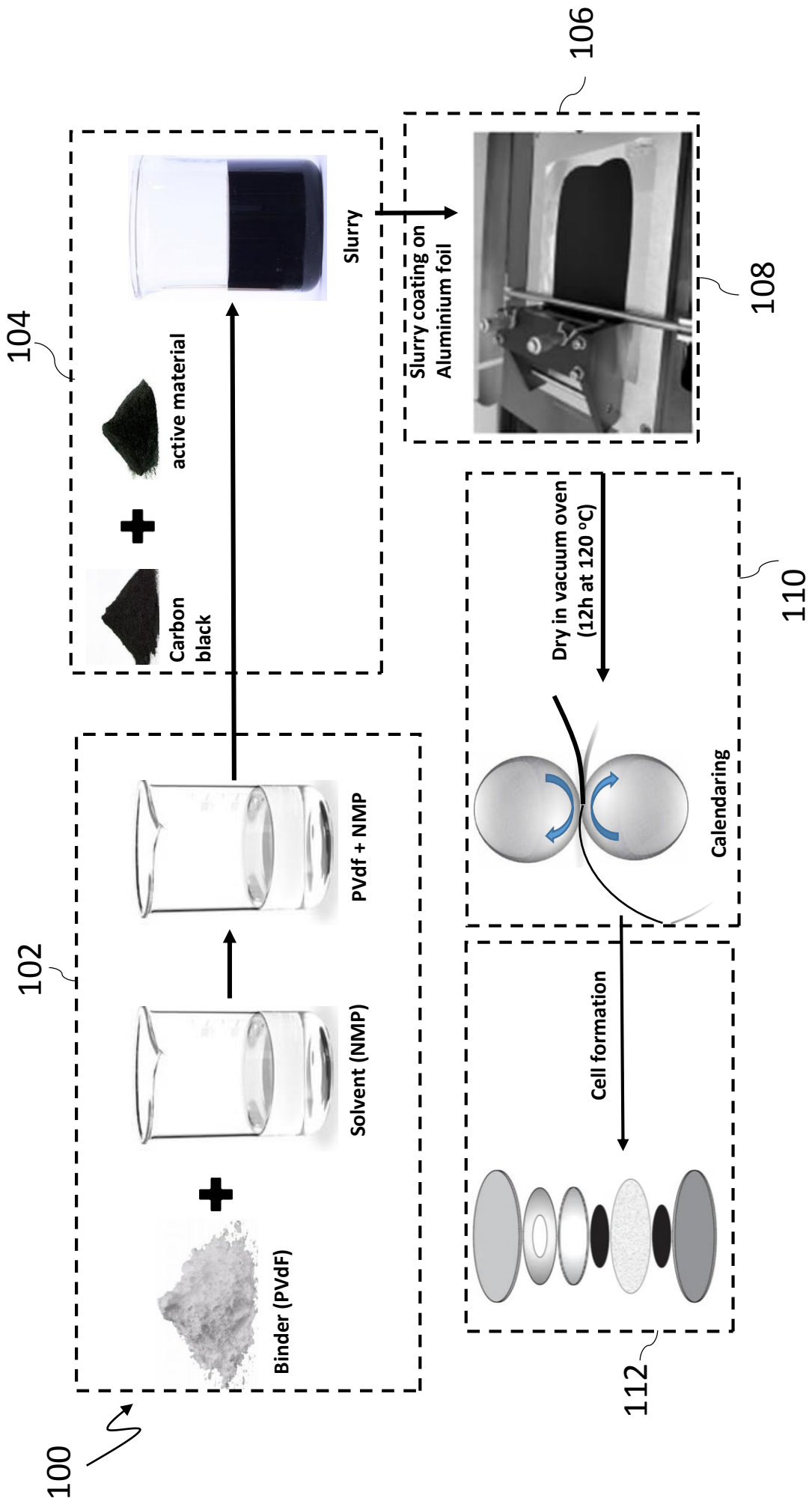


Fig. 1A
(Prior Art)

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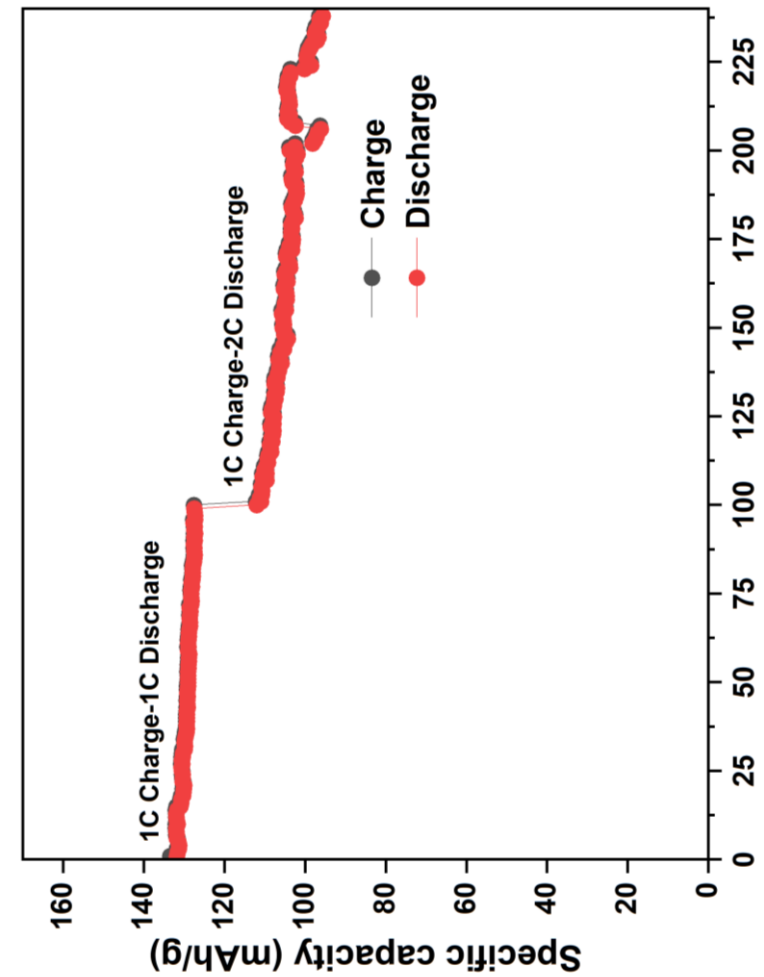


Fig. 1C
(Prior Art)

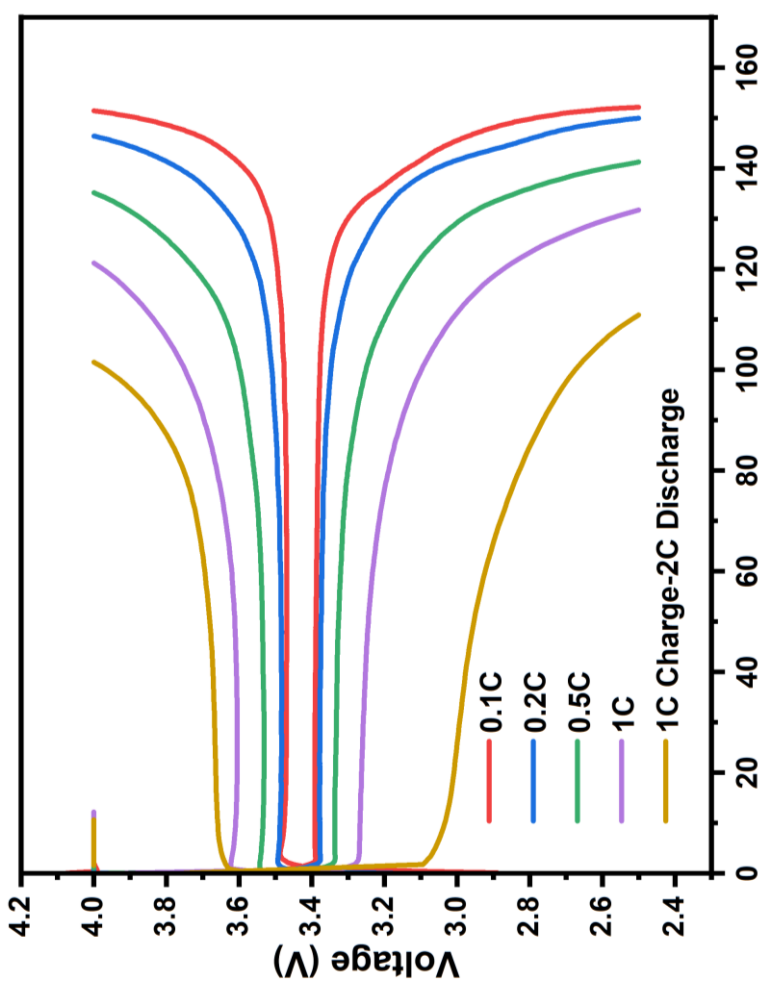


Fig. 1B
(Prior Art)

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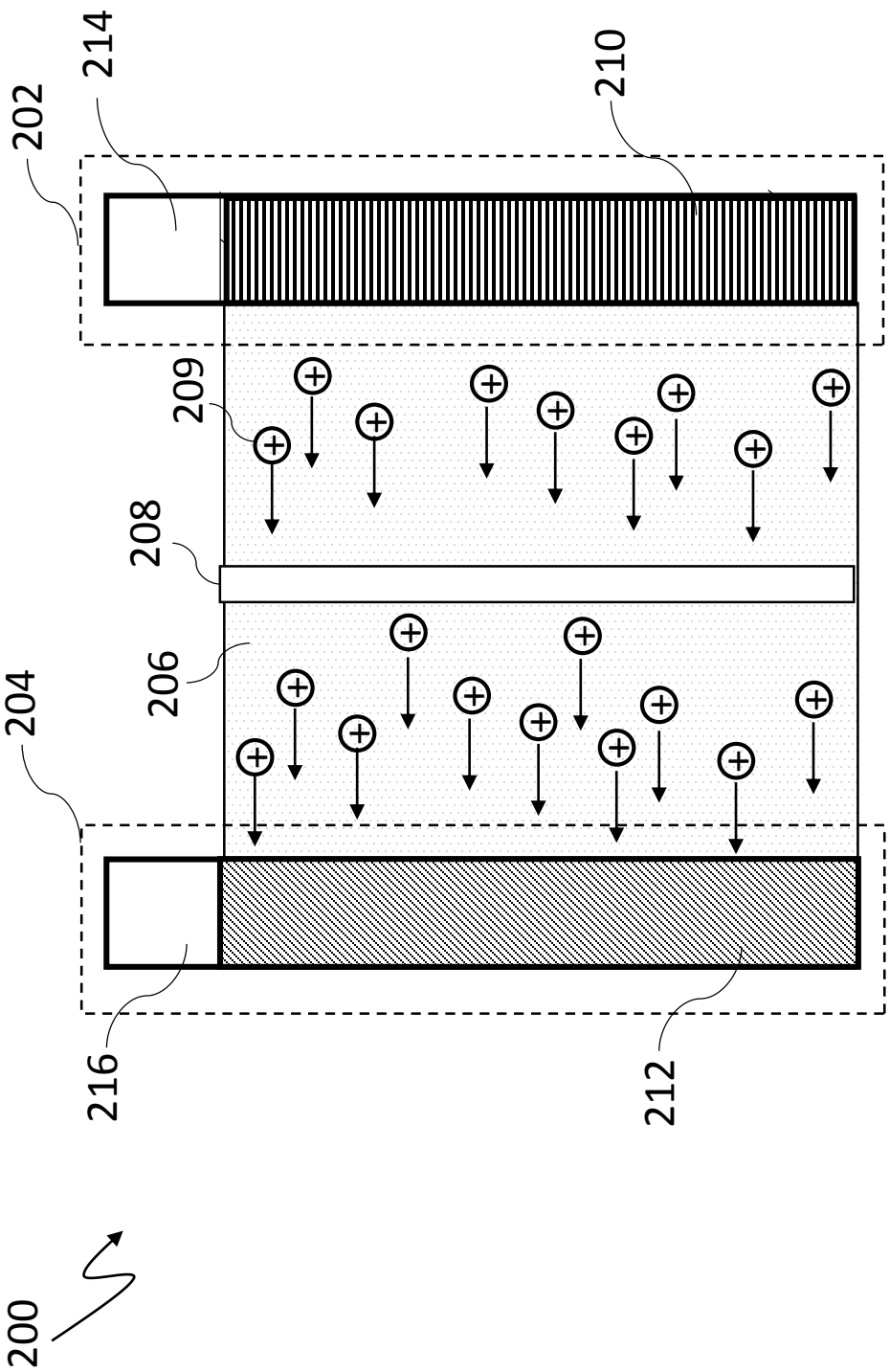


Fig. 2A

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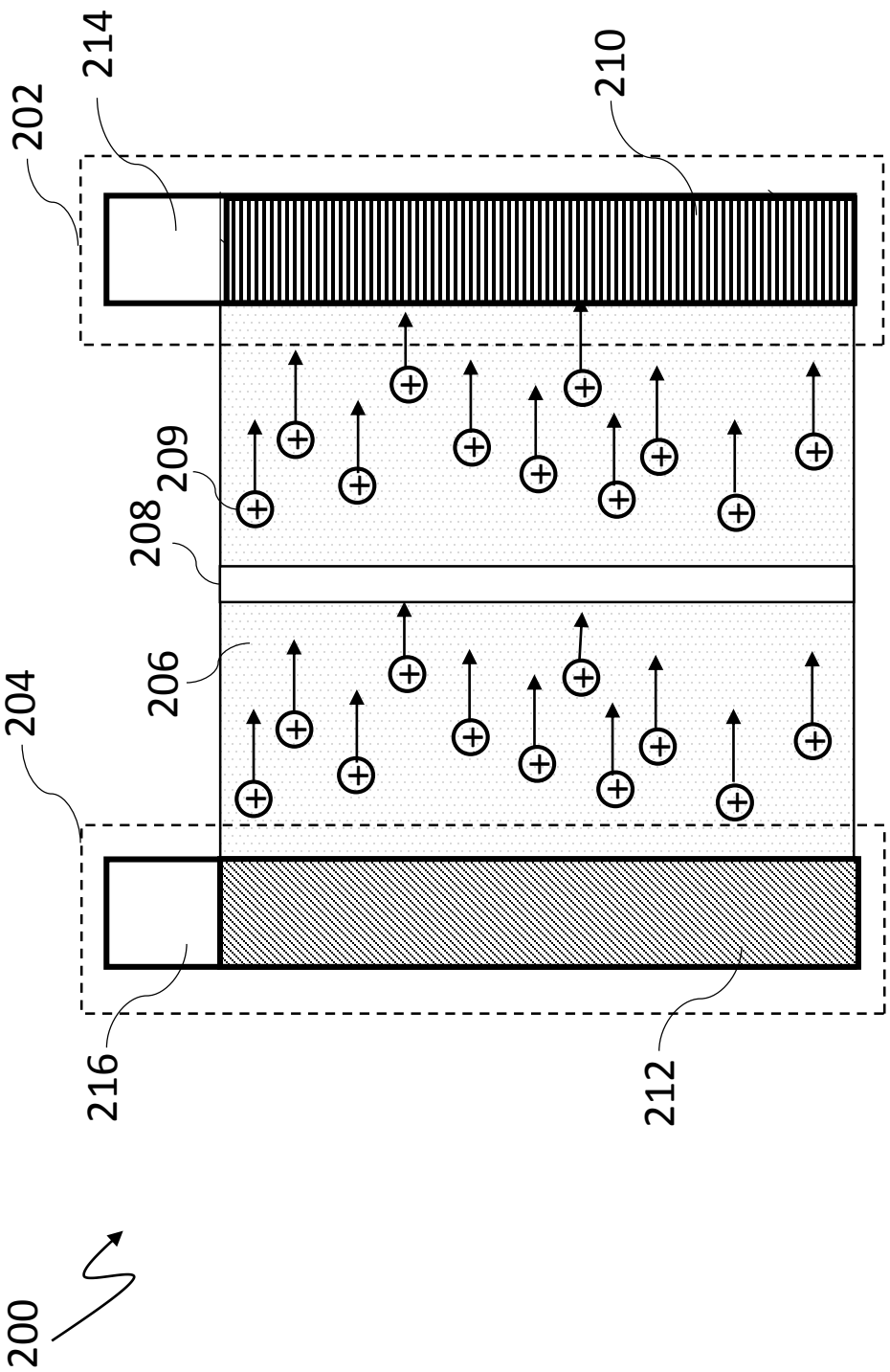


Fig. 2B

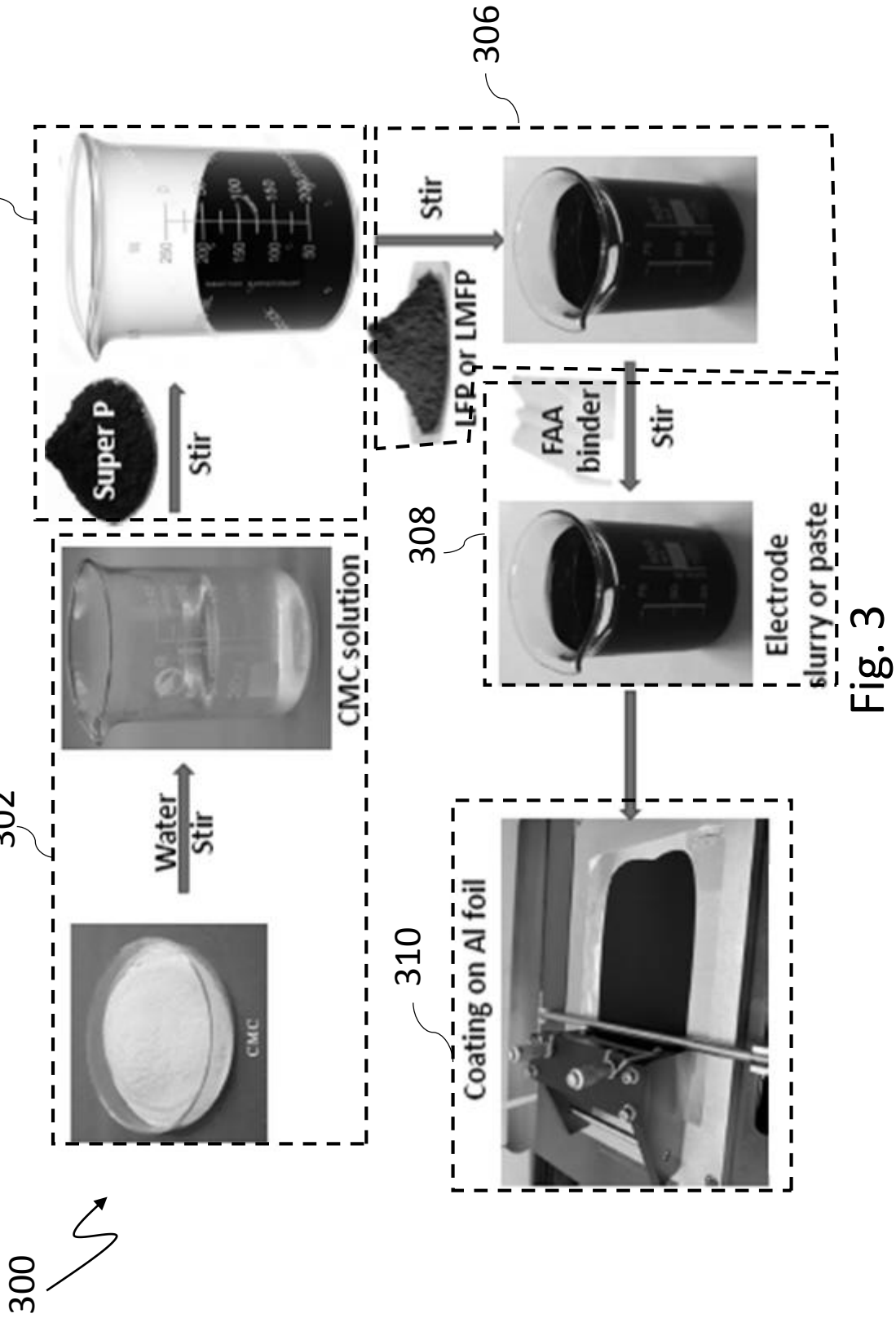

300
302
CMC
Water
Stir
CMC solution
304
Super P
Stir
306
LFP or LMFP
Stir
308
FAA binder
Stir
Electrode slurry or paste
310
Coating on Al foil

Fig. 3

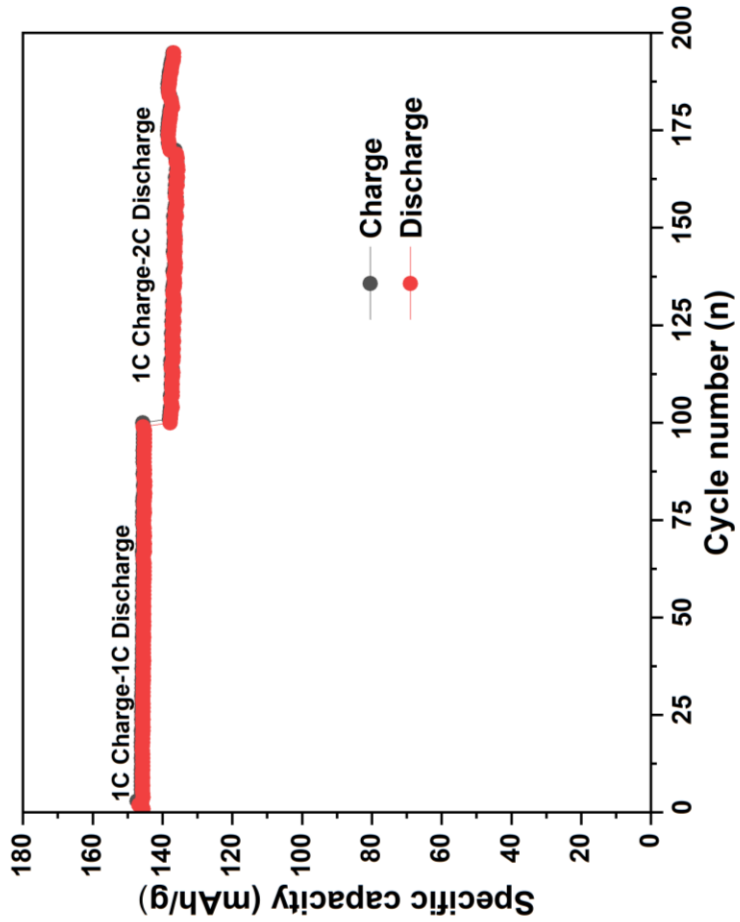


Fig. 4B

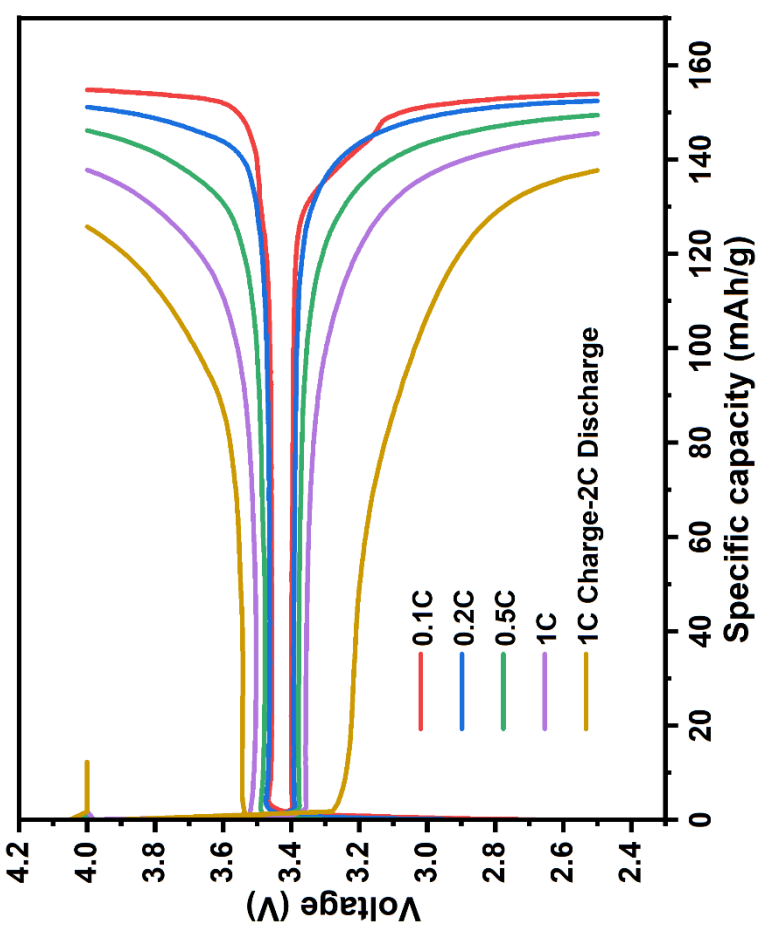


Fig. 4A

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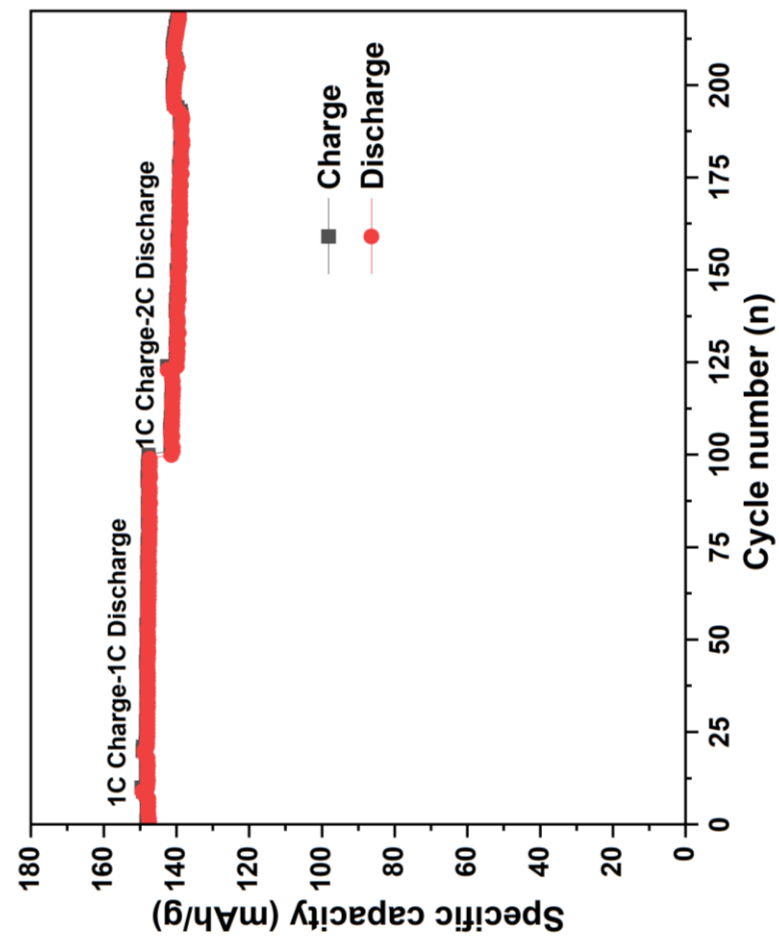


Fig. 5B

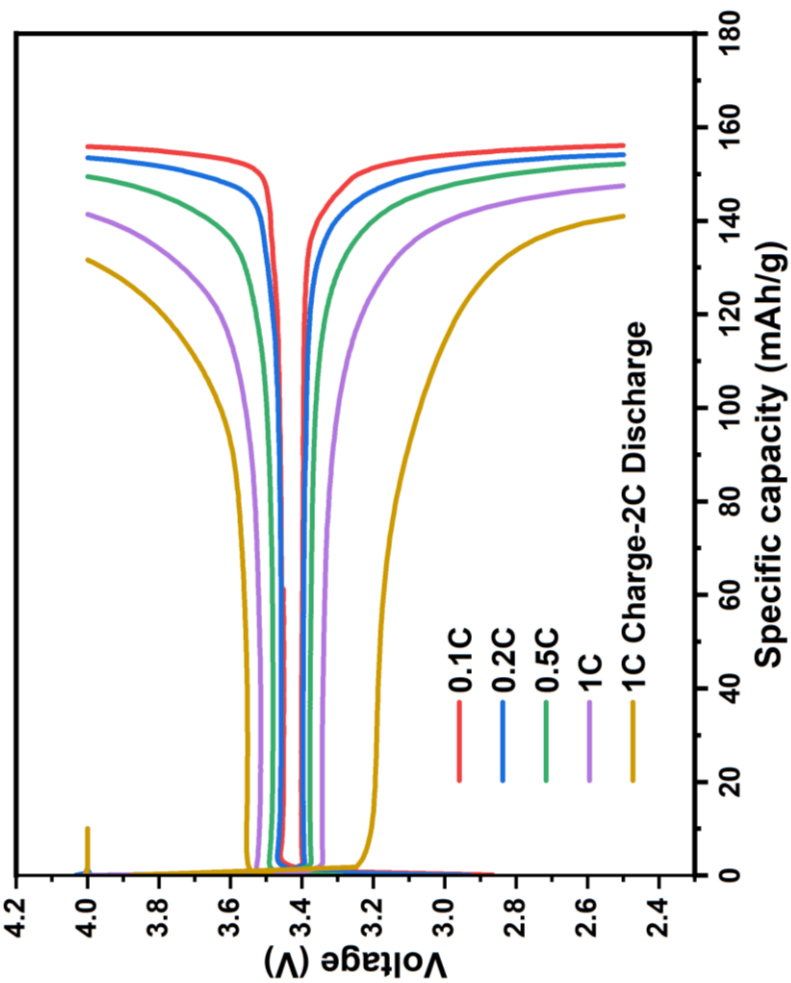


Fig. 5A

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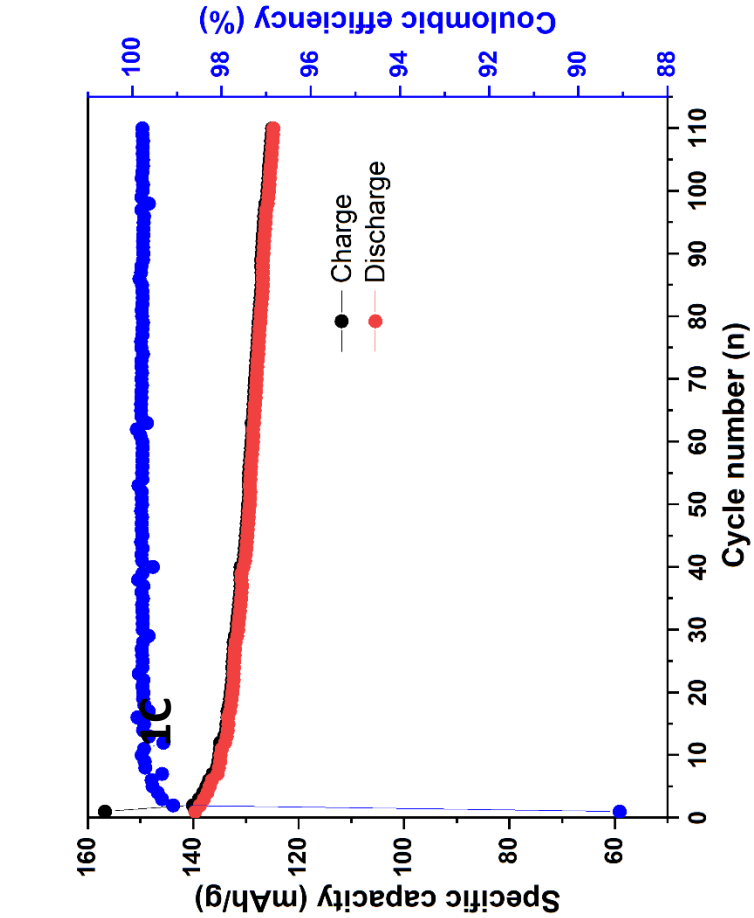


Fig. 6B

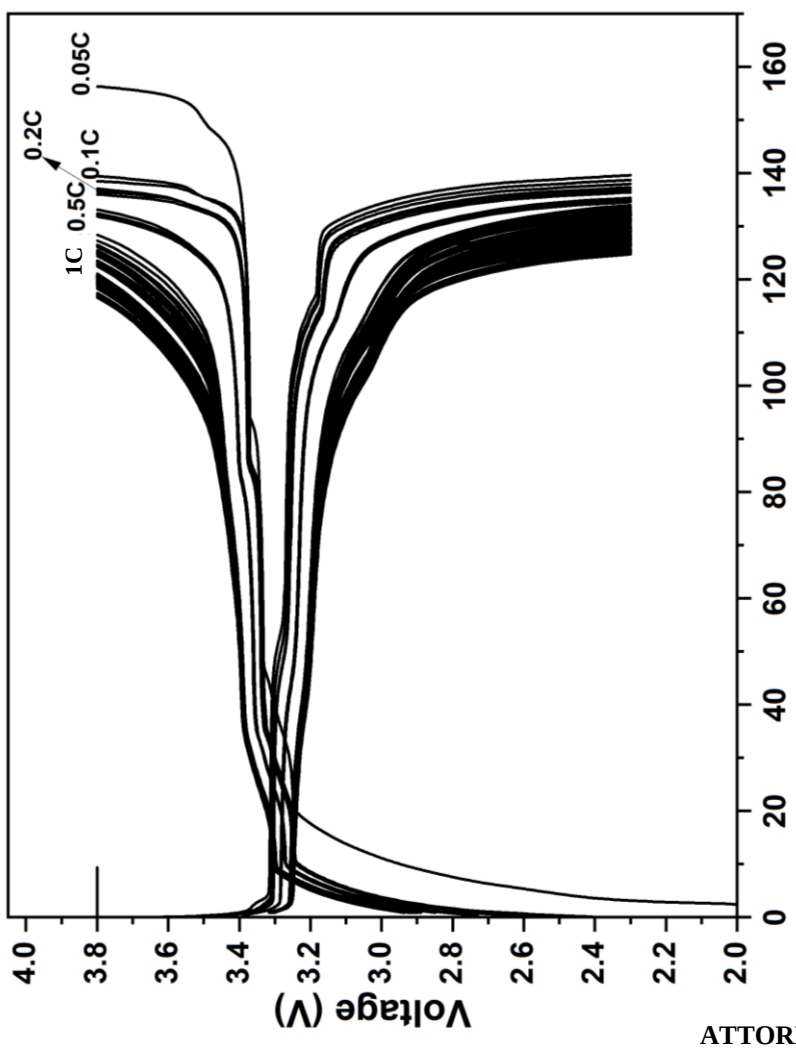


Fig. 6A

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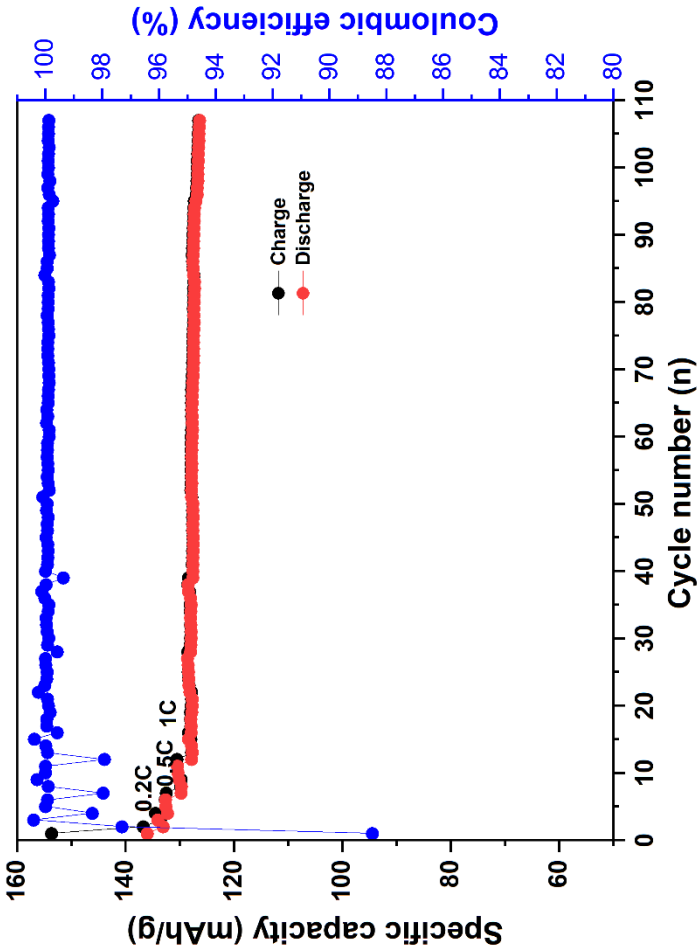


Fig. 7B

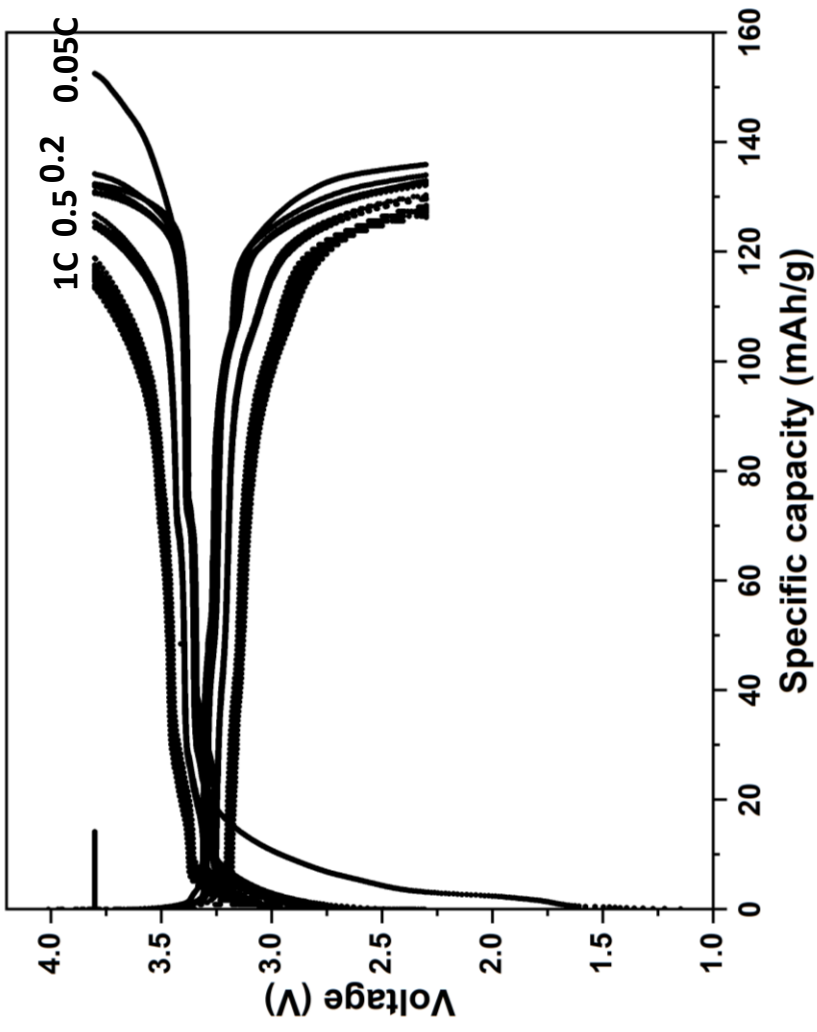


Fig. 7A

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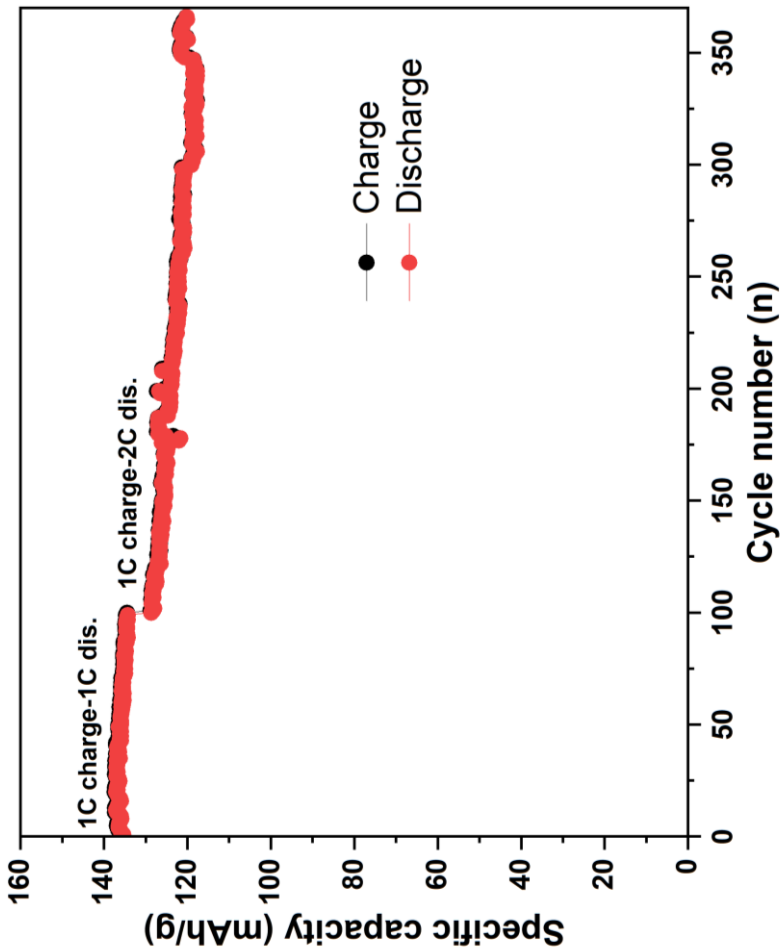


Fig. 8B

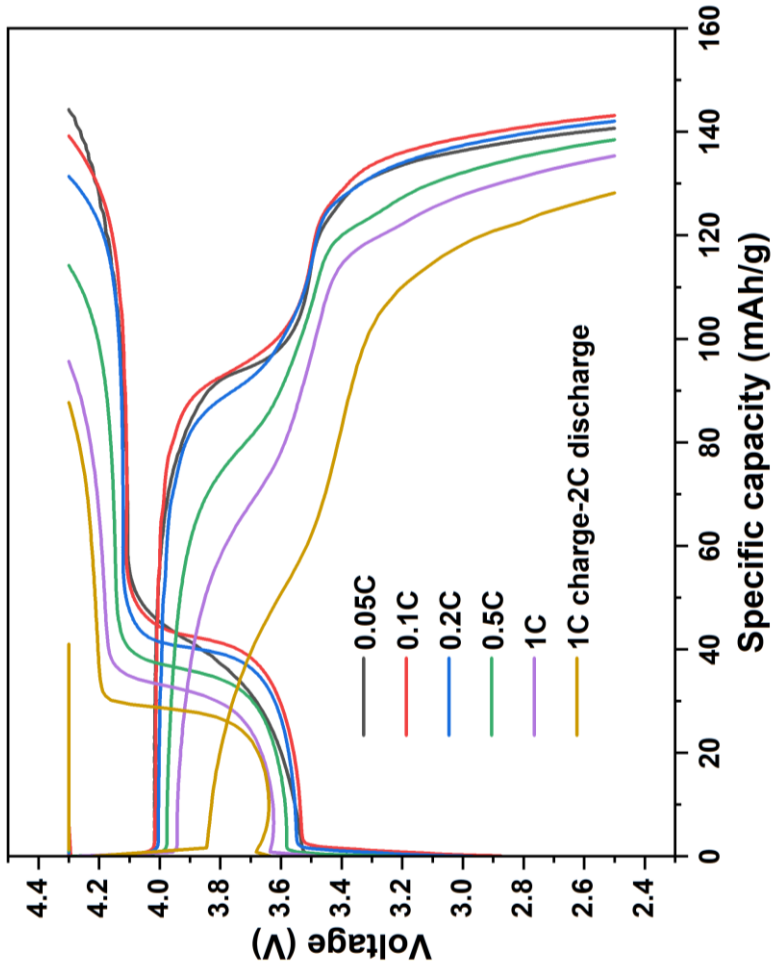


Fig. 8A

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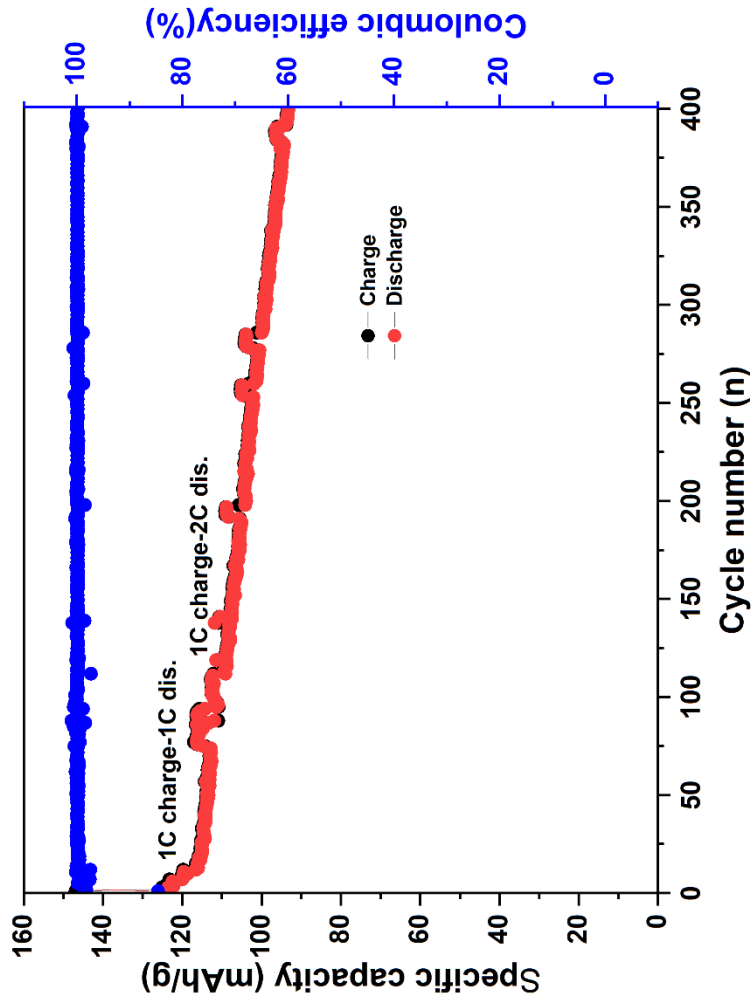


Fig. 9B

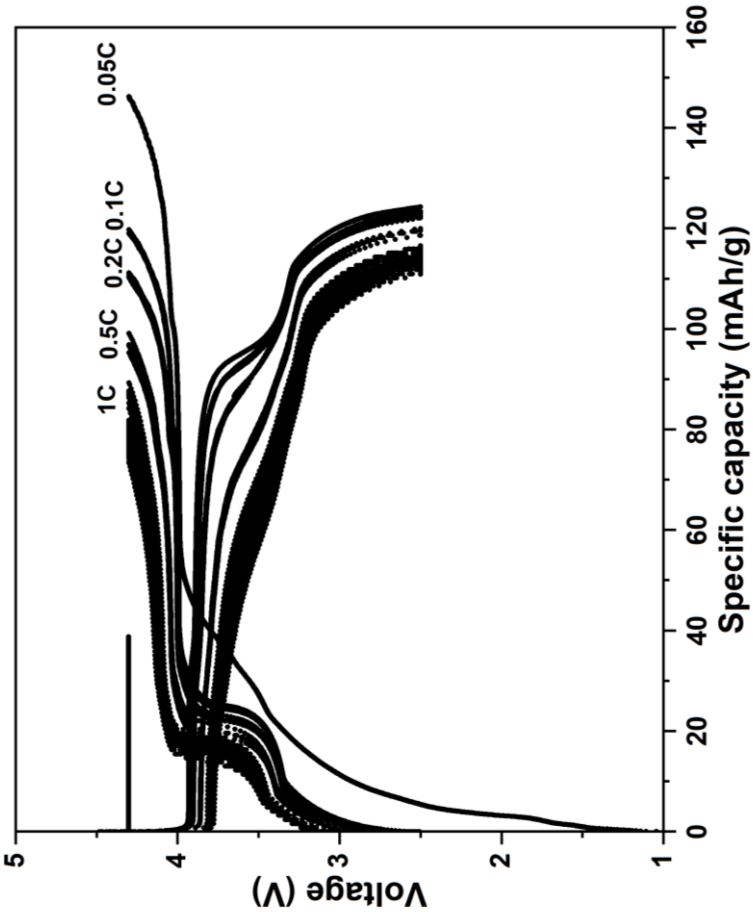


Fig. 9A

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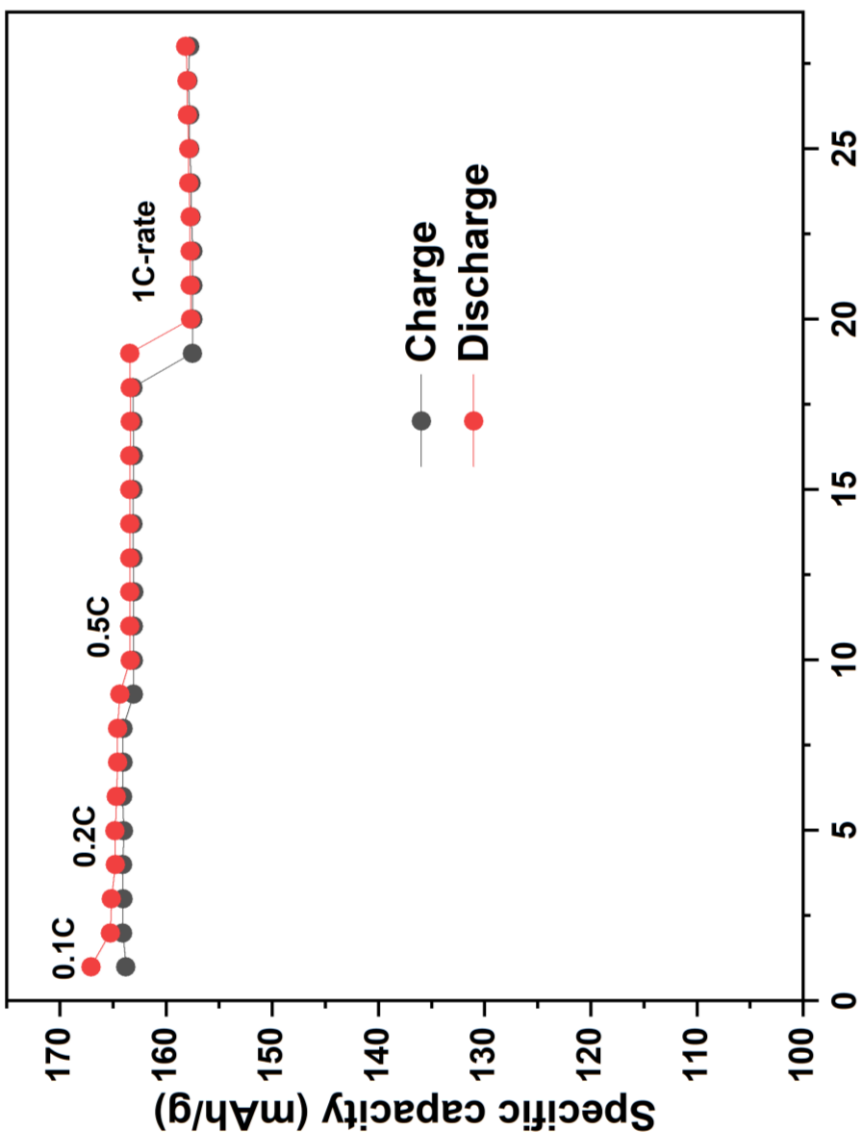


Fig. 10

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FORM 2
THE PATENTS ACT 1970
[39 OF 1970]
&
THE PATENTS (AMENDMENT) RULES, 2006
COMPLETE SPECIFICATION
[See Section 10; rule 13]

"LITHIUM-ION CELL UTILIZING ELECTRODES MADE FROM AQUEOUS SLURRY"

GODI INDIA PVT. LTD., an Indian company, of 12(p), 13, 14(p), Road No:2, Hardware Park, Near International Airport, Hyderabad – 500005, India,

The following specification particularly describes the invention and the manner in which it is to be performed:

LITHIUM-ION CELL UTILIZING ELECTRODES MADE FROM AQUEOUS SLURRY

FIELD OF INVENTION

The present invention relates to lithium-ion cells, and specifically relates to electrodes of lithium-ion cells.

BACKGROUND

Lithium (Li)-ion cells are energy storage elements used in portable devices, such as laptops, cellular phones, and personal digital assistants. Costs of the Li-ion cells are high due to materials used in fabrication of the Li-ion cells, labour charges, and processing of the materials. Thus, usage of the Li-ion cells are limited in electric vehicles and grid energy storage. Lowering of the costs of the Li-ion cells can be achieved by usage of low-cost materials and reducing the cost of processing of the materials. An overall cost of the materials used in fabrication of electrodes such as cathodes and anodes of the Li-ion cells is a major portion of a total cost of the Li-ion cells.

A Li-ion cell consists of a cathode, an anode, and an electrolyte. The cathode and the anode are present in a form of a film fabricated using a slurry coated over a current collector. The slurry is made through mixing of active materials with additives, such as binder and conductive carbon dispersed in a solvent.

Fig. 1A illustrates a process flow **100** of fabrication of a Li-ion cell, in accordance with prior art. Polyvinylidene Fluoride (PVdF) binder solution is prepared by adding PVdF binder into N-methyl Pyrrolidone (NMP) solvent, at step **102**. The PVdF binder solution is mixed with the materials such as carbon black (C65) and active materials such as Lithium Iron Phosphate (LFP) or Lithium Iron Manganese Phosphate (LMFP) using a ball mill or slurry mixer for about 5 to 12 hours, to obtain a slurry, at step **104**. Further, the slurry is coated on a current collector, at step **106**. The current collector coated with the slurry is kept in a vacuum oven at a temperature of about 120^{o} C for about 12 hours to obtain an electrode sheet, at step **108**. The electrode sheet is pressed using a hot rolling cylinder press to obtain an electrode, at step **110**. The Li-ion cell is fabricated using the electrode, at step **112**.

Fig. 1B illustrates a voltage vs. specific capacity plot and **Fig. 1C** illustrates a specific capacity vs. cycle number plot for a Li-ion cell, in accordance with prior art. The Li-ion cell fabricated using NMP solvent was tested and results of the testing were plotted in graphs, as illustrated in **Fig. 1B** and **1C**. As illustrated in **Fig. 1B**, a specific capacity of 152 mAh/g is obtained at a charging rate of 0.1C. Further, specific capacity retention of 86% is obtained at a charging rate of 1C and a specific capacity of 111 mAh/g is obtained at a charging rate of 2C. Polarization between charge and discharge profile is about 750 mV at a high rate, such as 1C charge rate and 2C discharge rate. Thus, it is observed that specific capacity retention of NMC based Li-ion cells is lower than aqueous based Li-ion cells. As illustrated in **Fig. 1C**, a specific capacity of the Li-ion cell decreases from its initial capacity of about 150 mAh/g to about 90 mAh/g with an increase in a number of charging and discharging cycles from 0 to 250. Here, a charging rate of 1C indicates that a charge current or a discharge current is applied to a cell for 1 hour and charging rate of 2C indicates that the a charge current or a discharge current is applied to the cell for 30 minutes.

As described with reference to **Fig. 1A**, the slurry is made through mixing of the NMP solvent, the PVdF binder, and a conductive carbon additive. The NMP solvent is highly toxic and hazardous to environment. In addition, the NMP solvent needs to be collected while coating on the current collector, and this leads to an increase in a manufacturing cost of the Li-ion cell. Further, while coating the slurry, the NMP solvent needs to be dried out at high temperature ranging from 100^{o} C to 120^{o} C, in a controlled atmosphere (RH 10 to 30% at 25^{o} C) which can further contribute to an additional cost in production of the Li-ion cell. Also, the electrode composed with the PVdF binder or PolyTetraFluoroEthylene (PTFE) is less conductive and flexible compared to water-based binders. Further, a copper (Cu) foil is generally used as an anode of the Li-ion cell. Usage of Cu in the Li-ion cell increases its overall cost.

Thus, there remains a need to reduce a cost of fabrication of a Li-ion cell, eliminate usage of toxic compounds used in fabrication of the Li-ion cell, and to enhance performance of the Li-ion cell.

OBJECTS OF THE INVENTION

A general objective of the present invention is to fabricate electrodes for use in a Li-ion cell.

Another objective of the present invention is to prepare a non-toxic slurry for fabrication of the electrodes of the Li-ion cell.

Another objective of the present invention is to prepare an aqueous slurry for fabrication of the electrodes of the Li-ion cell.

Another objective of the present invention is to reduce power consumed for fabrication of electrodes through heating.

Yet another objective of the present invention is to reduce a cost of fabrication of the electrodes.

Still another objective of the present invention is to enhance performance of the Li-ion cell.

SUMMARY OF THE INVENTION

Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

In one embodiment, to fabricate an electrode for use in a lithium-ion cell, Sodium-Carboxy Methyl Cellulose (CMC) may be dissolved in water to obtain a solution. A conductive additive may be mixed into the solution. An active material may be mixed into the solution. The active material is used in a weight ratio ranging from 90% to 95%. Fluorine Acrylate (FAA) latex binder may be mixed into the solution to obtain an aqueous slurry. The FAA latex binder is used in a weight ratio ranging from 2% to 4%. The aqueous slurry may be coated on a current collector to obtain the electrode.

In an aspect, one of Lithium Iron Phosphate (LFP) or Lithium Iron Manganese Phosphate (LMFP) may be used as the active material and Aluminium (Al) may be used as the current collector for fabrication of a cathode.

In an aspect, one of graphite or Lithium Titanate (LTO) may be used as the active material and one of Copper (Cu) or a carbon coated Al (C-Al) foil may be used as the current collector for fabrication of an anode.

In an aspect, the Sodium-CMC may be dissolved in the water for at least one hour before adding the conductive additive. Further, two portions of the active material may be added one after another into the solution, and mixed for five hours. The aqueous slurry may be placed under a vacuum condition for at least 15 minutes. The sodium-CMC is used as a thickening agent in the aqueous slurry.

In an aspect, the aqueous slurry may be coated on the current collector using a doctor blade and a pilot line roll-to-roll coating machine. The current collector coated with the aqueous slurry are dried at a pre-defined temperature.

In an aspect, a ratio of solid to liquid and a ratio of the FAA latex binder to the sodium-CMC in the aqueous slurry may be optimized.

Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings constitute a part of the description and are used to provide further understanding of the present invention. Such accompanying drawings illustrate the embodiments of the present invention which are used to describe the principles of the present invention. The embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings in which like references indicate similar elements. It should be noted that references to "an" or "one" embodiment in this invention are not necessarily to the same embodiment, and they mean at least one. In the drawings:

Fig. 1A illustrates a process flow of fabrication of a Li-ion cell, in accordance with prior art;

Fig. 1B illustrates a voltage vs. specific capacity plot and **Fig. 1C** illustrates a specific capacity vs. cycle number plot for a Li-ion cell, in accordance with prior art;

Fig. 2A illustrates an arrangement of components in a Li-ion cell during charging operation and **Fig. 2B** illustrates an arrangement of components in the Li-ion cell during discharging operation, in accordance with an embodiment of the present invention;

Fig. 3 illustrates a process flow of fabrication of an electrode for use in a Li-ion cell, in accordance with an embodiment of the present invention;

Fig. 4A illustrates a voltage vs. specific capacity plot and **Fig. 4B** illustrates a specific capacity vs. cycle number plot for a LFP based Li-ion half-cell having a first electrode composition ratio in accordance with an embodiment of the present invention;

Fig. 5A illustrates a voltage vs. specific capacity plot and **Fig. 5B** illustrates a specific capacity vs. cycle number plot for a LFP based Li-ion half-cell having a second electrode composition ratio in accordance with an embodiment of the present invention;

Fig. 6A illustrates a voltage vs. specific capacity plot and **Fig. 6B** illustrates a specific capacity vs. cycle number plot for a LFP/Graphite based Li-ion full-cell having a first electrode composition ratio, in accordance with an embodiment of the present invention;

Fig. 7A illustrates a voltage vs. specific capacity plot and **Fig. 7B** illustrates a specific capacity vs. cycle number plot for LFP/Graphite based Li-ion full cell having a second electrode composition ratio, in accordance with an embodiment of the present invention;

Fig. 8A illustrates a voltage vs. specific capacity plot and **Fig. 8B** illustrates a specific capacity vs. cycle number plot for a LMFP based Li-ion half-cell, in accordance with an embodiment of the present invention;

Fig. 9A illustrates a voltage vs. specific capacity plot and **Fig. 9B** illustrates a specific capacity vs. cycle number plot for a LMFP/Graphite based Li-ion full cell, in accordance with an embodiment of the present invention; and

Fig. 10 illustrates a specific capacity vs. cycle number plot for a LTO based Li-ion half-cell, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The detailed description set forth below in connection with the appended drawings is intended as a description of various embodiments of the present invention and is not intended to

represent the only embodiments in which the present invention may be practiced. Each embodiment described in this disclosure is provided merely as an example or illustration of the present invention, and should not necessarily be construed as preferred or advantageous over other embodiments. The detailed description includes specific details for the purpose of providing a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced without these specific details.

The present invention relates to fabrication of an electrode for use in a Lithium (Li)-ion cell. Before describing the fabrication of the electrode, components of the Li-ion cell have been described with reference to **Figs. 2A and 2B**.

Fig. 2A illustrates an arrangement of components in a Li-ion cell **200** during charging operation, and **Fig. 2B** illustrates an arrangement of components in the Li-ion cell **200** during discharging operation, in accordance with an embodiment of the present invention. The Li-ion cell **200** may comprise a cathode **202**, an anode **204**, and an electrolyte **206**. The cathode **202** and the anode **204** may be separated by a separator **208** soaked with the electrolyte **206**. Li^+ ions **209** may migrate toward the anode **204** during the charging operation, as illustrated in **Fig. 2A** and may migrate toward the cathode **202** during the discharging operation, as illustrated in **Fig. 2B**.

For fabrication of the cathode **202**, a first aqueous slurry **210** may be prepared by mixing an active material, Fluorine Acrylate (FAA) latex binder, and auxiliary materials dispersed in water. The first aqueous slurry **210** may be coated over a first current collector **214** for obtaining the cathode **202**. The active material may be used in a weight ratio ranging from 90% to 95%. The Fluorine Acrylate (FAA) latex binder and CMC together may be used in a weight ratio ranging from 3% to 5%. Particularly, the FAA latex binder may be used in a weight ratio ranging from 2% to 4%. The auxiliary materials may be used in a weight ratio ranging from 2% to 5%. The active material may be one of Lithium Iron Phosphate (LFP) or Lithium Iron Manganese Phosphate (LMFP). The first current collector **214** may be made of Aluminium (Al).

For fabrication of the anode **204**, a second aqueous slurry **212** may be prepared by mixing graphite or Lithium Titanate (LTO) as the active material, Fluorine Acrylate (FAA) latex binder, and auxiliary materials dispersed in water. The second aqueous slurry **212** may be

coated over a second current collector **216** for obtaining the anode **204**. The active material may be used in a weight ratio ranging from 90% to 95%. The Fluorine Acrylate (FAA) latex binder and CMC may be used in a weight ratio ranging from 3% to 5%. Particularly, the FAA latex binder may be used in a weight ratio ranging from 2% to 4%. The auxiliary materials may be used in a weight ratio ranging from 2% to 5%. The second current collector **214** may be made of Copper (Cu) or carbon coated Al (C-Al).

Fig. 3 illustrates a process flow **300** of fabrication of an electrode (**202, 204**) for use in a Li-ion cell **200**, in accordance with an embodiment of the present invention. At step **302**, Sodium-Carboxy Methyl Cellulose (CMC) powder may be dissolved in water and stirred for at least 1 hour, to obtain a solution. Carbon additive, such as SuperP may be added to the solution and stirred, at step **304**. The solution may be present in a dark color. Further, an active material may be mixed into the solution, at step **306**. The active material may be used in a weight ratio ranging from 90% to 95%. The active material may be added in two lots and stirred for 5 hours. In one implementation, one of Lithium Iron Phosphate (LFP) or Lithium Iron Manganese Phosphate (LMFP) may be used as the active material for fabrication of the cathode **202**. Further, one of graphite or Lithium Titanate (LTO) may be used as the active material for fabrication of the anode **204**.

Fluorine Acrylate (FAA) latex binder may be mixed into the solution to obtain an aqueous slurry, at step **308**. The FAA latex binder may be used in a weight ratio ranging from 2% to 4%. In an aspect, the FAA latex binder may be present in form of a solution. In another aspect, the FAA latex binder may be present in a powdered form. The FAA latex binder may be mixed in the solution by stirring for at least 15 min under a vacuum condition, to obtain an aqueous slurry. The aqueous slurry may be present as a stable and dispersible solution. The aqueous slurry may be coated on a current collector (**214, 216**) using a doctor blade and a pilot roll-to-roll coating machine, at step **310**. The current collector (**214, 216**) coated with the aqueous slurry may be dried at 80℃ to obtain the electrode (**202, 204**) for use in the Li-ion cell **200**. In one implementation, an Aluminium (Al) foil may be used as the current collector **214** for fabrication of the cathode **202**. Further, one of a Copper (Cu) foil or a carbon coated Al (C-Al) foil may be used as the current collector **214** for fabrication of the anode **204**.

The Li-ion cell fabricated according to the present invention was tested and results of the test were plotted, as illustrated by **Figs. 4-10**. Li-ion coin cells of different configurations, for

example active materials' composition ratio ranging from 90% to 95% and electrode materials' loading values ranging from 11 mg/cm^2 to 15 mg/cm^2, were tested, and results of the testing have been provided henceforth.

Fig. 4A illustrates a voltage vs. specific capacity plot and **Fig. 4B** illustrates a specific capacity vs. cycle number plot for a LFP based Li-ion half-cell having a first electrode composition ratio, in accordance with an embodiment of the present invention. The first electrode composition ratio was 93:4:3 indicating that the LFP was used in a weight ratio of 93%, FAA latex binder and CMC both together was used in a weight ratio of 4%, and auxiliary materials were used in a weight ratio of 3%. A voltage window for simulation of the LFP based Li-ion half-cell was set from 2.5V to 4V. As illustrated in **Fig. 4A**, a specific capacity of around 155 mAh/g was obtained at a charging rate of 0.1C. Further, the specific capacity decreases from around 155 mAh/g to around 140 mAh/g at a charging rate of 1C and a discharging rate of 2C. Also, the polarization between charge and discharge is significantly less compared to Li-ion cell fabricated using NMP based slurry. As illustrated in **Fig. 4B**, a specific capacity of the LFP based Li-ion half-cell is stable with an increase in a number of charge discharge cycles. A specific capacity of about 145 mAh/g is obtained at a charging rate of 1C and specific capacity retention of about 93% is achieved at about 200 charge discharge cycles, at a charging rate of 1C and a discharging rate of 2C.

Fig. 5A illustrates a voltage vs. specific capacity plot and **Fig. 5B** illustrates a specific capacity vs. cycle number plot for a LFP based Li-ion half-cell having a second electrode composition ratio and a first loading value, in accordance with an embodiment of the present invention. The second electrode composition ratio is 95:3:2 indicating that the LFP is used in a weight ratio of 95%, FAA latex binder and CMC is used in a weight ratio of 3%, and auxiliary materials are used in a weight ratio of 2%. A voltage window for electrochemical studies of the LFP based Li-ion cell was set from 2.5V to 4V. As illustrated in **Fig. 5A**, a specific capacity of about 157 mAh/g is obtained at a charging rate of 0.1C and a specific capacity of about 142 mAh/g is obtained at a charging rate of 1C and a discharging rate of 2C. Also, polarization between charge and discharge is significantly less for active material loading of 95%. As illustrated in **Fig. 5B**, a specific capacity of the LFP based Li-ion half-cell was stable with increase in a number of charge discharge cycles. A specific capacity of about 148 mAh/g is attained at a charging rate of 1C and specific capacity retention of about 92% is achieved at about 230 charge discharge cycles, at a charging rate of 1C and a discharging rate of 2C.

Fig. 6A illustrates a voltage vs. specific capacity plot and **Fig. 6B** illustrates a specific capacity vs. cycle number plot for a LFP based Li-ion full cell having a first electrode composition ratio, in accordance with an embodiment of the present invention. Electrochemical full cell studies were performed by setting voltage window between 2.3 V to 3.8 V. As illustrated in **Fig. 6A**, a specific capacity of about 140 mAh/g is obtained at a charging rate of 0.05C and a specific capacity of about 135 mAh/g is obtained at a charging rate of 1C and a discharging rate of 1C. As illustrated in **Fig. 6B**, a specific capacity of the LFP based Li-ion full cell is stable with an increase in a number of charge discharge cycles. A specific capacity of about 135 mAh/g is obtained at a charging rate of 1C and specific capacity retention of about 95% is achieved at about 110 charge discharge cycles.

Fig. 7A illustrates a voltage vs. specific capacity plot and **Fig. 7B** illustrates a specific capacity vs. cycle number plot for a LFP based Li-ion full cell having a second electrode composition ratio, in accordance with an embodiment of the present invention. As illustrated in **Fig. 7A**, a specific capacity of about 138 mAh/g is obtained at a charging rate of 0.05C and a specific capacity of about 128 mAh/g is obtained at a charging rate of 1C and discharging rate of 1C. As illustrated in **Fig. 7B**, a specific capacity of the LFP based Li-ion full cell was stable with an increase in a number of charge discharge cycles. A specific capacity of about 128 mAh/g is obtained at a charging rate of 1C and specific capacity retention of about 97% is achieved at about 110 charge discharge cycles.

Fig. 8A illustrates a voltage vs. specific capacity plot and **Fig. 8B** illustrates a specific capacity vs. cycle number plot for a LMFP based Li-ion half-cell, in accordance with an embodiment of the present invention. The electrode composition ratio is 95:3:2 indicating that the LMFP is used in a weight ratio of 95%, FAA latex binder and CMC together are used in a weight ratio of 3%, and auxiliary materials are used in a weight ratio of 2%. A voltage window for electrochemical studies of the LMFP based Li-ion half-cell was set from 2.5V to 4.3V. An electrode loading value was 10 to 12 mg/cm^2. As illustrated in **Fig. 8A,** a specific capacity of about 143 mAh/g is obtained at a charging rate of 0.05C and a specific capacity of about 130 mAh/g is obtained at a charging rate of 1C and discharging rate of 2C. As illustrated in **Fig. 8B**, a specific capacity of the LMFP based Li-ion half-cell is stable with an increase in a number of charge discharge cycles. A specific capacity of about 135 mAh/g is obtained at a charging

rate of 1C and specific capacity retention of about 90% is achieved at about 370 charge discharge cycles.

Fig. 9A illustrates a voltage vs. specific capacity plot and **Fig. 9B** illustrates a specific capacity vs. cycle number plot for a LMFP based Li-ion full cell, in accordance with an embodiment of the present invention. As illustrated in **Fig. 9A**, a reversible specific capacity (also known as specific capacity after 1st discharge) of about 125 mAh/g with 85% Coulombic efficiency is obtained at a charging rate of 0.05C and a reversible specific capacity of about 115 mAh/g is achieved at a charging rate of 1C and discharging rate of 1C. As illustrated in **Fig. 9B**, a specific capacity of the LMFP based Li-ion full cell is stable with an increase in a number of charge discharge cycles. A specific capacity of about 115 mAh/g is obtained at a charging rate of 1C and specific capacity retention of about 83% is achieved at a charging rate of 1C and a discharging rate of 1C at about 400 charge discharge cycles.

Fig. 10 illustrates a specific capacity vs. cycle number plot at different charging rates for a LTO based Li-ion half-cell, in accordance with an embodiment of the present invention. A reversible specific capacity of about 164 mAh/g is attained at a charging rate of 0.1C and a specific capacity of about 155 mAh/g at a charging rate of 1C. Further, it is observed that the specific capacity is stable for the measured 28 cycles.

It was observed that the Li-ion cell, fabricated through the above-mentioned method, reduces a cost of the Li-ion cell by 15% compared to a Li-ion cell fabricated using organic solvent (NMP) based slurry. In addition, usage of LFP or LMFP or LTO active material of weight ratio in a range of up to 95% for fabrication of the electrodes increases energy density of the Li-ion cell. FAA latex binder used for preparing the aqueous slurry enables an environmental friendly green processing route. Also, the FAA latex binder and CMC binder have high conductivity and flexibility compared to PVdF and PTFE binders. C-Al foils used as current collectors for fabrication of anodes are cheaper than conventionally used Cu foils. In addition, electrochemical performance and rate or power density performance of LTO coated C-Al foil is better than convention anode and leads to increase in performance of the Li-ion cell. Furthermore, a temperature and a time period required for heating a current collector coated with aqueous slurry has been minimized due to usage of water in preparation of the aqueous slurry. Additionally, the aqueous slurry prepared using water is environment friendly. Further, the electrode has qualified 180^{o} bend test and scratch test at around 60^{o}C.

Although the details provided above are referenced to a Li-ion cell, it must be noted that the described arrangement of components, materials used, and other essential principles could be utilised in other Li-ion cells of different designs.

The terms “or” and “and/or” as used herein are to be interpreted as inclusive or meaning any one or any combination. Therefore, “A, B or C” or “A, B and/or C” mean “any of the following: A; B; C; A and B; A and C; B and C; A, B and C.” An exception to this definition will occur only when a combination of elements, functions, steps or acts are in some way inherently mutually exclusive.

Any combination of the above features and functionalities may be used in accordance with one or more embodiments. In the foregoing specification, embodiments have been described with reference to numerous specific details that may vary from implementation to implementation. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense. The sole and exclusive indicator of the scope of the invention, and what is intended by the applicants to be the scope of the invention, is the literal and equivalent scope of the set as claimed in claims that issue from this application, in the specific form in which such claims issue, including any subsequent correction.

WE CLAIM:

1. A method (300) of fabrication of an electrode (202, 204) for use in a Lithium-ion cell (200), the method comprising:

dissolving Sodium-Carboxy Methyl Cellulose (CMC) in water to obtain a solution;

mixing a conductive additive into the solution;

mixing an active material into the solution, wherein the active material is used in a weight ratio ranging from 90% to 95%;

mixing Fluorine Acrylate (FAA) latex binder into the solution to obtain an aqueous slurry (210, 212), wherein the FAA latex binder and CMC together are used in a weight ratio ranging from 3% to 5%; and

coating the aqueous slurry (210, 212) on a current collector (214, 216), thereby obtaining the electrode (202, 204).

2. The method (300) as claimed in claim 1, wherein one of Lithium Iron Phosphate (LFP) or Lithium Iron Manganese Phosphate (LMFP) is used as the active material for fabrication of a cathode (202).

3. The method (300) as claimed in claim 2, an Aluminium (Al) foil is used as the current collector (214) for fabrication of the cathode (202).

4. The method (300) as claimed in claim 1, wherein one of graphite or Lithium Titanate (LTO) is used as the active material for fabrication of an anode (204).

5. The method (300) as claimed in claim 4, wherein one of Copper (Cu) foil or a carbon coated Al (C-Al) foil is used as the current collector (216) for fabrication of the anode (204).

6. The method (300) as claimed in claim 1, wherein the Sodium-CMC is dissolved in the water for at least one hour before adding the conductive additive.

7. The method (300) as claimed in claim 1, wherein two portions of the active material are added one after another into the solution, and mixed for five hours.

8. The method (300) as claimed in claim 1, wherein the aqueous slurry (210, 212) is placed under a vacuum condition for at least 15 minutes.

9. The method (300) as claimed in claim 1, wherein the aqueous slurry (210, 212) is coated on the current collector (214, 216) using a doctor blade and a pilot line roll-to-roll coating machine.

10. The method (300) as claimed in claim 9, wherein the current collector (214, 216) coated with the aqueous slurry (210, 212) is dried at a pre-defined temperature.

11. The method (300) as claimed in claim 1, wherein a ratio of solid to liquid in the aqueous slurry (210, 212) is optimized.

12. The method (300) as claimed in claim 1, wherein a ratio of the FAA latex binder to the sodium-CMC in the aqueous slurry (210, 214) is optimized.

13. The method (300) as claimed in claim 1, wherein the sodium-CMC is used as a thickening agent in the aqueous slurry (210, 214).

Dated this 09th day of August, 2022

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ABSTRACT

LITHIUM-ION CELL UTILIZING ELECTRODES MADE FROM AQUEOUS SLURRY

The present invention relates to a lithium-ion cell (200) including electrodes (202, 204) made from an aqueous slurry (210, 212). The electrodes (202, 204) are fabricated by dissolving (302) Sodium-Carboxy Methyl Cellulose (CMC) in water to obtain a solution. Conductive additive may mixed into the solution. An active material of weight ratio in a range of 90% to 95% may be added and mixed into the solution. The active material may be one of Lithium Iron Phosphate (LFP), Lithium Iron Manganese Phosphate (LMFP), or Lithium Titanate (LTO). Fluorine Acrylate (FAA) latex binder of weight ratio in a range of 2% to 4% may be added and mixed into the solution to obtain the aqueous slurry (210, 212). The aqueous slurry (210, 212) may be coated on a current collector (214, 216) for obtaining the electrode (202, 204).

(***To be published with Fig. 3***)

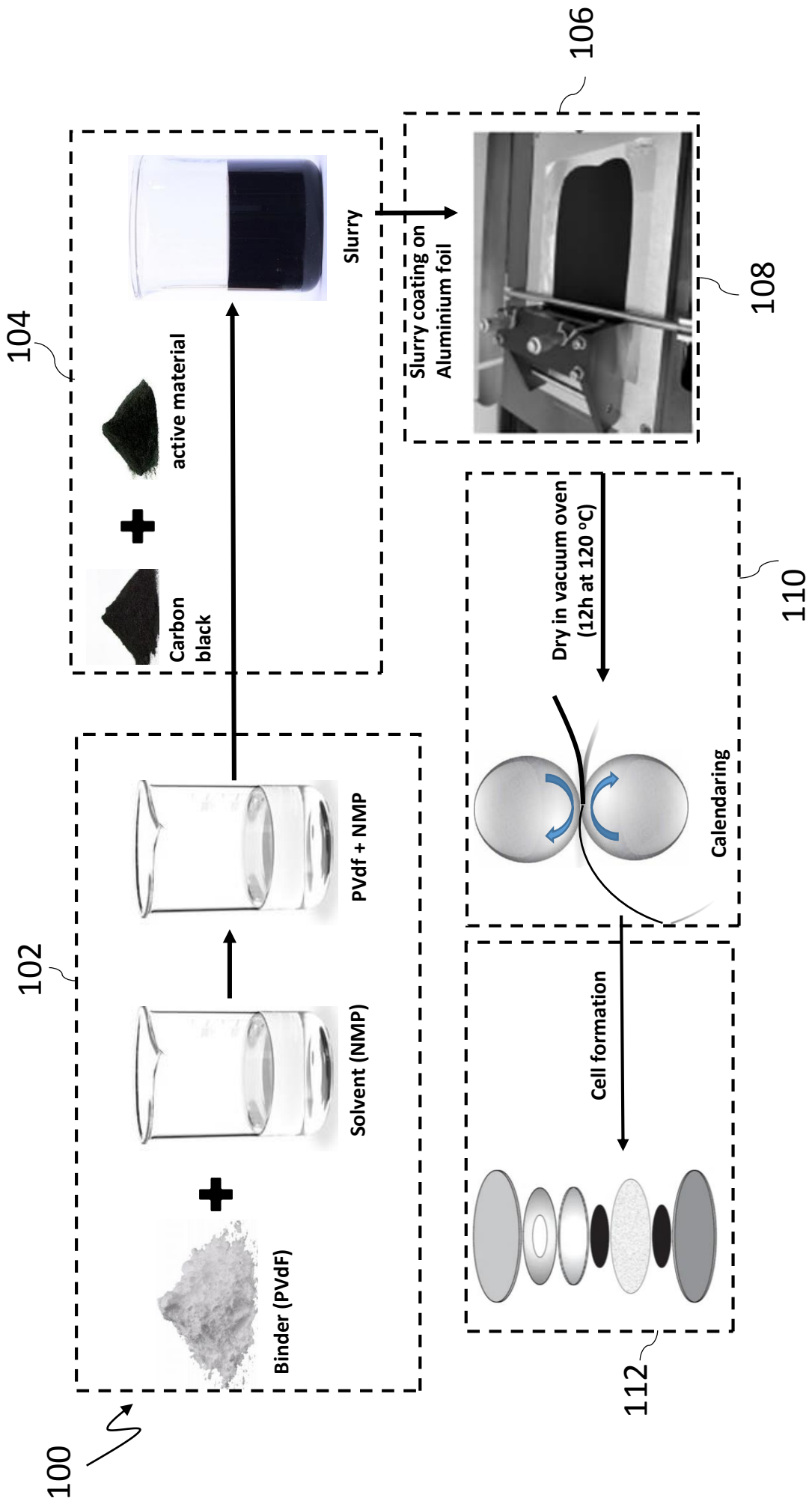


Fig. 1A
(Prior Art)

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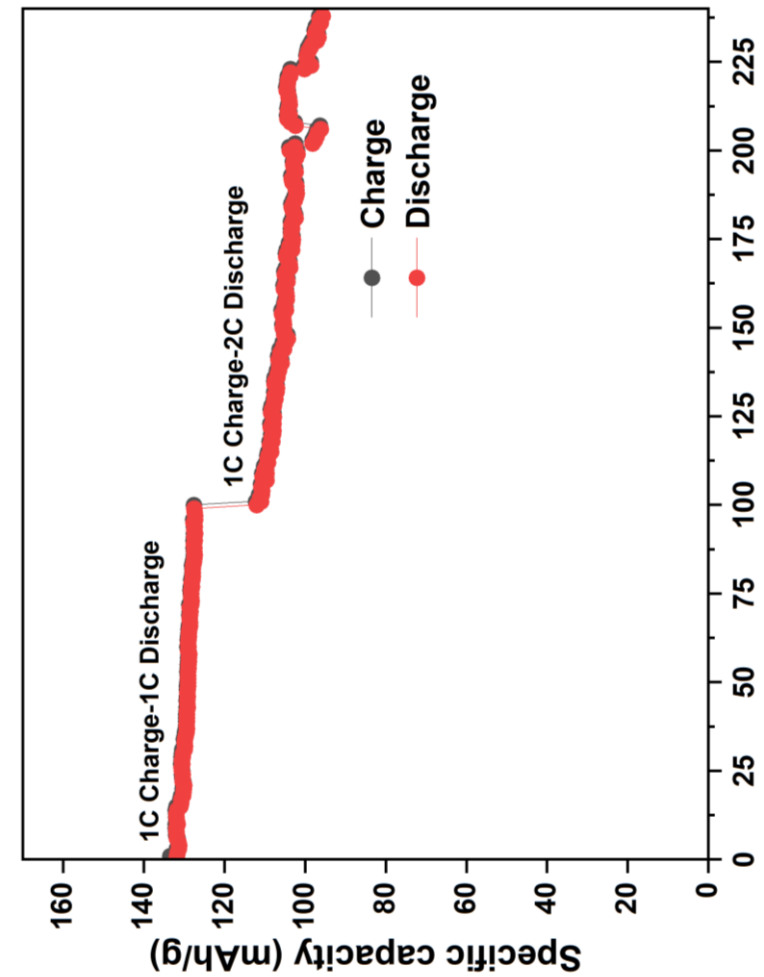


Fig. 1C
(Prior Art)

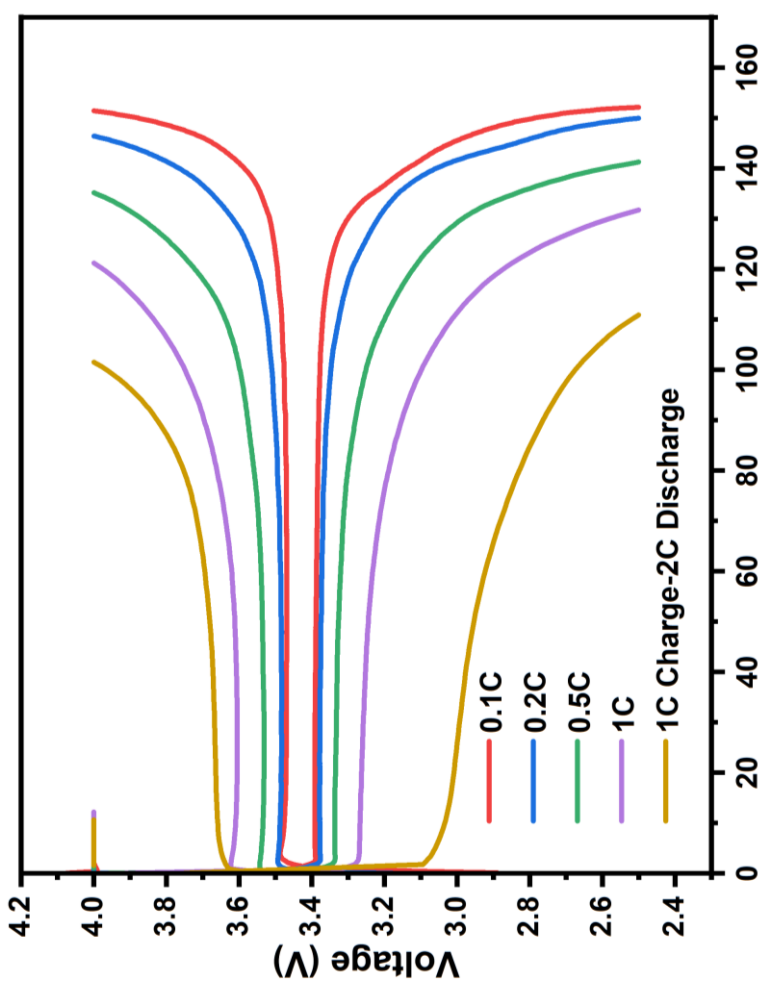


Fig. 1B
(Prior Art)

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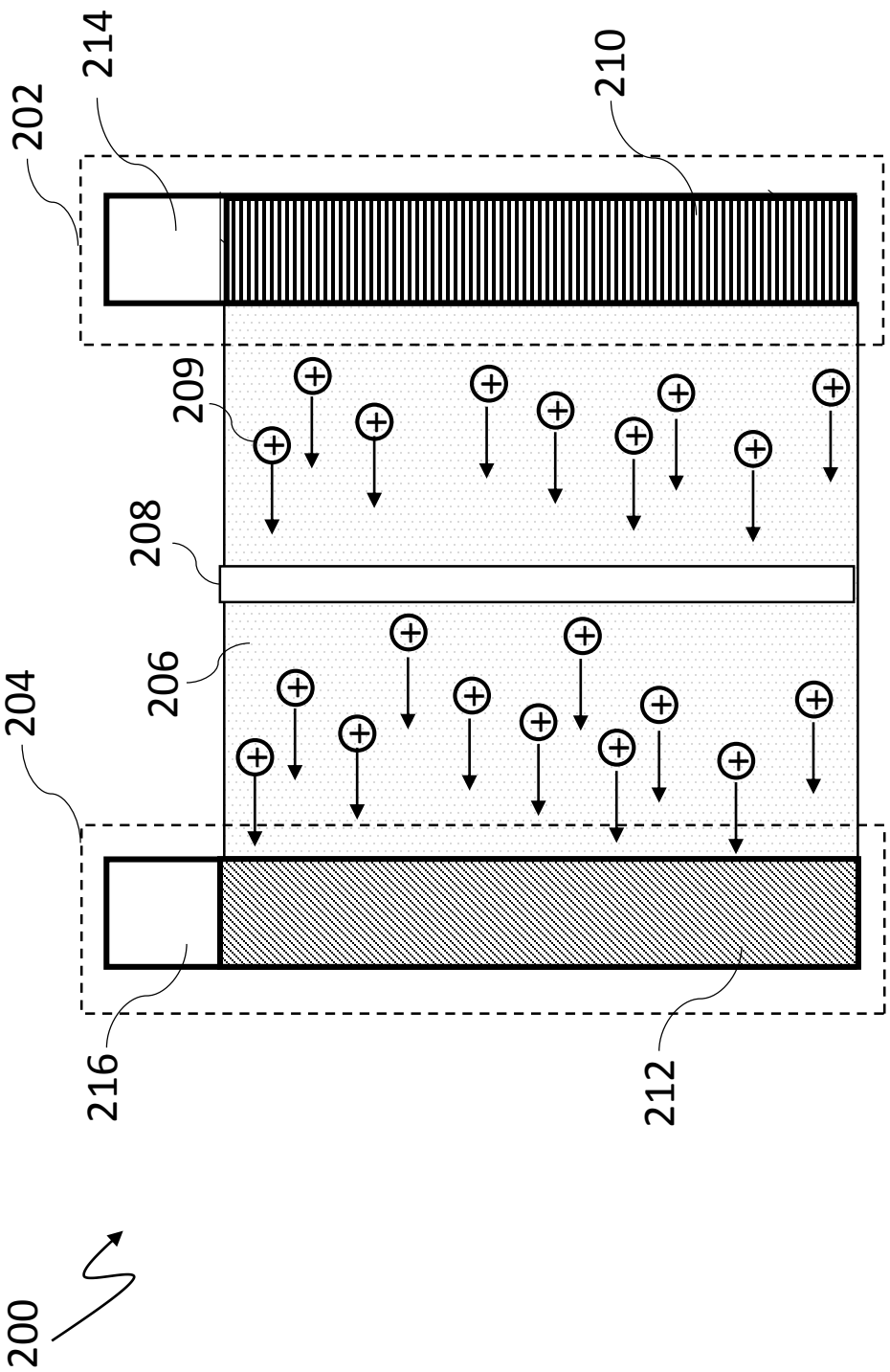


Fig. 2A

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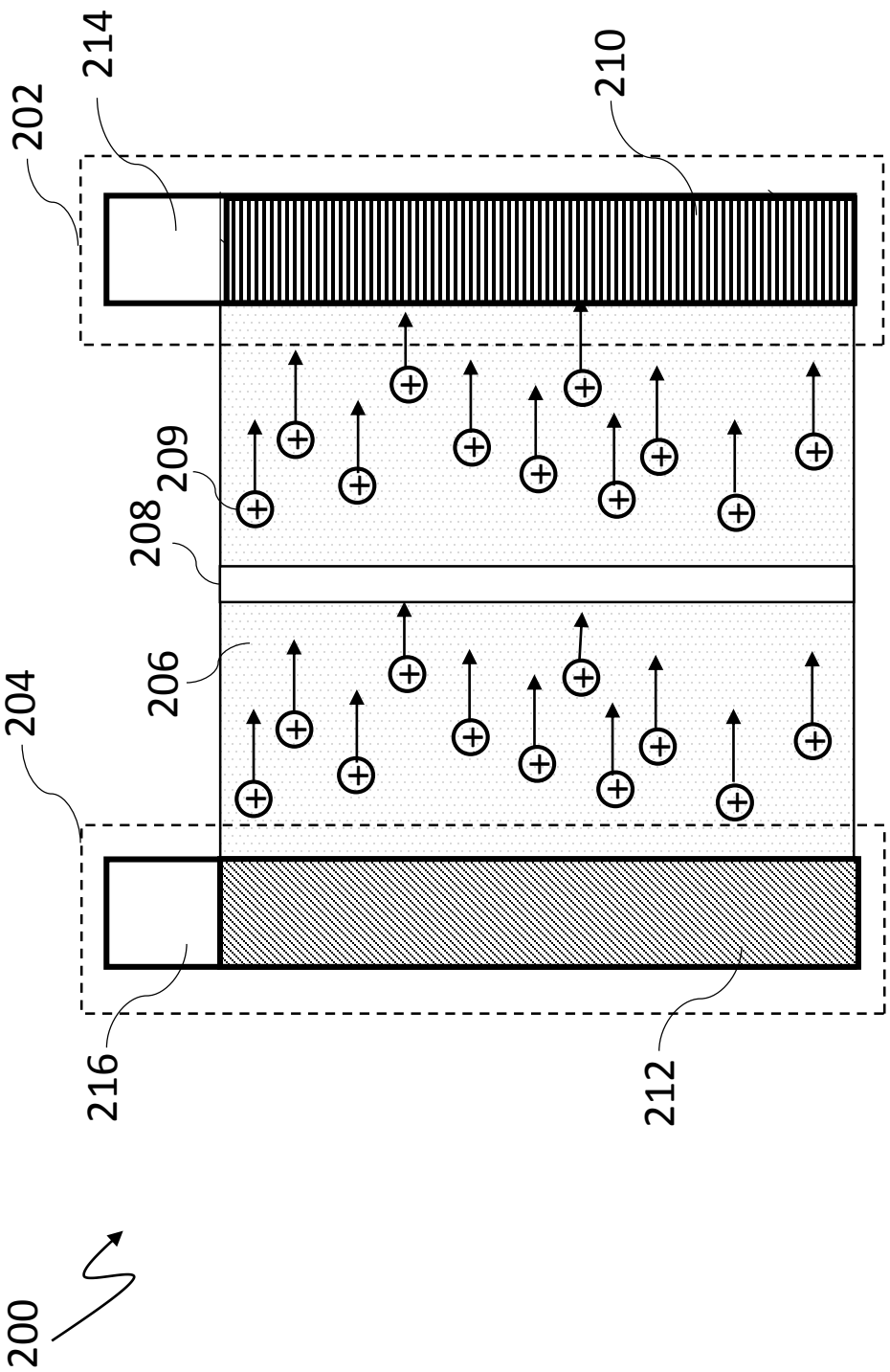


Fig. 2B

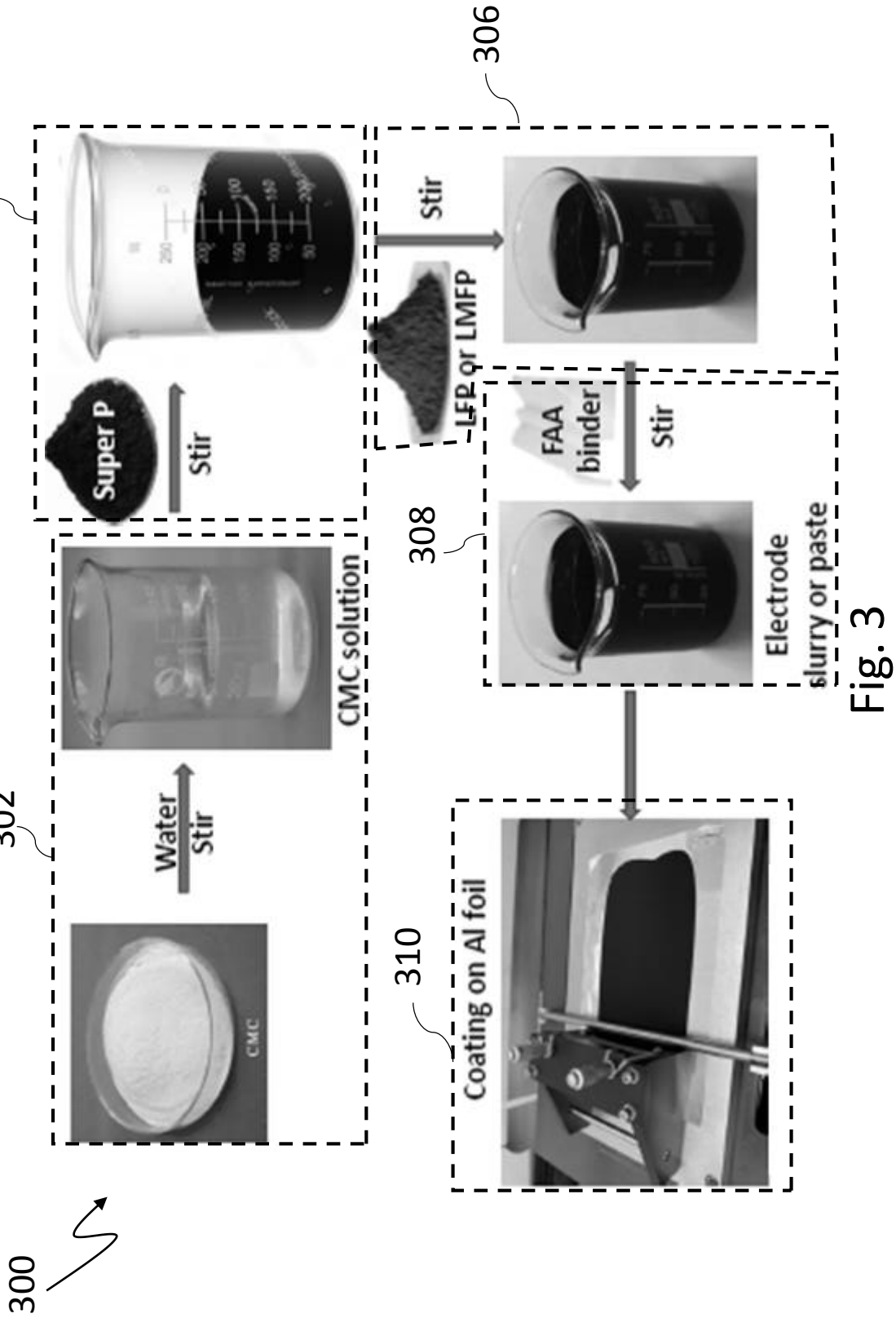

300
302
CMC
Water
Stir
CMC solution
304
Super P
Stir
306
LFP or LMFP
Stir
308
FAA binder
Stir
Electrode slurry or paste
310
Coating on Al foil

Fig. 3

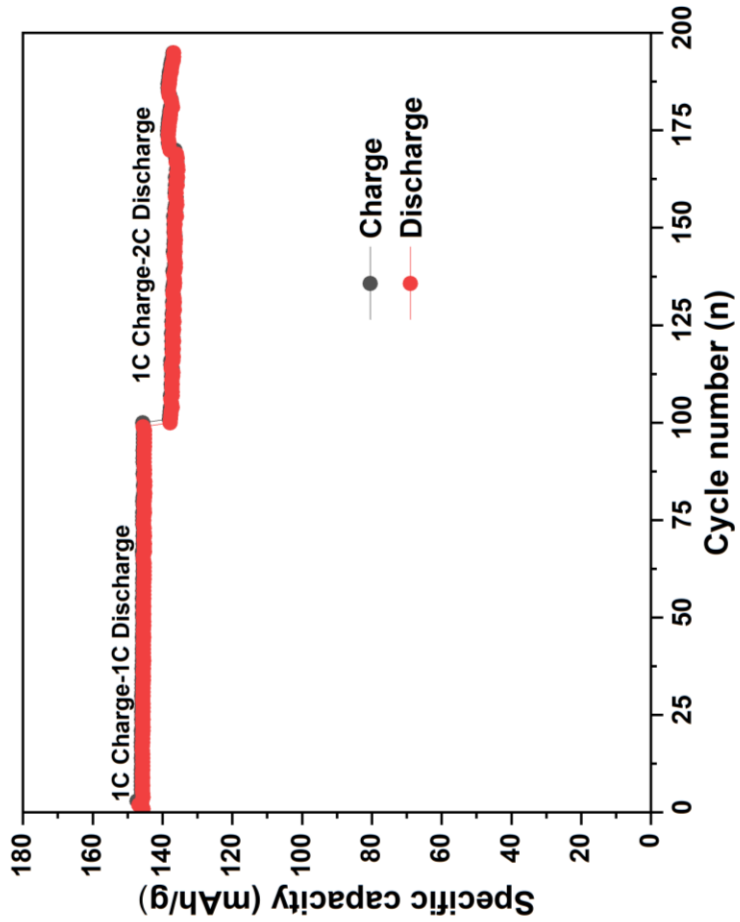


Fig. 4B

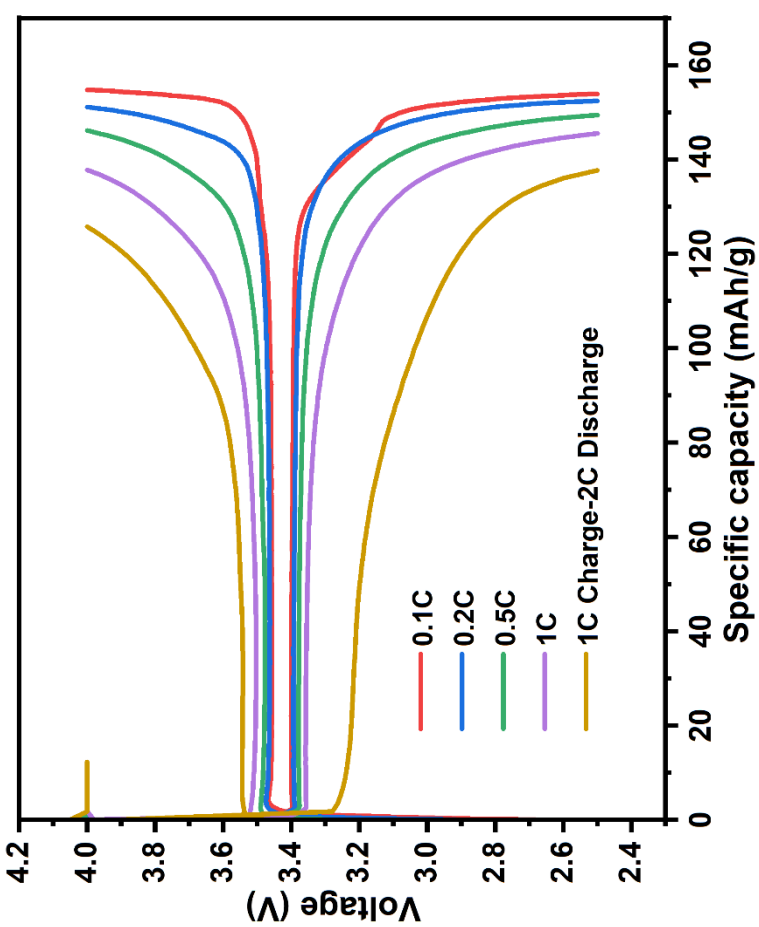


Fig. 4A

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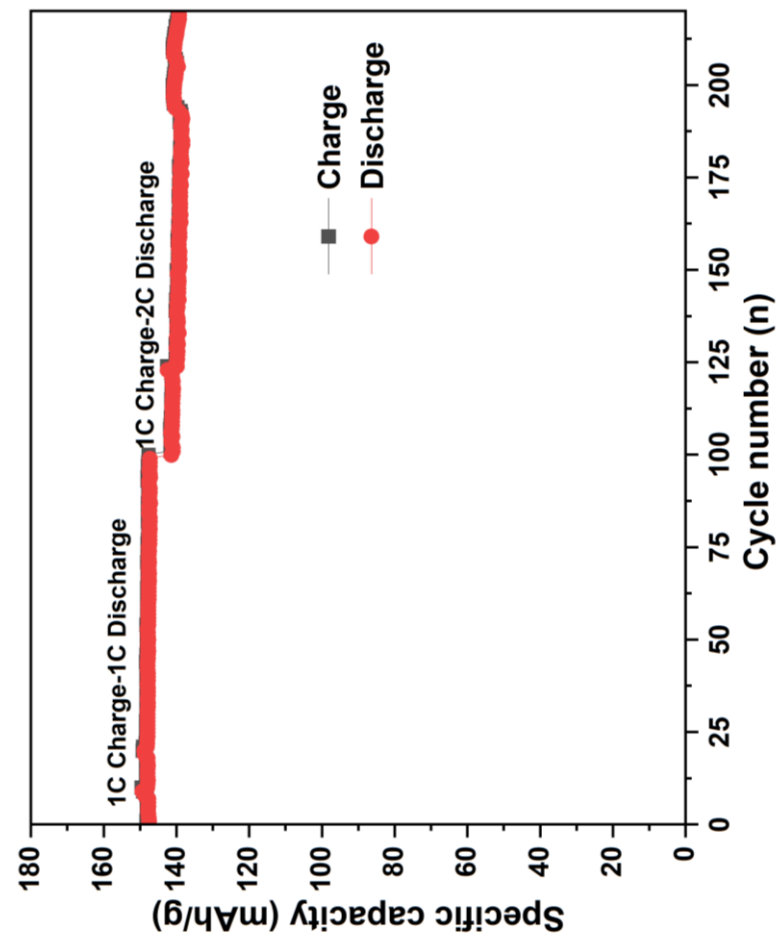


Fig. 5B

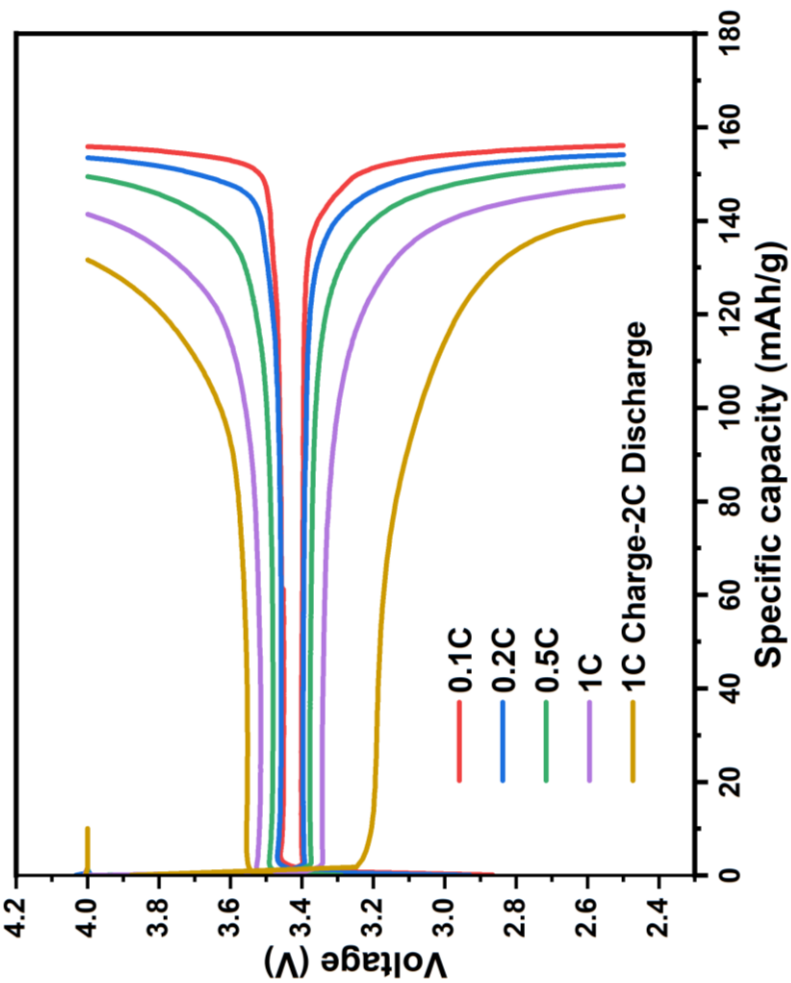


Fig. 5A

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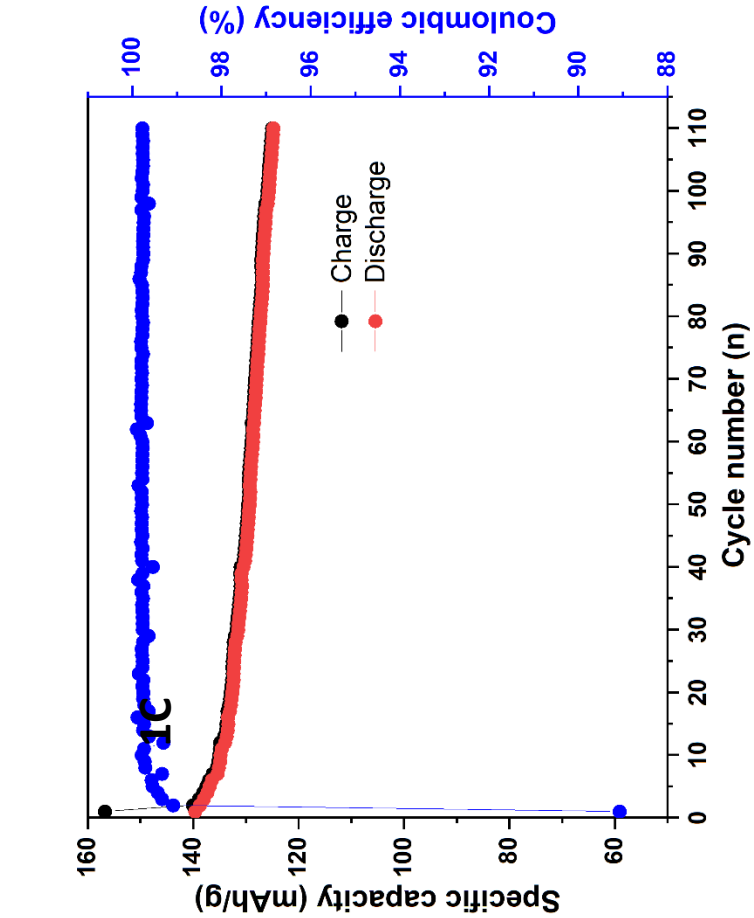


Fig. 6B

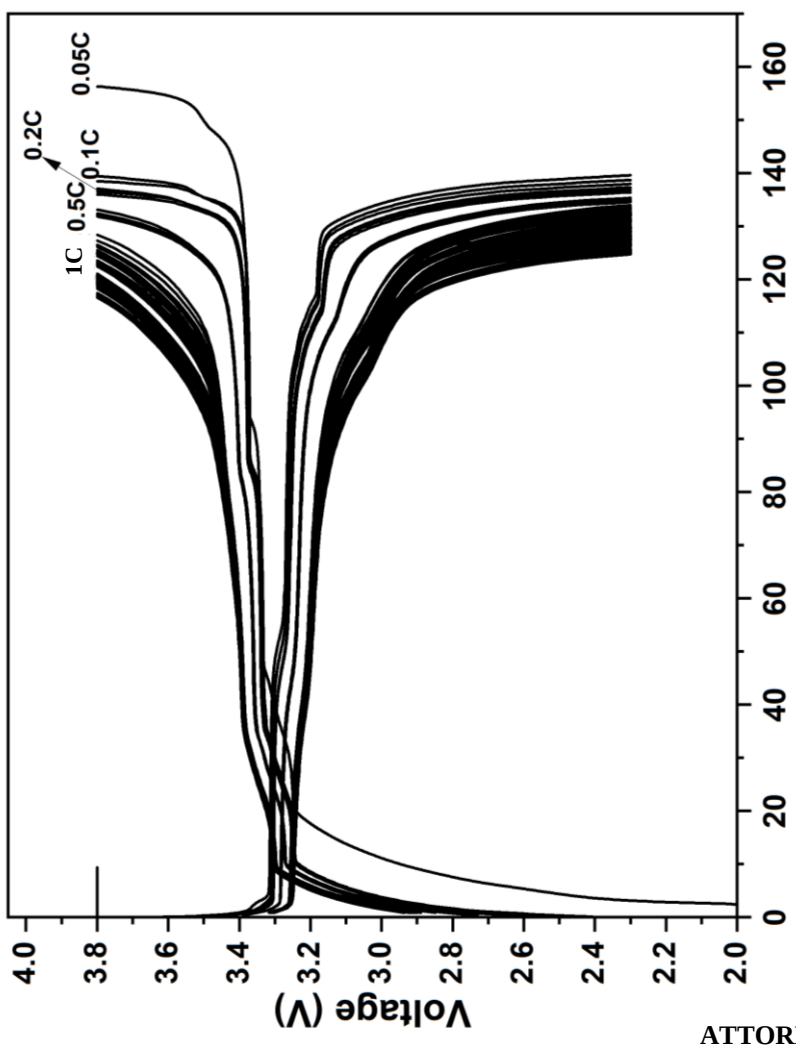


Fig. 6A

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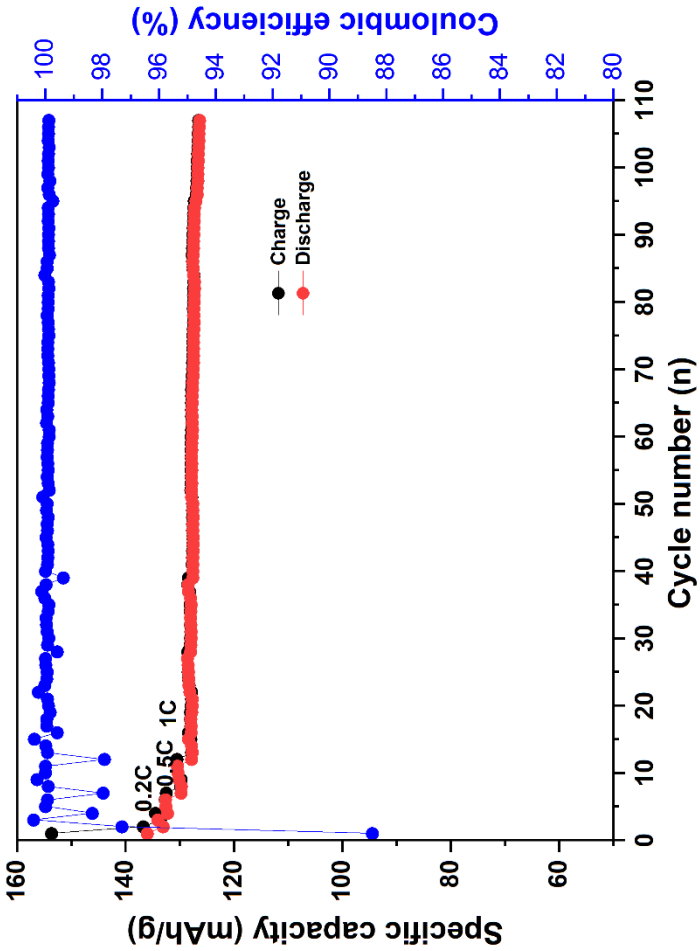


Fig. 7B

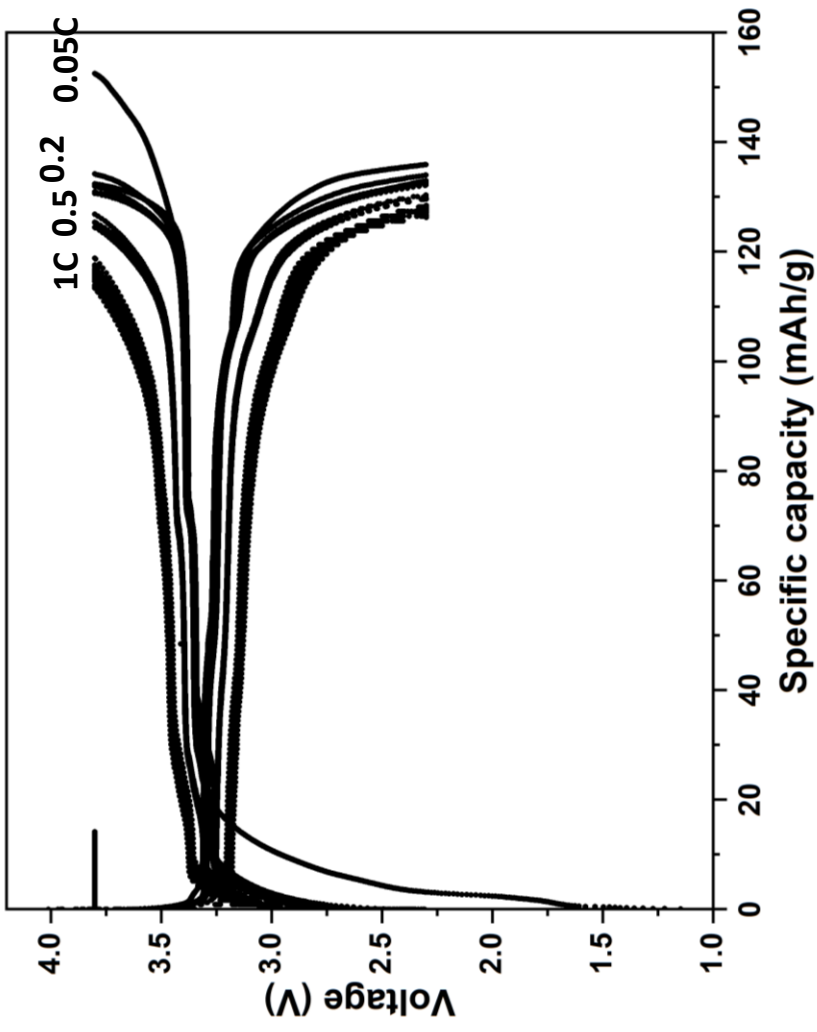


Fig. 7A

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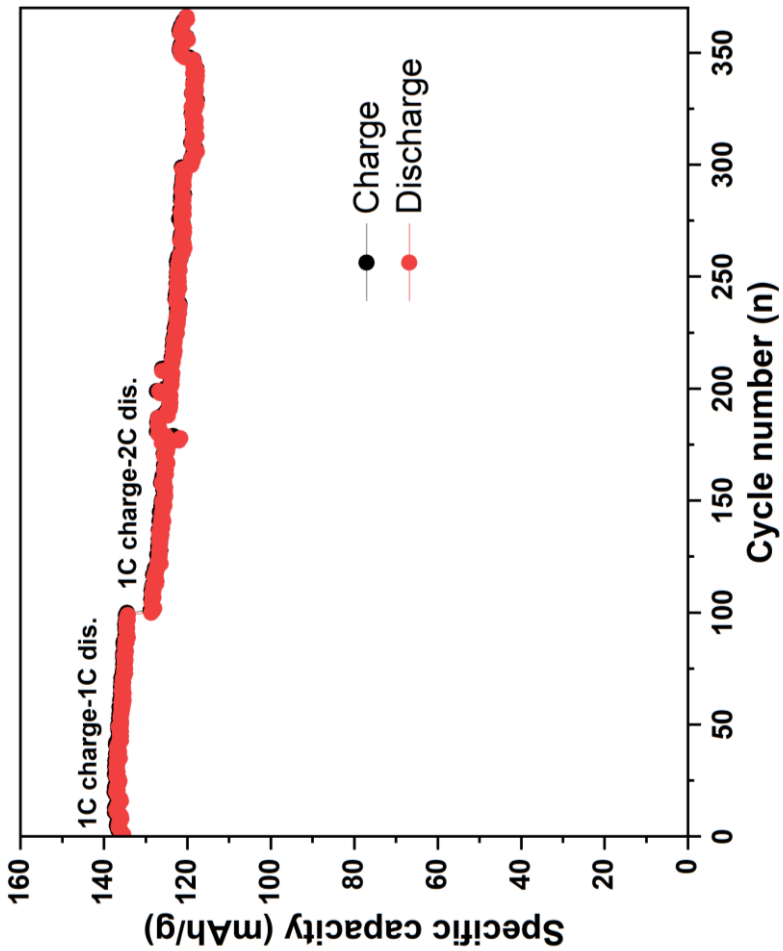


Fig. 8B

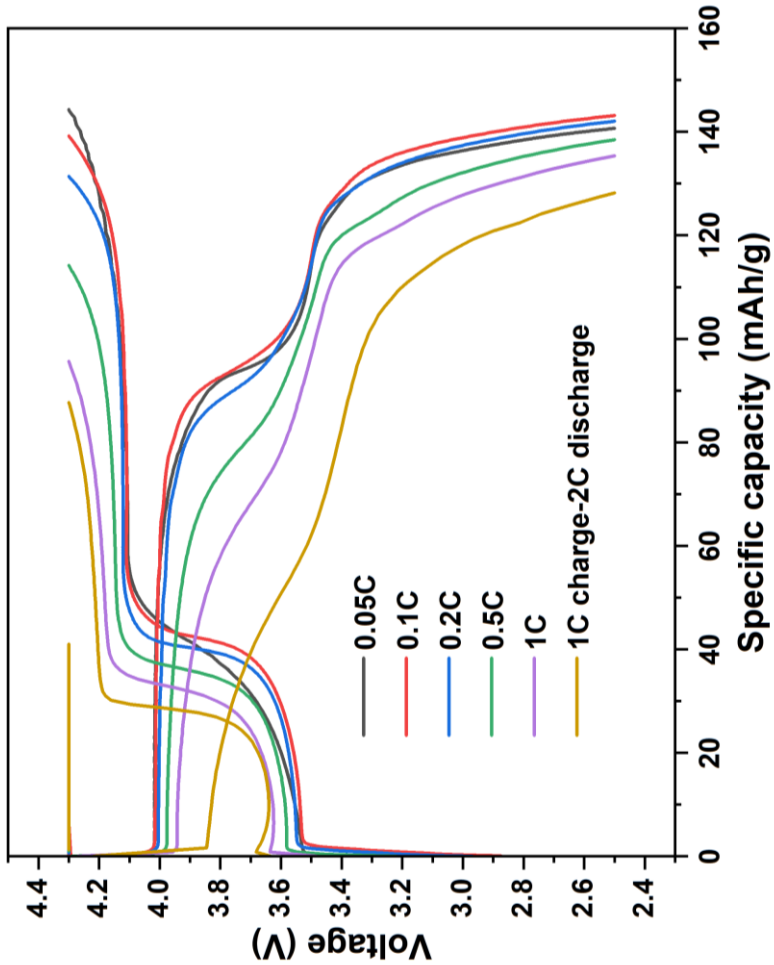


Fig. 8A

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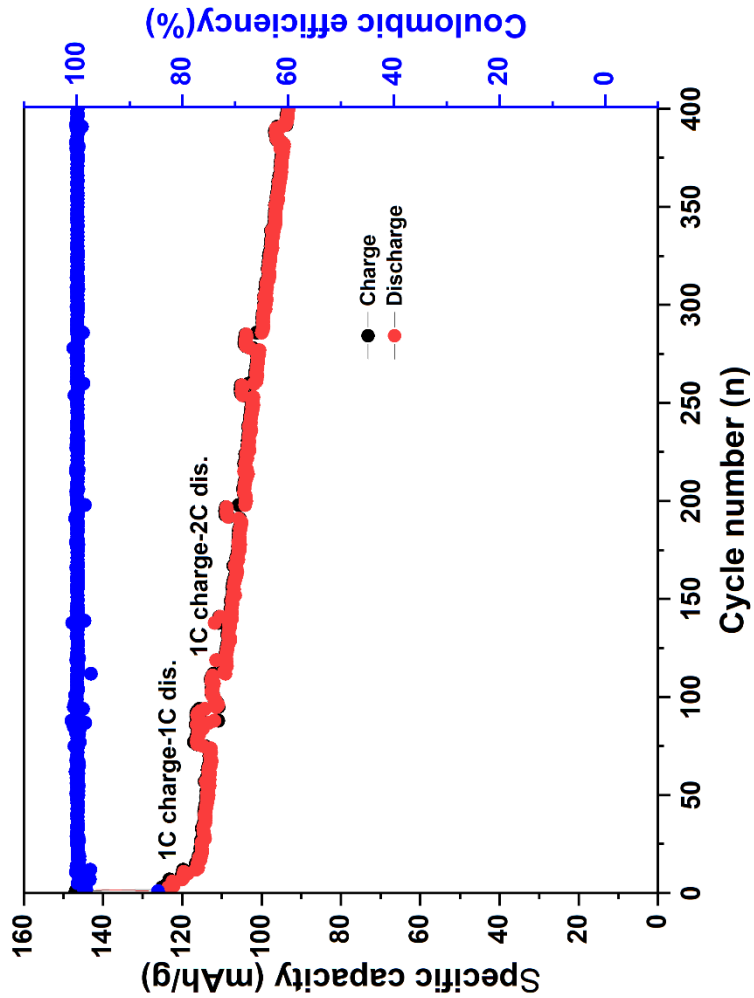


Fig. 9B

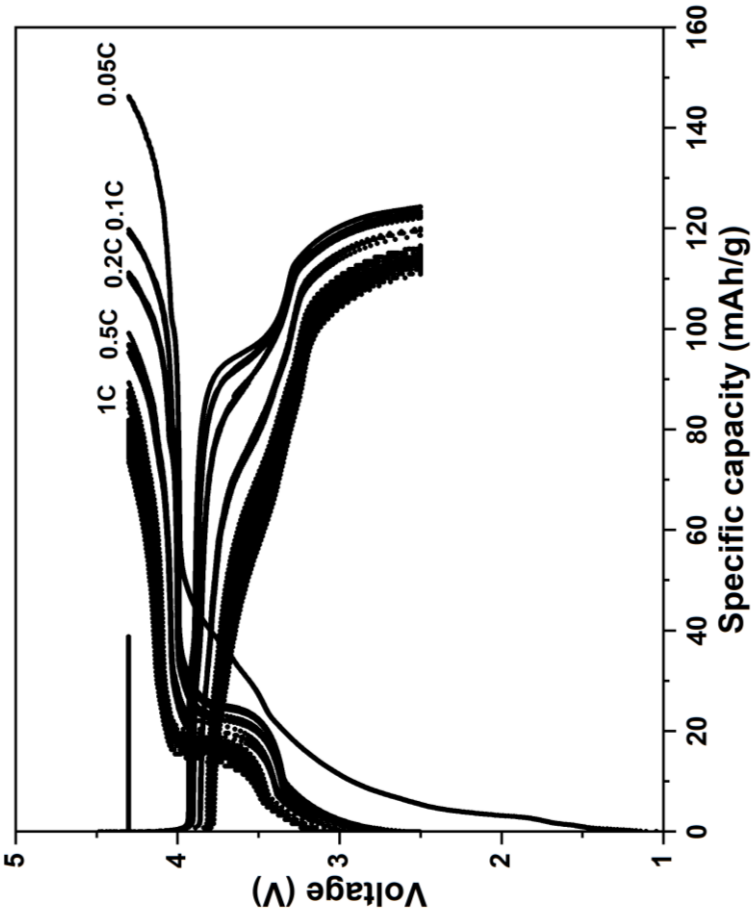


Fig. 9A

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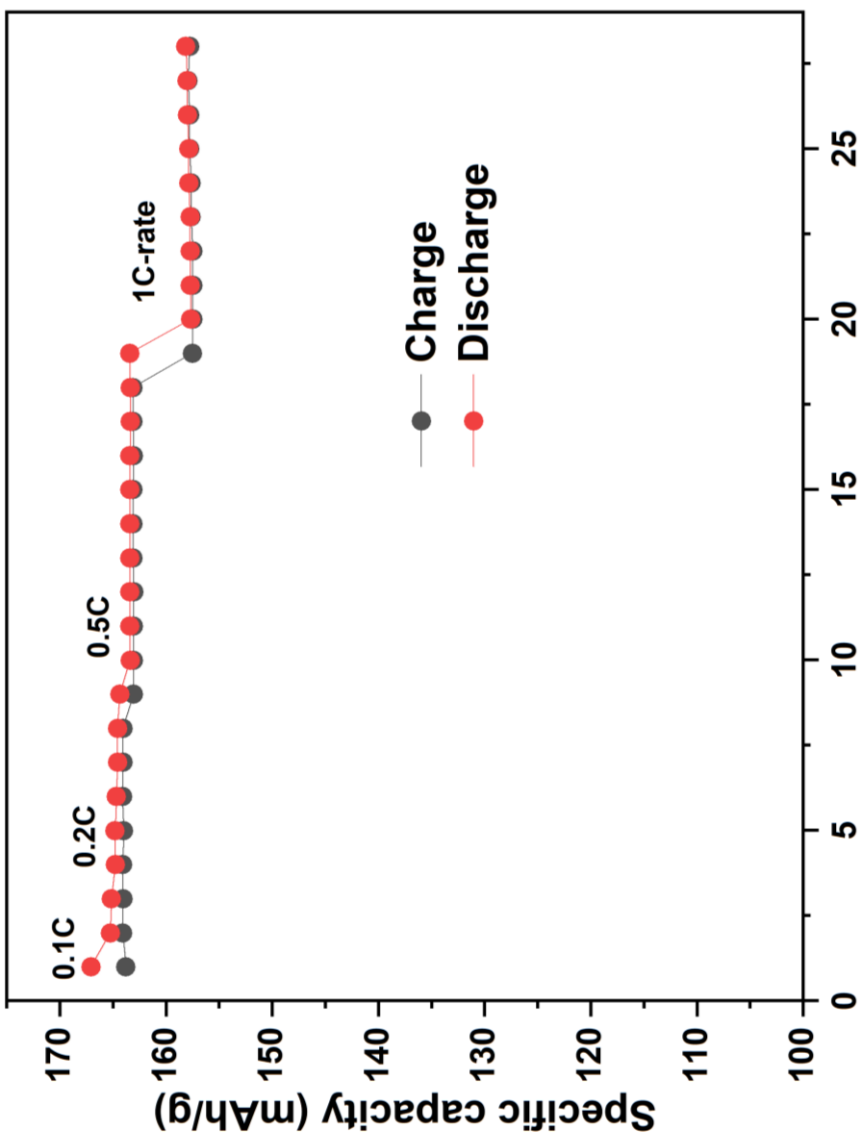


Fig. 10

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