Perspectives of non-chemical batteries today

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Apstract

Vehicle electrification has posed a new challenge for the scientific community. The success of the vehicle electrification processes depends on the ability of scientists and engineers to develop sufficiently cheap and environmentally friendly rechargeable batteries. The battery powered vehicles, as hybrid or fully electric, are limited in performance by the price and size of the rechargeable batteries. The electrochemical batteries are in intensive use to power today's vehicles. Environmental and safety risks associated with this type of battery, their price and an limited lifespan are the reasons why great efforts are being made today in the search for a more suitable type of battery. This presentation provides an insight into the achievements of electricity storage in materials without electrochemical processes. The absence of chemical processes would dramatically extend the life of such batteries compared to the existing batteries on the market, and the choice of materials for their manufacture could be more environmentally friendly. Energy density storage is the biggest problem of non-chemical batteries, but their aforementioned advantages over electrochemical batteries justify the further development of such battery systems.

Rechargeable batteries today

	type	energy density [J/g]	power density [W/g]	lifespan	ecology
electrochemical	Metal-water/salt	medium	low	low	bad
	Ni-metal (hydride)	medium	low	low	bad
	Li-metal oxide	high	medium	medium	bad
	Na-metal oxide	high	medium	medium	bad
	Supercapacitor	high	medium	medium	bad
physical	Ceramic capacitor	low	high	medium	medium
	Polymer capacitor	low	high	high	the best

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Polypropylene(PP)/graphite capacitor vs. electrochemical

type	PP/graphite capacitor	electrochemical battery
Energy density [Wh/kg]	0.05	10-150
Power density [W/kg]	250 000	100
Lifespan	100 years	5-10 years
Radiation stability – gamma radiation	500 kGy	5-30 kGy
Edibility 	YES	very toxic
Recycling	100%, cheap and clean technology	50-90%, dirty technology
Battery price	3 EUR/kg (20 000 kg ~ 1 kWh)	31 EUR/kg (7 kg ~ 1 kWh, Li-bat.)
Disposal price of 1 kWh calculated per year of use without recycling	600 EUR	22 EUR (Li-battery)

The use of polymer capacitors

Primarily in systems that require a very rapid release of large amounts of energy: low and high voltage electronics, control circuits in the production and transport of electricity and the like.

The improvements of polymer capacitors

PP is a non-polar polymer, the energy density shown by PP capacitors can be increased about 10 times by using polar polymers and their composites instead of PP. However, this proportionally increases the price of such a capacitor and impairs its environmental value.

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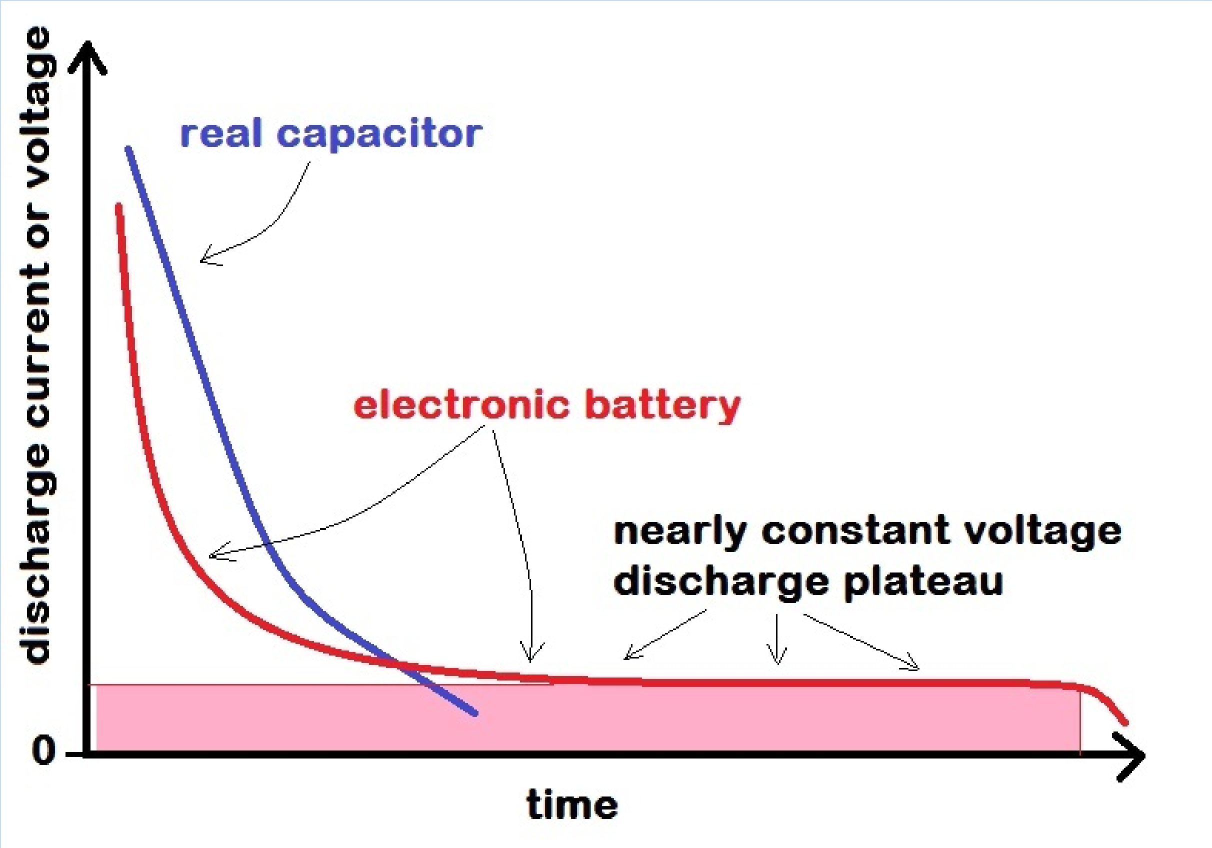
But one idea could improve the performance of polymer capacitors…

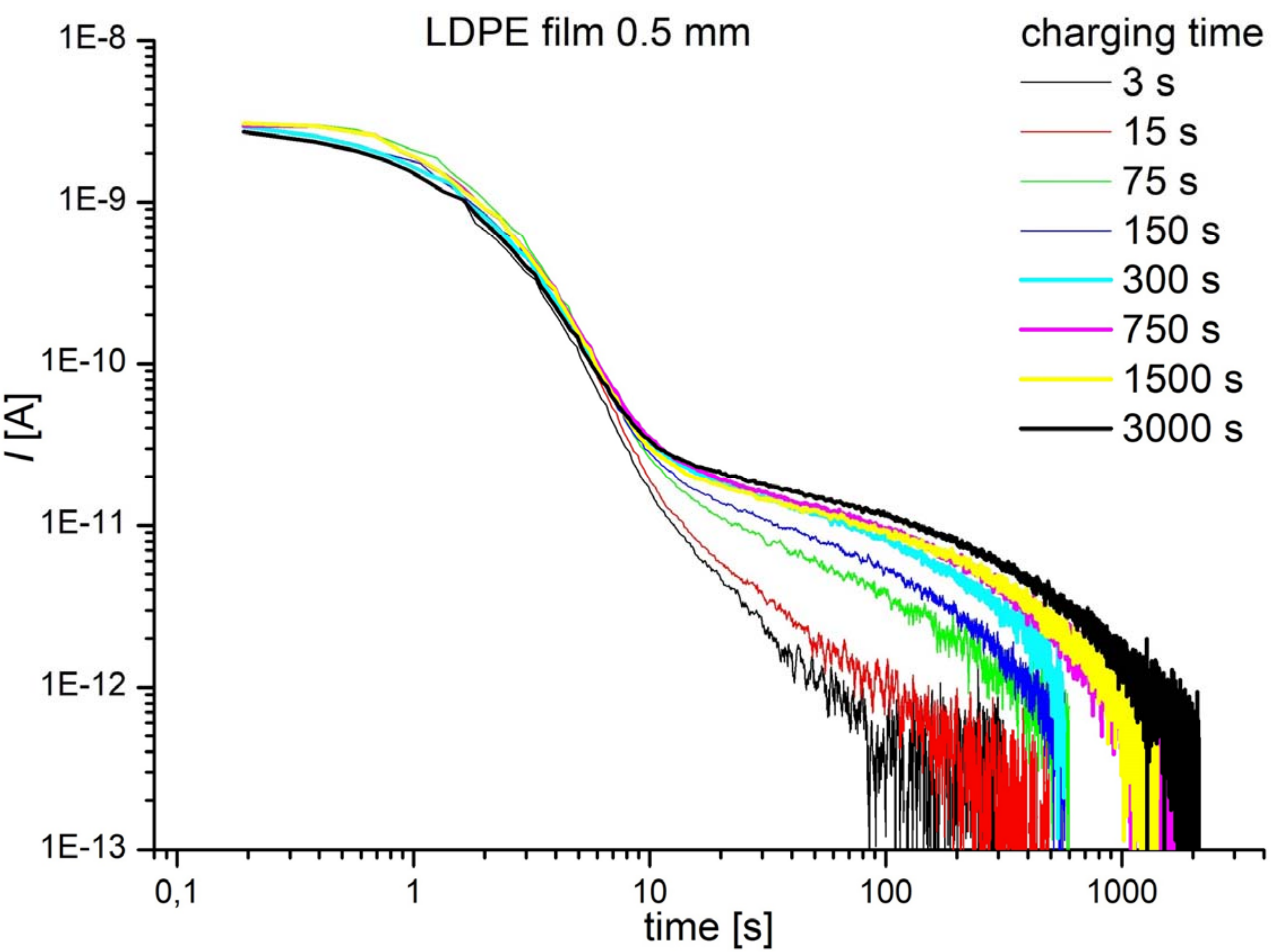
The idea - trapping of electrons in the polymer

The principle of operation of the proposed electronic battery is similar to the principle of operation of an electrostatic capacitor, with the difference that the energy deposit is improved by trapped electrons in the volume of a suitably selected (polymer) cathode, the anode can be made of metal. Due to the existence of trapping energy, the process of electron detrapping can be characterized by a certain electromotive force.

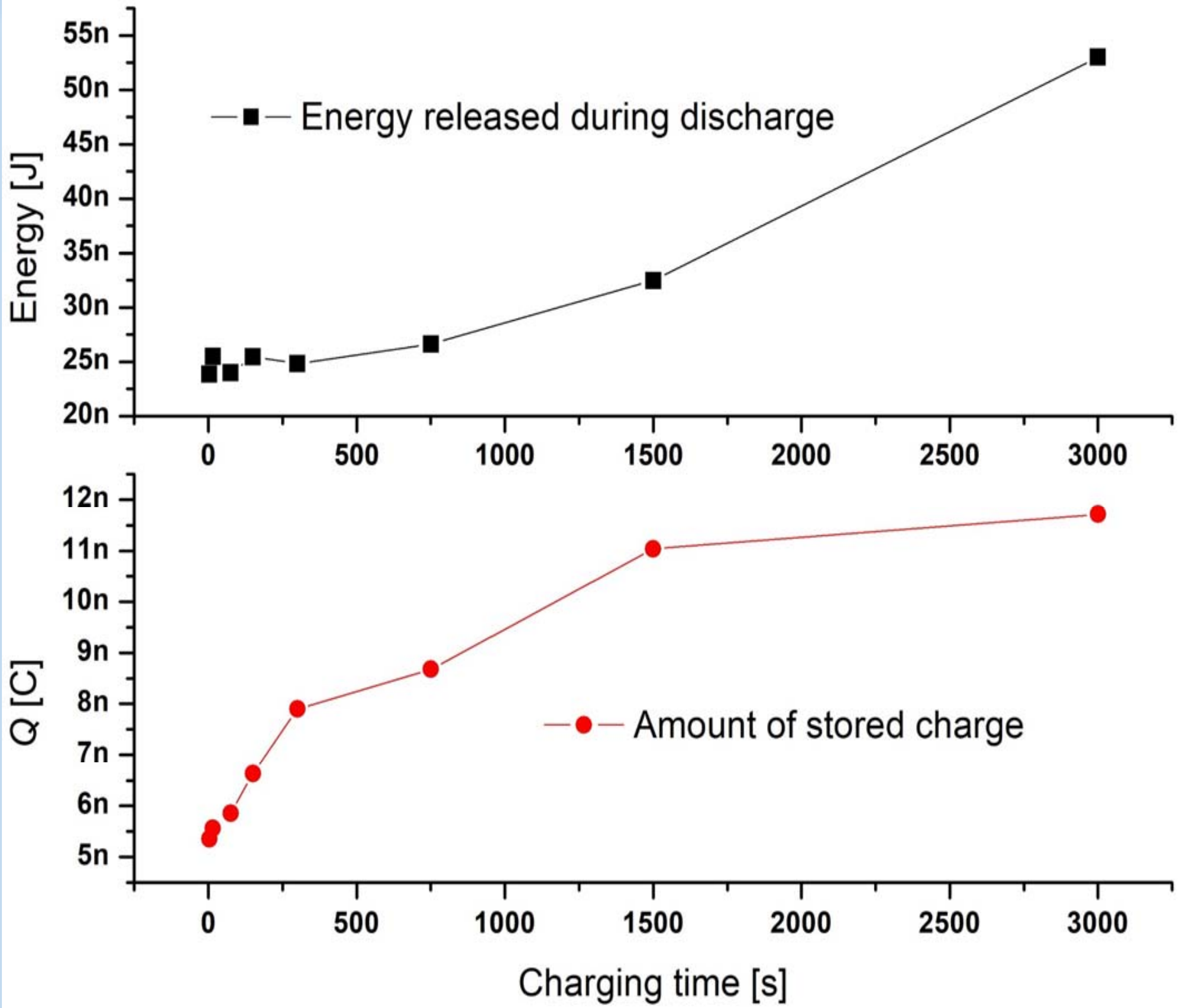


The first results

Discharge currents of a LDPE film charged (1 V/mm) at different time intervals (indicated in the figure). The film rests on the negative electrode, while it is separated from the positive electrode by air. The contribution of trapped electrons to the discharge current is clearly visible after ten seconds from the start of the discharge. More details about this experiment can be obtained from the author (ddudic@vinca.rs).



The picture show: above - released energy and below - released charge during LDPE film discharge depending on the charging time. The classical capacity of the measuring cell (free charges on the capacitor plates) should be a little changed by the input of the LDPE film (0.5 mm) at an electrode distance of 10 mm. The results show that with increasing charging time, the amount of deposited charge and the amount of energy obtained by discharging that charge increase. Charging time of 3 s corresponds to the discharge of a classic capacitor (free charges). Longer charging times have shown that charge trapping can double the capacity and energy density of this material.



The conclusions

- Polymer capacitors show a very low energy density and therefore cannot be widely used for electricity disposal. At the same time, all their other features that characterize battery systems are ideal.

- The presented experimental results indicate that the phenomenon of charge trapping in polymers can increase the energy capacity of these materials.

- Studying the energy aspects of electron trapping in polymers could contribute to greater use of polymer capacitors instead of conventional electrochemical batteries.

Thank you

THE END