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Comparison of Different Types of Carbon Materials as Electrodes of Super Capacitor

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ABSTRACT: Supercapacitor also known as electric double-layer capacitordiffers from conventional capacitor due to absence of solid dielectric.Supercapacitors are compose of two electrode immersed in electrolyte. Different types of materials are used for electrodes of supercapacitor. Activated carbon was first material chosen as electrode of supercapacitor. Carbon has properties like high conductivity, highly porous nature, and high specific area. This paper focuses on comparison of different types of carbon materials as electrodes for supercapacitor. Supercapacitors have merits such as safe to environment, fast charging, long life, 1000 times cycle's life than batteries, low internal resistance. Supercapacitor can be charged and discharged several times, much more times than rechargeable batteries. Thus supercapacitor bridges gap between conventional capacitor and battery. Supercapacitor is ideal for energy storage purpose and has used for many applications, when merged with batteries used for hybrid electric vehicles. Supercapacitors are used in solar energy storage, inverters, ups and computer system. In USA supercapacitors are used in defence area like tanks, submarines, vehicles.

KEYWORDS: supercapacitor, electrodes, carbon, electrolyte.

I. INTRODUCTION

Capacitor is very useful component in the field of engineering and it is used invarious electrical and electroniccircuitries. Capacitor stores energy in the form of electric field [1].Capacitor also known as condensers which stores energy when charge and release energy when discharge [2],[3]. Capacitor is made of two conductors separated by single layer dielectric of uniform thickness. Various dielectricsare used for capacitors such as vacuum, glass, mica, plastics, aluminiumoxides etc. Dielectric in capacitor provides insulation between two conductors and also increases value of capacitance [4]. When potential difference is applied across conductors of capacitor, electric field develops across dielectric and conductors hold equal and opposite charges on their surfaces. These conductors are close together thus opposite charges on conductor attract one another due to development of electric field which in results allow capacitor to store more charge [5][6]. Capacitor is characterized by capacitance; capacitance is greatest when there is narrow separation between conductors and vice versa [7]. Capacitor perform two function first is to charge and discharge electricity and second one is to block direct current. Capacitors ranges from microfarad and use for applications such as smoothening circuits for power supply, back up for microcomputers and timer circuits, filters to eliminate unwanted frequency [8].

Supercapacitor is also known as electric double layer capacitor and store more energy than normal capacitor [9]. Supercapacitors are based upon same physical principle as normal capacitor. But normal capacitorhasdrawback of low capacitance. Supercapacitor has overcome such drawbacks and provides high capacitance in small volume. They also have high energydensity than conventional capacitors [10]. Supercapacitors are composed of two electrodes immersed in an electrolyte solution. Main difference between supercapacitor and normal capacitor is supercapacitor provides high specific surface area with thinner electrodes as compare to normal capacitors. Thus energy storage in double layer capacitor results from charge separation in thin layers formed between a solid conducting surface and liquid electrolytes containing ions [11]. In supercapacitor charge does not accumulate between two conductors, but in

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between surface of conductor and electrolyte [12].Hence value of capacitance and performance of supercapacitor depends upon electrode material used. Therefore depending upon design of electrodes supercapacitors are categorised into three classes i) double layer capacitors (ii) pseudocapacitors and (iii) hybrid capacitors [13],[14].
Mechanism of double layer capacitor depends on the electrostatic storage, which is achieved by the separation of charges at interface between the conductive electrode surface and electrolytic solution. Capacitance of double layer capacitor is proportional to the specific surface area of electrode material therefore carbon material such as activated carbon, carbon fibres are selected as electrode materials for double layer capacitors which provides higher capacitance than pseudocapacitors [14], [15]. Pseudocapacitors are electrochemical capacitors, in which energy storage is depends on transfer of electrons achieved by redox reaction with ions from electrolyte solution.The electrochemical capacitors include metal oxide supercapacitors and conducting polymersupercapacitors. Capacitance of electrochemical capacitors depends on the utilization of active material of electrodes [16]. Hybrid super-capacitor combines properties of electrolytic capacitor and electrochemical capacitor, so it has thebest features with the high specific capacitance and high energy density of electrochemical capacitor [17], [18].

This paper is organised as follows: section II deals with experiment for comparison of different carbon materials. Section III includes observation and conclusion based on experiments done.

II. EXPERIMENTS AND ANALYSIS

Capacitance of supercapacitor is affected by electrode materials, hence electrode plays very important role in supercapacitors,. For obtaining higher value of capacitance, electrodes should have large specific area in small volume [17]. Electrodes for supercapacitor are made of highly porous material like activated carbon with high specific area. In addition to this electrode should have properties like high conductivity, high temperature stability, chemical stability, corrosion resistance, low cost high porosity and environment friendly [5]. Carbon materials in different forms such as carbon fibres, carbon aerogels, activated carbons and carbon nanotubes are most commonly used electrode materials for supercapacitors [10].Pseudocaptive materials like manganese oxide, ruthenium oxide, nickel oxide, conducting polymers are used extensively. Composite electrodes are also used as electrodes for supercapacitor which are obtained by deposition of carbon-based material with pseudocapacitve materials. The carbon-based material provides static double-layer capacitance and pseudocapacitive material facilitate high amount of faradaic pseudocapacitance.
In this paper experiments have been performed for comparison on various carbon materials like Vulcan XC-72, RP-20, YP -50F, NORIT are performed. After performing experiments following observation are obtained:

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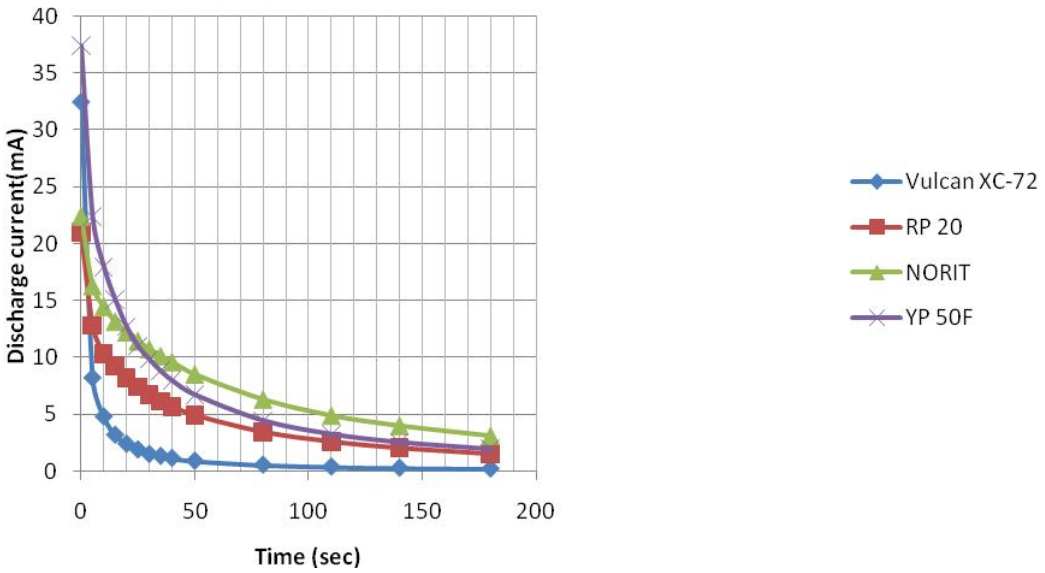

Fig 1 Supercapacitor discharge current characteristics for different carbon materials

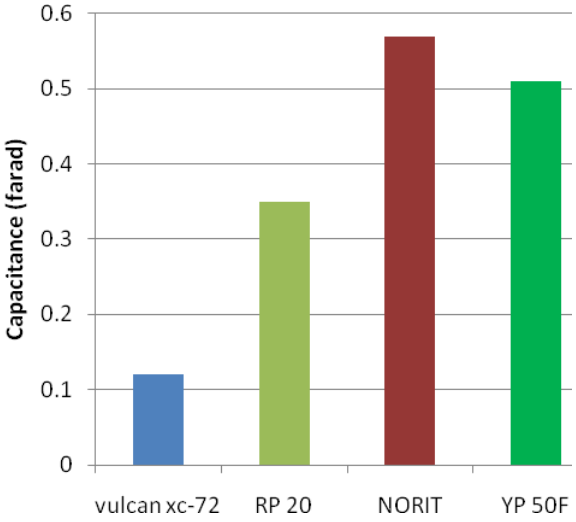

Fig 2 Capacitance of supercapacitors using different carbon materials

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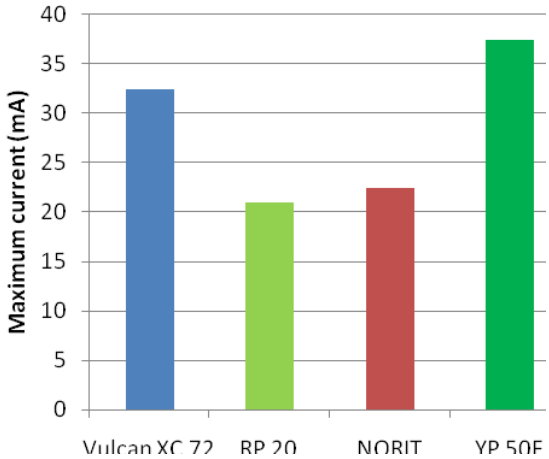

Fig 3 Characteristics of maximum value of current for different types of carbon materials

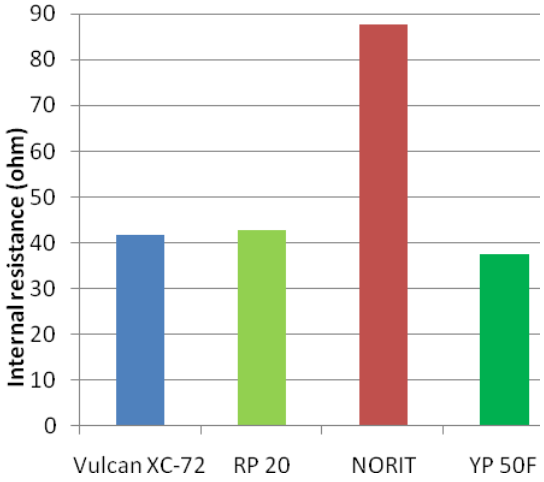

Fig 4: Internal resistance characteristics of supercapacitor for different supercapacitor

III. CONCLUSION

Different characteristics of supercapacitors using various supercapacitors are studied. After studying such characteristics it is observed thatNORIT has high capacitance of value 0.57F and it has internal resistance of value 87.71Ω, which is much higher than other carbon grades. Hence after performing such experiments it is found thatcarbon grade YP 50F has high capacitance (0.53 F) with much low internal resistance (38 Ω). Hence YP 50F carbon grade is found to be most suitable material for supercapacitor.

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REFERENCES

[1] R. P. Deshpande, Capacitor Technology and trends, Paperback 2013
[2] W. E., Anderson, Calibration of High Voltage Capacitor, Vol. 94, May 1998
[3] RamasamyNatarajan, Power System Capacitors technology and Engineering, CRC Press, Mar 2005
[4]*Arco Electronics - Camarillo, CA Distributor, Custom Manufacturer, Service Company*
[5] L. Borsody, "New Impregnation for Paper Capacitors", Component Parts IRE Transactions Vol. 7, issue 1, Mar 1960, Page 15 – 25, ISSN: 0096-2422
[6] *Difference between Capacitor and Supercapacitor [online] Available: http://www.differencebetween.com/difference*
[7] *Simple Capacitors to Supercapacitors - An Overview [online] available: http://www.electrochemsci.org/papers/vol3/3111196)*
[8] *Table of Dielectric [online] Available: http://www.sofia.usra.edu/edu/materials/activeastronomy/sec5-capacitor.pdf*
[9] B.E. Conway, Electrochemical supercapacitors, Kluwer Academics, New York, 1999.
[10] *Maxwell technologies, Automotive Applications [online] Available: http://maxwell.com/ultracapcitors*
[11] *Ultracapacitors & Supercapacitors Forum [online] available: http://www.ultracapacitors.org/*
[12] *Supercapacitors: A Brief Overview [online] Available: http://services.eng.uts.edu.au/cempe/subjects_JGZ/eet/Capstone%20thesis_AN.pdf*
[13] Andrew Burke, "The present and projected performance and cost of double layer and pseudo-capacitive ultracapcitors for hybrid electric vehicles applications," IEEE transactionson Industry Applications, vol.40, no.9, May 2005, pp356-366.
[14] Andrew Burke, M. Miller, "Electrochemical capacitors as Energy Storage in hybrid electric vehicles; present status and future prospects," proceedings of International battery, Hybrid and Fuel Cell Electric Vehicle Symposium (EVS24), 13-16 May 2009, Stavanger, Norway- pp 1-11
[15] P. B. Karandikar, D. B. Telange," Implementation and Study of Regenerative Breaking on Motorised Bicycle," Journal of Asian Electric Vehicles, Vol.9, No.2, December 2011, pp 1497-1504.
[16] P. B. Karandikar, D. B. Telange, UdayMhaskar, Ramesh Bansal, "Validation of Capacitance and ESR Model of Manganese Oxide Based Aqueous Supercapacitor," Electric Power Componants and Systems, Taylor and Francis, July 2012, Vol. 40 pp 1105-1118
[17] Andrew Burke, "Supercapacitor: Why, How and Where is the Technology," Journal of Power Sources 2000, 91, 37- 50
[18] Parashuram B. Karandikar, Dhanjay B. Talange, "Materials based Characterization of Aqueous Metal Oxide Based Supercapacitor," IEEE International Conference on Power and Energy-PEC on 2010, 2, 485-488.

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