International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 1 Jan-Feb 2021, pp: 303-305 www.ijaem.net ISSN: 2395-5252

Cellulose Fibre Superdielectric Materials: Aqueous Salt Solution Applied on Paper

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Submitted: 15-01-2021 Revised: 27-01-2021 Accepted: 30-01-2021

ABSTRACT: The current paper is about a new group of super dielectric materials that's based on SDM (super dielectric material)hypothesis in which a combination of liquid electrolytes filled inside tiny pores of a non conducting solid material leads to formation of tiny dipolesunder influence of an electric field. The combined strength of these dipoles results in formation of giant dipole **.**One point that should be mentioned explicitly is that there should be complete isolation between electrolyte and any one of the two plates so as to avoid close circuit between the plates .The Dielectric constant of an ordinary notebook paper which was made partially wet by applying a saturated salt (Nacl) aqueous solution was found to be greater than 10^5The current result support the general SDM hypothesis according to which whena highly porous non-conductive material which is notebook paper in present case, is dipped in an aqueous salt solutionwhich acts as electrolytes, the pores of the notebook paper forms a dipole in the presence of electric field, this giving birth to a super dielectric material. The current combination of an ordinarynotebook paper and salt solution gives birth to a completely new and unique class of SDM.The paper should be partially wet as to avoid any direct contact between electrolyte and the two plates so that the plates does not start conducting . This can be ensured by taking two layers of paper and applying electrolyte on only one side or we can also apply electrolyte in between the layers of paper. Electrolytes should be applied with the help of paint brushto carefully control the wetness.

I. INTRODUCTION.

To improve the energy density of parallel plate capacitors currently two methods are under development 1) to develop platesof parallel plates capacitor with highly porous material such as activated charcoal which has a very high surface area 2000 m^2 /g . This results in huge increase in surface area of plates and thus increases the capacitance, since no dielectric is involved in this method, the breakdown voltage is as very low, 1.1v in case of aqueous electrolyte and 2.7 to 3.6v in case of organic electrolyte .2)Another way is development of SDM based on the hypothesis for SDM stated above . The current paper is related to the second one.

For the development of SDM currently two types of materials are used, one is the powderedalumina and another isanodized titania filmsboth dipped in aqueous salt solution. Both of them have got very high dielectric constant. The third method of making SDM (notebook paper with aqueous salt solution)also works well and produces dielectric constant of order $\mathbf{10^6}$If the paper is only partially wet, . generally speaking the formula for capacitance is c = ka/d

C = capacitance

K = dielectric constant of material between plates

A = area of the plate

d = distance between the plates

but the formula for energy that can be stored in capacitor is:

$$\mathbf{E = I/2(CV^2)}$$

E = energy stored in the capacitor

C = capacitance of the capacitor

v = is the voltage applied to the capacitor

now from this formula we can see that energy density of capacitor depends more on applied voltage than on capacitance of capacitor. We can conclude that higher the breakdown voltage is, more is the energy storage capacity of the capacitor . Breakdown voltage for most of the available supercapacitor is ~1.1V for aqueous electrolytes and 2.3v – 3.6v for organic electrolytes.Since here we are using aqueous solution. The present SDM is tested at 1v and at 0.3v. One very important point that should be noted that in any materials with perfectly cylindrical pores(which is perpendicular to the area of sdm being used), the dipoles created will be very strong . Some materials like carbon nanotubes are currently being tested for this.Vantablack, which is vertically aligned carbon nanotubes grown on a sheet of ametal(preferably aluminium) is one material that contain this property is currently under development for sdm. But vantablack is way too expensive , In the current research, we are just

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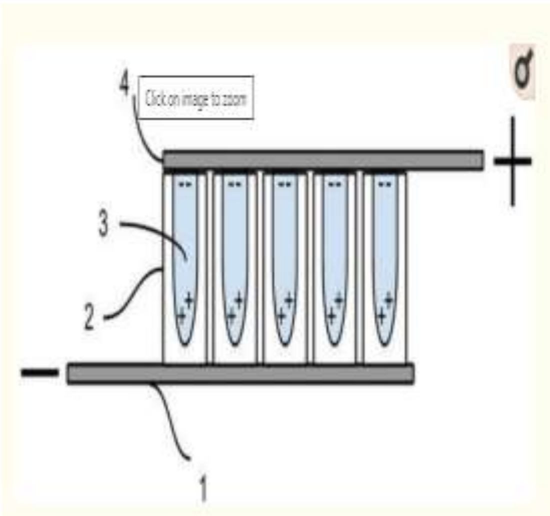
using ordinary notebook paper which will be way too cheap than any material like vantablack.



The above figure explains roughly about the concept.Here 1 is negatively charged plate, 4 is positively charged plate, 2 is the insulating material which is paper in this caseand 3 is the pore of the paper which is filled with electrolyte. When under influence of electric field the anions of electrolyte moves towards positive plate and cation moves towards negative plate.

II. RESEARCH METHODOLOGY

For experiment we used two copper plates with dimensions 2 × 3 cm in area and two layers of normal notebook paper . Prepare a saturated salt water solution and apply it to one of the two plates with help paint brush. The salt water solution should be prepared with deionised water to keep the impurities away, the plates also should be washes with deionised water and then dried,the double layer of the paper is placed between the plates and the reading is taken with the help of multimeter.First take the reading when the paper is dry, then apply the electrolyte on paper and take the reading. You will observe a high increase in the value of capacitance second time.

For more accurate readings, This experiment should be repeated multiple times, you should also use another method(where electrolyte is applied in between the layers of paper). All the methods mentioned above should be tested for accurate results.

III. RESULTS

The capacitance of the capacitor with plate dimension of 2 × 3 cm when double layer of paper was used with one side dry and other side partially wet as dielectric, a capacitance of (2.5 +/- 25%)millifarad was observed which was just ~ 0.70 nanofarad when the paper was dry. The result can be depicted in a graphical manner as shown below in a voltage to time graph to show the discharge behaviour of the capacitor and also the effect of this sdm material on such capacitors.

Time (milliseconds)

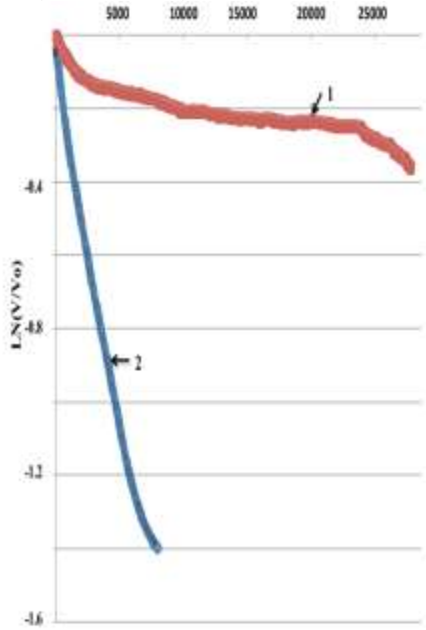


Figure 6- High Salt Capacitor. The discharge cycle behaviour is graphed as two regions of dielectric performance. Line 1- The capacitance is extremely high (>1*1.011) below 300 mV. Line 2- The capacitance between 1.0 V and 300 mV (>6*.109).

CYCLE	VOLTAGE	CAPACITANCE (milli Farad)	DIELECTRIC CONSTANT	Max Error % Capacitance and Dielectric
1st discharge, High Volts	1.0-0.3	0.18	4.3×10^6	+/-25%
1st discharge, Low Volts	<0.3	1.51	3.9×10^7	+/-25%
2nd discharge,	1.0-0.3	0.25	5.1×10^6	+/-25%

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High Volts				
2nd discharge, Low Volts	<0.3	4.9	1.3×10^{8}	+/-25%
3rd discharge, High Volts	1.0-0.3	0.21	4.7×10^{6}	+/-25%
3rd discharge, Low Volts	<0.3	2.51	4.6×10^{7}	+/-25%

IV. DISCUSSION.

The above experiment proved the general SDM hypothesis that when a highly porous insulating material is dipped into electrolyte ,the pores are filled with electrolyte and produces dipoles, the combined strength of these dipoles result into giant dipole .But Here we are not dipping the paper into the electrolyte. The main reason for this is that saltwater is a good conductor of electricity, if we dip the dielectric completely into the electrolyte and then place it in between the plates, the plates start conducting and thus the capacitance will be shown as infinite in the capacitance measuring instrument.

In experiment the salt water is applied with the help of painting brush . For a safer side, water can also be applied in the inner part of paper fold thus avoiding direct contact of electrolyte with both plates. The second experiment has given similar results.

The phenomena in experiment can also lead us to different category of supercapacitor which does not allow the ions to pass through separator but only the electric field . The maximum rated voltage will be much higher till the separator gets saturated with electrolyte . This hypothesis will definitely take some more research to understand. whenever we dip a paper into water, the watertake some time to saturate the paper. But before water saturates the paper, the paper can definitely act as the super dielectric material .

A fact that must be noted is that in case of composite state dielectric which uses a combination of both solid and liquid as dielectric, the capacitor takes some time to achieve maximum capacitance as the ions takes some time to travel to the ends of pores(so as to form a dipole).The smaller the pores, the lesser is the time taken to reach the ends, The larger the pore is more ions it can incorporate thus forming a larger dipole. More experimentis needed to be done in order to understand the exact effect of the size of the pores on SDM.

It is also argued that in case of ordinary notebook paper, length of the pores is perfectly lined that is perpendicular to the area of the paper thus forming a perfect dipole .This greatly increases the strength of dipole.In other sdm materials like alumina, pores arenot perpendicular to the area and thus many different shapes of dipole comes into existence, this leads to cancelling of some of the dipole effect and the dielectric constant is greatly reduced.

One last point that should be kept in mind that as the time passes more and more water dries up from the paper, this will reduce the dielectric constant of the SDM and also if the water is reapplied, paper gets damaged by this constant phenomena DE moisturisation and RE moisturisation . If more water is applied , then paper can become conductive after some.

V. CONCLUSION

The above experiment proves the hotly discussed hypothesis of super dielectric material. It also proves that many ordinary materials of everyday use like paper can be used to manufacture SDM. SDM can be very cheap to manufacture when compared to vantablack (vertically aligned carbon nanotubes).when ordinary paper is made wet with help of an electrolyte (aqueous salt solution in present scenario), It can act as SDM provided proper insulation is made from any one of the two capacitor plates.

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International Journal of Advances in Engineering and Management

ISSN: 2395-5252

IJAEM

Volume: 03 Issue: 01 DOI: 10.35629/5252