Performance comparison of Lead-Carbon Hybrid Ultracapacitors with substrate-integrated and pasted-positive plates

A. Banerjee, P. Suresh Kumar, M. K. Ravikumar and A. K. Shukla†

Solid State and Structural Chemistry Unit, Indian Institute of Science, Bangalore-560012, India

Lead-carbon hybrid ultracapacitors comprise positive lead oxide plates of the lead-acid battery and negative plates of the carbon-based electrical double layer capacitor (EDLC). Accordingly, a lead-carbon hybrid ultracapacitor has the features of both the storage battery and that of an EDLC. In the literature, [1-4] Lead carbon ultracapacitors with pasted-positive plates as well as substrate-integrated positive plates have been reported. However, a performance comparison study on the two types of lead-carbon hybrid ultracapacitors is lacking in the literature. In this study, we present the performance comparison between the two types of lead-carbon hybrid ultracapacitors.

The study suggests that the faradaic efficiencies for the two types of lead-carbon hybrid ultracapacitors are nearly similar. However, their capacitance values as well as energy and power density values differ widely. For substrate-integrated configuration, capacitance and energy density values are lower but power density values are observed to be higher than pasted-plate hybrid ultracapacitors owing to their shorter response time. Similarly, internal resistance values are also lower for substrate-integrated ultracapcitors. Both types of lead-carbon hybrid ultracapacitors exhibit good cycle-life up to 100,000 pulse charge-discharge cycles with a little capacitance loss. The performance comparison data are presented in Tables 1 and 2.

It is noteworthy that, unlike lead-acid batteries, lead-carbon hybrid ultracapacitors can be charged and discharged at much higher rates. The study also suggests that lead-carbon hybrid ultracapacitors function well over a wide range of temperatures. Lead-carbon hybrid ultracapacitors are fully recyclable, safe and cost-effective. In recent years, lead-carbon hybrid ultracapacitors have come of age and it is now more-or-less established that the future of batteries might not be batteries alone. Some of the potential applications of the lead-carbon hybrid ultracapacitors will be discussed.

†akshukla2006@gmail.com

Table.1: Performance comparison for 12V / hundred-Farad (h-F) range Lead-Carbon Hybrid Ultracapacitors.

Parameter	12 V / h-F range			
	AGM Configuration		Gel Configuration	
	Pasted-positive plate	SI-PbO_2 positive plate	Pasted-positive plate	SI-PbO_2 positive plate
Faradaic Efficiency (%)	91	91	88	89
Internal Resistance (mΩ)	204	87	213	118
Capacitance (F)	463	184	528	269
Energy Density (Wh/kg)	3.05	1.15	3.06	1.42
Power Density (W/kg)	718	2671	413	1060

Table.2. Performance comparison of 12V / kilo-Farad (k-F) range Lead-Carbon Hybrid Ultracapacitors.

Parameter	12 V / k-F range			
	AGM Configuration		Gel Configuration	
	Pasted-positive plate	SI-PbO_2 positive plate	Pasted-positive plate	SI-PbO_2 positive plate
Faradaic Efficiency (%)	92	93	87	92
Internal Resistance (mΩ)	78	23	91	24
Capacitance (kF)	4.08	1.38	5.45	2.45
Energy Density (Wh/kg)	3.63	0.9	3.65	1.8
Power Density (W/kg)	660	1937	457	1333

References

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