Since the 1950s, the United States has been lumped hemp into the same category of marijuana, and thus the extremely versatile crop was doomed in the United States. Hemp is technically from the same species of plant that psychoactive marijuana comes from. However, it is from a different variety, or subspecies that contains many important differences.

Industrial hemp has very low Tetrahydrocannabinol (THC) levels, which is the principal psychoactive constituent. Compared to marijuana which is specifically cultivated for personal psychoactive use, it is nearly impossible to "get high" on hemp. Marijuana that can be smoked usually contains between 5-10% THC, industrial hemp contains about one-tenth of that. In order to get a psychoactive effect, one would need to smoke more than a dozen hemp cigarettes over a very short period of time to achieve any kind of psychoactive effect.

The reason for the low THC content in hemp is that most THC is formed in resin glands on the buds and flowers of the female cannabis plant. Industrial hemp is not cultivated to produce buds, and therefore lacks the primary component that forms the marijuana high. Furthermore, industrial hemp has higher concentrations of a chemical called Cannabidiol (CBD) that has a negative effect on THC and lessens its psychoactive effects when smoked in conjunction.

Scientists had long suspected there was more value to the hemp bast — it was just a matter of finding the right way to process the material.

"We've pretty much figured out the secret sauce of it," says Mitlin, who's now with Clarkson University in New York. "The trick is to really understand the structure of a starter material and to tune how it's processed to give you what would rightfully be called amazing properties."

His team found that if they heated the fibers for 24 hours at a little over 350 degrees Fahrenheit, and then blasted the resulting material with more intense heat, it would exfoliate into carbon nanosheets.

Mitlin's team built their supercapacitors using the hemp-derived carbons as electrodes and an ionic liquid as the electrolyte. Fully assembled, the devices performed far better than commercial supercapacitors in both energy density and the range of temperatures over which they can work. The hemp-based devices yielded energy densities as high as 12 Watt-hours per kilogram, two to three times higher than commercial counterparts. They also operate over an impressive temperature range, from freezing to more than 200 degrees Fahrenheit.

"We're past the proof-of-principle stage for the fully functional supercapacitor," he says. "Now we're gearing up for small-scale manufacturing."

Governments have cooperated with powerful corporate lobbyists the ensure that hemp is lumped into the same category as marijuana. The primary reason is that hemp has too many abundant resources for fuel, housing, food, medicine that corporations cannot exploit.

Think about how many polluting conglomerates would go down if hemp was permitted as a resource. The oil, pharmaceutical, supplement and constructions industry would need to radically shift their business model to survive.

Mitlin, who conducted the research while at the University of Alberta, acknowledges funding from Alberta Innovates Technology Futures,National Institute for Nanotechnology (Canada) and Alberta Livestock and Meat Agency.

Environmental Benefits of Hemp

* Hemp results in a 95.5% fuel-to-feed ratio when used for pyrolysis the thermochemical process that converts organic matter into fuel.
* Biomass has heating value of up to 8,000 BTU/lb., with virtually no residual sulphur or ash during combustion.
* Hemp is the #1 producer of biomass per acre in the world. Biomass energy expert Lynn Osburn estimates that 1 1/2 to 3 1/2 million acres of hemp would replace all of Canada's fossil fuel demands.
* From 75Â°/O to 90% of all paper was made with hemp fiber until the late 1800′s.
* An acre of hemp will produce as much pulp for paper as 4,1 acres of trees over a 20 year period.
* The hemp paper-making process requires no dioxin-producing chlorine bleach and uses 75% to 85% less sulphur-based acid.
* Hemp paper is suitable for recycle use 7 to 8 times, compared with 3 times for wood pulp paper.
* Hemp produces the strongest, most durable natural soft-fiber on earth. Until the 1 820′s, up to 80% of all textiles and fabrics for clothes, canvas, linens and cordage were made principally from hemp.
* Hemp cloth is stronger, more durable, warmer and more absorbent than cotton. Best of all. ' grown in Canada, cotton cannot.
* An acre of land will produce 2 to 3 times as much fiber as cotton, about 1,000 Ibs. of fiber per acre.
* Hemp grown in most parts of Canada will require no herbicide, fungicide or insecticide applications. Up to Â½ of all agricultural pesticides used in North America are applied to the cotton crop.
* Natural, organic hemp fiber breathes and is recyclable, unlike petroleum-based synthetic fibers.
* A fully mature hemp plant may contain 1/2 of its dry-weight in seed.
* Once hemp seed oil has been extracted, the remaining seed cake is second only to soya bean for protein content and is an excellent source of nutrition for either farm animals or humans.

Agricultural Benefits of Hemp

* England, France and Spain have all legalized low THC varieties of hemp for an agricultural crop. England planted 1,500 acres of hemp as a first year crop. Reports from England state that farmers are receiving in excess of 3,000$ per acre for their hemp crop.
* Low THC hemp is not suitable as a psychoactive drug.
* A Canadian report from the late 1800′s demonstrated that hemp works very well in rotation with bean and corn crops.
* In 1991 Ontario farmers receiver 290$ and 240$ per acre for grain corn and soya bean respectively.

* Hemp was grown successfully in Canada for over 100 years. For a period in the late 1800′s Canada produced ‘hi: of all England’s hemp requirements. At kite time, England was the largest hemp consumer in the world.
* In the 1930′s, a South Western Ontario newspaper reported that Canadian grown hemp was among the best in the world and far superior to tropical hemp.
* In Canada hemp can be grown successfully from our southern borders to approximately 60O North Latitude, the parallel that divides the North West Territories from the provinces. This remarkable range is possible due to hemp’s short growing season, usually 90 to 110 days.
* The hemp plant will reach a height of up to 5m (16ft.) and sink a main tap root down 1 ft. This tap root will draw nutrients from deep in the soil and make them available to subsequent crops when the hemp leaves are shed on the soil. This extensive root system also helps to alleviate the problem of soil compaction.
* Hemp is very easy on the soil and returns up to 60% of the nutrients it takes from the soil, when dried in the field.
* A report from Kentucky states that hemp was grown on the same land for 14 consecutive years without soil depletion or reduction in yield.
* Hemp is very economical crop to grow since it requires virtually no pesticide applications.
* Hemp is also relatively drought-resistant and has been relied upon several times during drought-induced famine for its high protein seed.
* Hemp is very resistant to increased UV radiation and should not suffer decreased yields, unlike soya bean and corn.

Marco Torres is a research specialist, writer and consumer advocate for healthy lifestyles. He holds degrees in Public Health and Environmental Science and is a professional speaker on topics such as disease prevention, environmental toxins and health policy.

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