LDPE/ZIF-8 composite as a cathode in an electron battery

Duško Dudić

* Department of Radiation Chemistry and Physics, „VINČA" Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, P.O. Box 522, 11001 Belgrade, Serbia

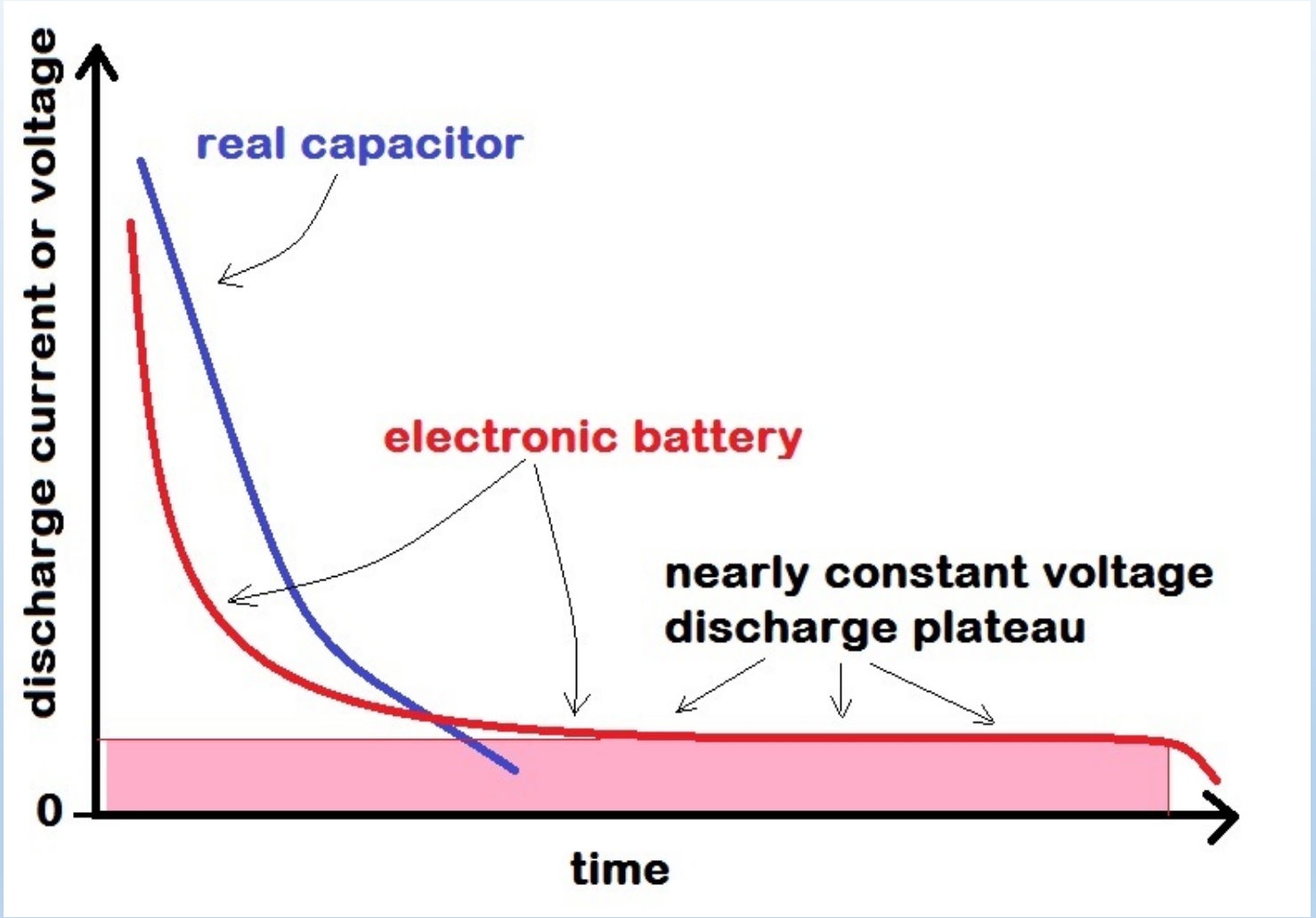
* Department of Chemistry, University of the Free State, Private Bag X13, 9866 Phuthaditjhaba, South Africa

Apstract

The problem of electricity storage is today the most significant limiting factor for the use of autonomous electric vehicles and the wider use of electricity from the solar panels. Rechargeable lithium batteries are currently the best choice for storing electricity for most industrial needs and products. Environmental and safety risks associated with this type of battery, their price and relatively short life are the reasons why great efforts are being made today in the search for a more suitable type of battery. The idea of a battery in which the processes of charging and discharging take place by the movement of electrons, not ions, is relatively new. This presentation contributes to the development of that idea. A significant improvement in the electron deposition characteristics in a non-polar polymer (linear low density polyethylene - LDPE) was presented, which was achieved by adding a small proportion (4%) of the non-polar metal-organic complex (ZIF-8).

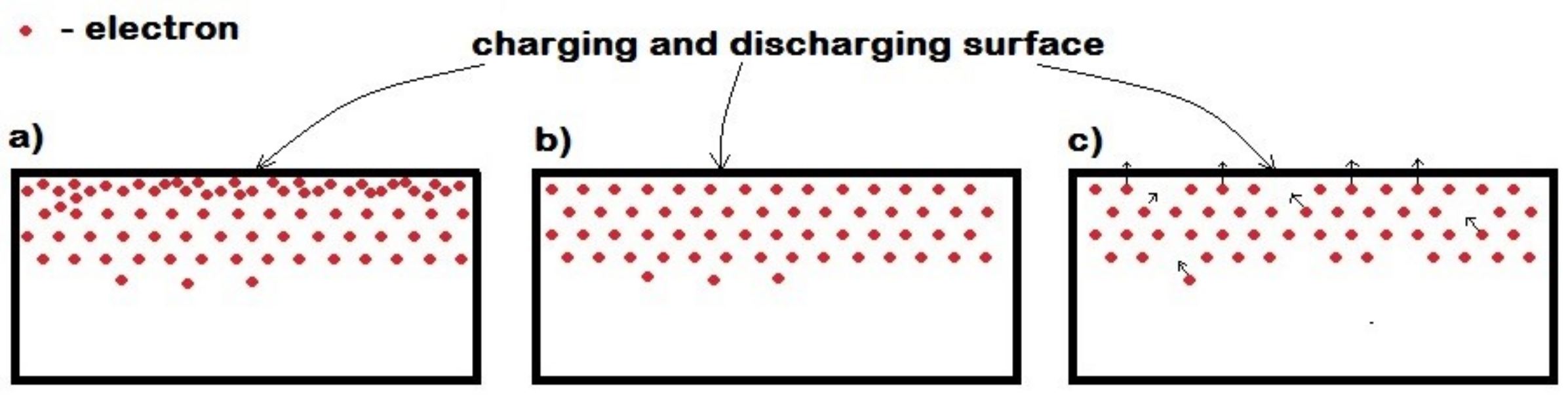
The idea

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 achieved 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 will be characterized by a certain electromotive force.



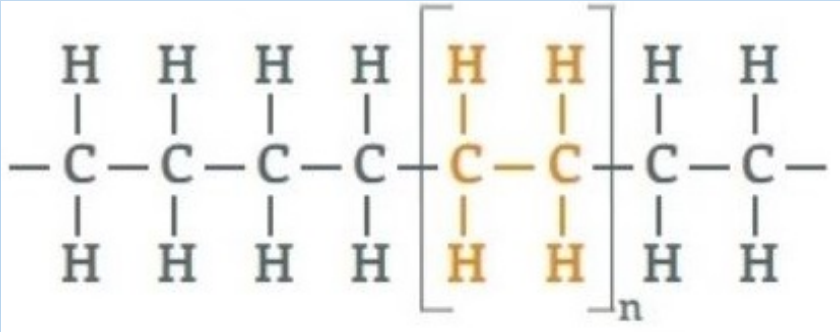
The idea

Trapped electrons in the cathode

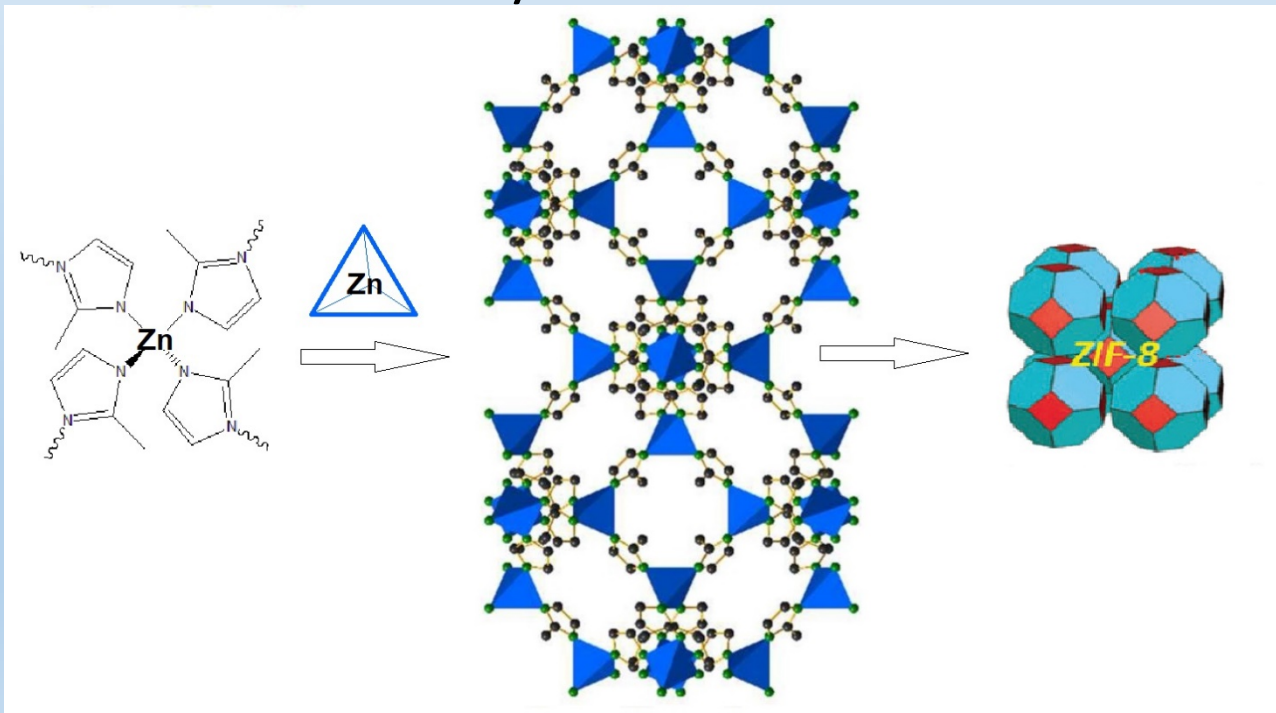


The material LDPE/ZIF8 (96/4)

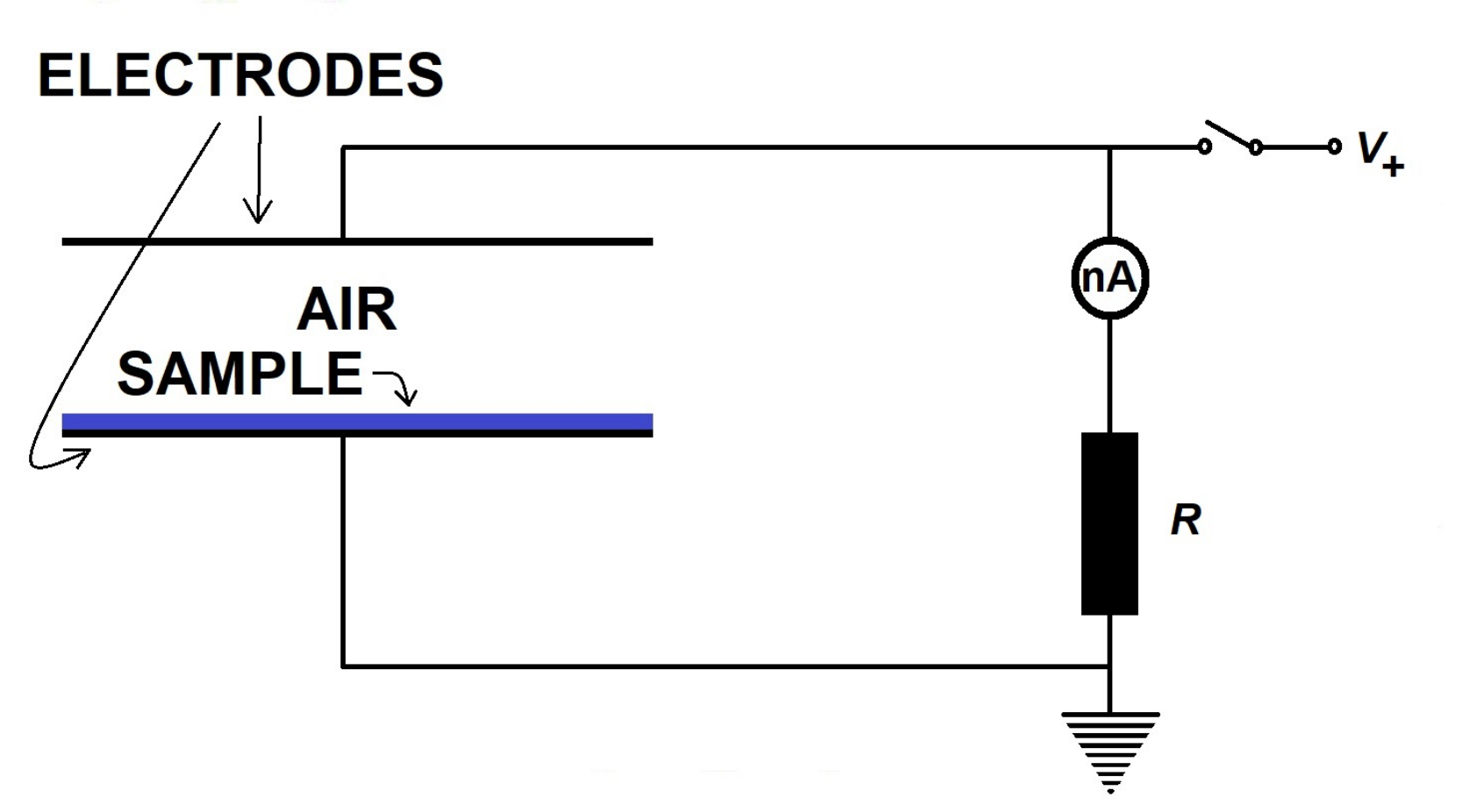
LDPE - linear low density polyethylene
- hydrophobicity
- low permittivity
- ε_r = 2.2
- air stable
- melting point >120 °C



ZIF8 -Zeolitic Imidazolate Framework
$[Zn(2\text{-methylimidazolate})2.2S]_n$
- porous structure, 10 μm powder
- low permittivity
- ε_r = 1.98 (theoretical)
- air stable
- thermal stability >250 °C



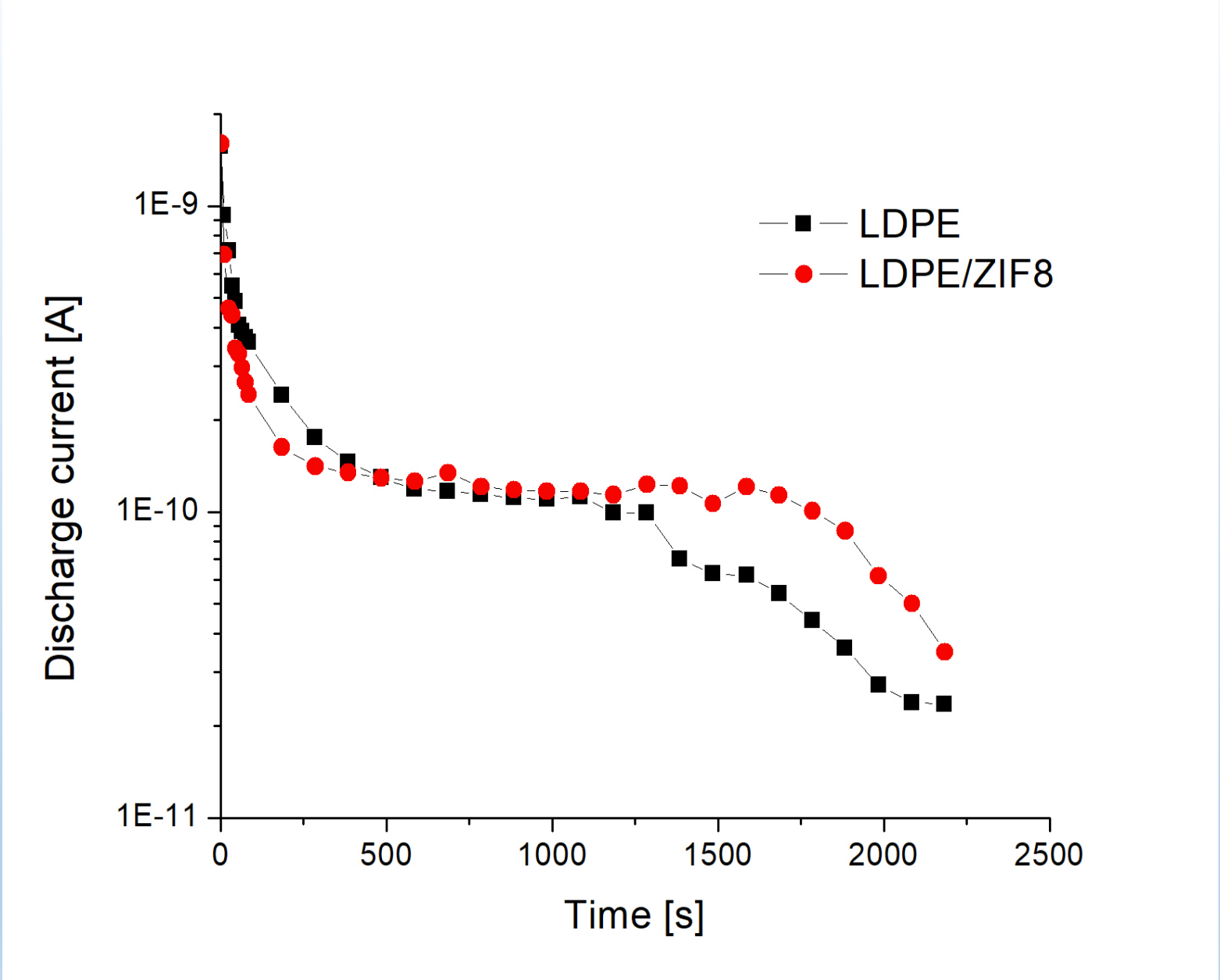
The experimental setup



The samples 50x50x0.5 mm, charging time 10 min at *E*=2 V/cm, *R* = 1.2 GΩ, RH=60%.

The result

In order to detect the discharge plateau, it is necessary to use a sufficiently large resistance in the circuit, under the mentioned conditions, this was achieved with a value of 1.2 GΩ. The current values on the plateau are about 0.12 nA, which corresponds to a discharge voltage of about 0.14 V. The composite shows a longer duration of the discharge plateau compared to the corresponding time shown by LDPE.



The conclusion

Both materials in this experiment, LDPE and LDPE/ZIF8 composite, showed the ability to maintain a constant discharge voltage across a sufficiently large resistor during the relaxation of electrons from their volume. The presented result indicates that the amount of trapped electrons as well as their detrapping rate can be increased in non-polar polymers by adding non-polar fillers. Batteries whose operation is based on the described phenomenon will probably not reach the specific capacity of today's metal-ion batteries. But the lifespan of batteries designed in this way can be estimated at several decades and maybe more, then one can expect low cost and environmental friendliness.

THE END