

A REVIEW ON SODIUM ION BATTERY FOR ELECTRIC VEHICLE AS A SUSTAINABLE SOURCE OF ENERGY

O TRECERE ÎN REVISTĂ A BATERIEI CU IONI DE SODIU PENTRU VEHICULE ELECTRICE CA SURSĂ SUSTENABILĂ DE ENERGIE

Vishal RAVI SRIDEVI¹ Prakash ELANGO VAN² Sivakandhan CHINNASAMY³ Sanjay Kumar SRINIVASAN⁴ Sanjay Mohan SUJATHA⁵ Kanagaraj VENUSAMY⁶ Ramnat VENKATARAMANAN⁷

Abstract: Sodium-ion batteries show promise for electric vehicle (EV) adoption due to their affordability and availability. Developing high-performance batteries requires addressing challenges like energy/power density, rapid charging, and safety standards. Anode materials such as layered oxides and hard carbon, along with advanced assembly techniques and nanostructured materials, enhance performance. However, obstacles persist, including electrolyte improvement and terminal/electrolyte interface optimization. While sodium-ion batteries could replace lithium-ion in EVs, further research is necessary to enhance their viability and overcome limitations such as low energy density. Advancements in materials, electrolytes, and cell design may facilitate widespread EV adoption in a sustainable future.

Keywords: Electrical Vehicle, Sodium Ion Battery, Li-Ion Battery and Sustainable future.

Rezumat: Bateriile cu ioni de sodiu sunt promițătoare pentru adoptarea la vehiculele electrice (VE) datorită accesibilității și disponibilității lor. Dezvoltarea unor baterii de înaltă performanță necesită abordarea unor provocări precum densitatea de energie/ putere, încărcarea rapidă și standardele de siguranță. Materialele anodice, cum ar fi oxizii stratificați și carbonul dur, împreună cu tehnicile avansate de asamblare și materialele nanostructurate, îmbunătățesc performanța. Cu toate acestea, persistă obstacole, inclusiv îmbunătățirea electrolitului și optimizarea interfeței

^{2,6} Assistant Prof., Dept. of Mechatronics Engineering, Rajalakshmi Engineering College, India, e-mail: prakasrajes@gmail.com

^{1,4,5,7} Undergraduate students., Dept. of Mechatronics Engineering, Rajalakshmi Engineering College, India

³ Prof., Dept. of Mechanical Engineering, Nadar Saraswathi College of Engineering and Technology, India

terminal/electrolit. În timp ce bateriile cu ioni de sodiu ar putea înlocui bateriile litiu-ion în vehiculele electrice sunt necesare cercetări suplimentare pentru a le spori viabilitatea și pentru a depăși limitările, cum ar fi densitatea energetică scăzută. Progresele în materie de materiale, electrolizi și proiectare a celulelor pot facilita adoptarea pe scară largă a VE într-un viitor sustenabil.

Keywords: Vehicul electric, baterie cu ioni de sodiu, baterie cu ioni de litiu, viitor sustenabil.

1. Introduction

Electric vehicles are becoming well known among individuals harmless to the ecosystem options in contrast to ordinary fueled by ignition cars. One of the main difficulties by EVs is the restricted scope of their batteries, and that implies they should be re-energized frequently [14]. This is where sodium-particle batteries (Sib's) become possibly the most important factor as a potential substitution to lithium-particle batteries.[10][15] A sodium-particle battery is a type of recharged battery that releases and stores energy involving charged sodium particles as the transporter ions. The sodium particles have a little, positive charge and are little in size. SIB's proposition a few benefits over Lib's, including lower cost, higher energy thickness, and the wealth of sodium, a more plentiful and more affordable component than lithium. Sodium is additionally less receptive than lithium, which makes it more secure to deal with and less inclined to cause fires. The improvement of SIB's for EVs is still in its beginning phases, however there have been a few promising progressions lately.

Specialists have had the option to work on the exhibition of SIB's by involving various materials for the cathodes, electrolytes, and separators, as well as streamlining the cell design.[11]-[24] One of the issues in creating SIBs for EVs is the necessity for high power and quick charging abilities, which are significant for fulfilling present day transportation requests. Nonetheless, ongoing examination has demonstrated the way that SIB's can accomplish high power thickness and quick charging rates by utilizing a mix of high-limit cathodes and low-obstruction electrolytes.[6]-[7][14] One more test in the improvement of SIB's for EV's is the need to keep up with their presentation over a significant stretch of time. SIBs have been known to experience the ill effects of unfortunate cycle life, and that implies they break down quicker after some time and lose their ability to store energy. Nonetheless, late examinations have shown that the utilization of new terminal materials and streamlined electrolytes can further develop the cycle

life of SIB'S. By and large, SIB's can possibly be a unique advantage for the EV business by giving a more reasonable and manageable option in contrast to LIBs. Be that as it may, more examination is expected to conquer the difficulties and improve the exhibition of SIBs for EV's [4]-[5].

2. Materials and Methods

2.1. Non-flammable Technology

The original sodium-particle innovation created by PNNL utilizes a normally fire-quenching arrangement that is likewise temperature safe and fit for working at high voltages. This property is important because of the extremely thin protective layer that forms on the anode. [27]. When created, this super dainty layer keeps up with its strength and offers the drawn out cycle life portrayed in the examination article. As far as energy thickness, lithium innovation actually beats sodium-particle innovation. Despite the fact that, it additionally has benefits that make it significant for applications later on, for example, network energy capacity and protection from temperature changes, strength, and long cycle life [12]. The research group is as yet dealing with working on their plan. According to Le, the group is experimenting with various designs to reduce and eventually eliminate the requirement for cobalt, which is risky and costly if not recovered or repurposed [6]-[20].

2.2 Dendrites

Engineers as well as researchers have been chipping away at sodium batteries, which utilize more affordable, all the more harmless to the ecosystem sodium to supplant both lithium and cobalt in conventional lithium-particle batteries. Tragically, in more established sodium batteries, a part known as the anode would foster needle-like fibers known as dendrites, which might make the battery electrically short and perhaps burst into flames or detonate. When a rechargeable battery is charged, ions (like lithium or sodium) move from the cathode to the anode. Particles, which venture out from the anode to the cathode when the battery makes power. Antimony and intermetallic sodium telluride. Na metal composite (NST-Na) anode material is made by moving a meager sheet of sodium metal on antimony telluride powder, collapsing it over on itself, and rehashing the interaction on different occasions. This interaction delivers an exceptionally uniform scattering of sodium ions, making it less inclined to dendrites or surface erosion than regular sodium metal anodes. This upgrades battery strength and empowers

for speedier charging, identical to that of a lithium-particle battery, as well as a more prominent energy limit than present sodium-particle batteries. The sodium (Na) ions that transport the charge in a sodium battery join more unequivocally to another than to the anode, producing hazards or bunches of sodium that draw in more sodium molecules and at last lead to dendrites [12]. This composite ties sodium fairly more emphatically than sodium ties itself, permitting the sodium particles to descend and consistently spread out over the surface, dispensing with these dangers.

2.3 Anode used in sodium ion battery

2.3.1 *Hard carbon -300 mAh/g*

Hard carbon or single is broadly involved material anode in sodium-particle batteries because of its great cycling security, minimal expense, and moderate explicit capacity. [13][16][21] The effectiveness of scorch as an anode material in Na-particle batteries is by and large high. The particular limit of roast in Na-particle batteries is regularly around 200-350 mAh/g, this is not exactly the particular limit of a few other anode materials, for example, tin-based materials [22]-[24]. Notwithstanding, hard carbon has a somewhat low working potential, which lessens the gamble of side responses and works on the security of the battery. The Coulomb proficiency (CE) of hard carbon in Na-particle batteries is regularly more than 98%.

2.3.2 *Graphene 350 mAh/g*

A potential Na-particle battery material anode, graphene has surprising underlying and electronic qualities such an enormous surface region, magnificent electrical conductivity, and mechanical robustness.[9] In sodium-particle batteries, graphene performs very well as anode material. Commonly, Na-particle batteries have a graphene explicit limit of 200-350 mAh/ordinarily, sodium-particle batteries use graphene with a Coulombic productivity (CE) of above close to 100%.

2.3.3 *Tin-based materials -800-1000 mAh/g*

SnO₂ and SnSb, two tin-based materials with high hypothetical explicit limits, remarkable electronic conductivity, and wide accessibility, are alluring anode materials for Na-particle batteries. Nonetheless, components like underlying soundness, cycling steadiness, and volume development can

affect how really they work in practice.[22]-[24] In sodium-particle batteries, tin-based materials ordinarily have extraordinary explicit limits, that reach from 600 to 1000 mAh/g. In sodium-particle batteries, tin-based materials normally have a Coulombic productivity (CE) of above 98%.

2.3.4 Carbon nanotubes-250-350 mAh/g

Carbon nanotubes (CNTs) have a huge surface region, phenomenal electrical conductivity, and high mechanical strength, making them a promising anode material for sodium-particle batteries. Carbon nanotubes act as an anode in sodium-particle batteries with phenomenal effectiveness [16] [21]. Carbon nanotubes for the most part have a particular limit of 300-400 mAh/g in sodium-particle batteries. Carbon nanotubes frequently have a Coulomb effectiveness (CE) of more noteworthy than close to 100% in sodium-particle batteries.

2.4 Justification for selecting hard carbon as anode

Hard carbon is one of the most incredible anode materials for Na-particle batteries. This is because of its high unambiguous limit, long cycle life and solid rate capability[13]-[16]. In spite of the fact that they are still in the innovative work stage, graphene and carbon nanotubes additionally display empowering results as anode materials. Tin-based materials have demonstrated great capacity, despite frequently exhibiting low rate and cycling stability. Accordingly, hard carbon is at present considered the most ideal anode material among the choices that anyone could hope to find for sodium-particle batteries.

2.5 Electrolyte

A sodium-particle battery's decision of electrolytic arrangement is impacted by various factors, including the expected presentation boundaries, the working climate and specific cathode materials. [7]The electrolyte framework for sodium-particle batteries should be upgraded to expand their general exhibition and steadiness. Three substances: sodium bis (trifluoromethyl sulfonyl) imide (NaTFSI), sodium perchlorate (NaClO₄) and sodium hexafluorophosphate (NaPF₆). [7][28] The electrolyte in a Na-particle battery is commonly an answer of Na salt in a natural dissolvable or a strong state electrolyte.

2.6 Electrolyte organic

For Na-particle batteries, alkyl carbonate solvents like ethylene carbonate (EC), propylene carbonate (PC), and dimethyl carbonate (DMC) are the most often utilized natural electrolytes, which are blended in with sodium salts, for example, sodium hexa fluorophosphate (NaPF₆), sodium trifluoro methane sulfonate (NaCF₃SO₃), or sodium bis (trifluoro methane sulfonyl) imide (NaTFSI).[7][28] Natural electrolytes have high conductivity and low consistency, which can increment battery execution.

2.7 Solid State Electrolyte

Strong state electrolytes give different benefits over natural electrolytes, including higher warm strength, lower combustibility, and further developed safety.[6][19] Sodium beta-alumina (Na-β-Al₂O₃), sodium superionic guide (NASICON), and sodium-particle conductive glass-pottery are a few instances of strong state electrolytes for Na-particle batteries.[1][2] Solid-state electrolytes, then again, habitually have diminished ionic conductivity and restricted similarity with terminal materials, which can restrict their exhibition. By and large, the electrolyte for a sodium-particle not entirely set in stone by different measures, including the cathode materials, the ideal presentation boundaries, and the expense and accessibility of the electrolyte parts. To expand the presentation and wellbeing of sodium-particle batteries, specialists are examining new electrolyte plans and strong state electrolyte materials.

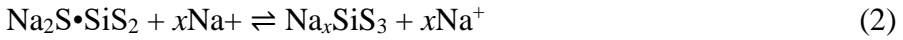
The electrolyte condition for a strong state electrolyte utilized in a sodium-particle battery relies upon the particular material utilized, yet as a rule, it includes the development of sodium particles (Na⁺) through the strong state electrolyte. [23] Here are two examples:

Sodium beta-alumina (Na-β-Al₂O₃) electrolyte:



In this equation, x represents the number of Na-ions that can be inserted into the β-Al₂O₃ structure. [28] During the operation of the battery, Solid-state electrolyte allows sodium ions to move from the anode to the cathode, as shown by the equation. The technique is reversible, the battery may be charged and drained several times.

Sodium-ion conductive glass-ceramic electrolyte:

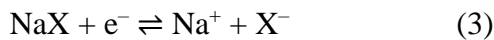


In this situation, $\text{Na}_2\text{S}\cdot\text{SiS}_2$ addresses a sodium-particle conductive glass-earthenware material, and x addresses the greatest number of sodium particles that might be placed into the SiS_3 structure. During the activity of the battery, Na-particles are moved from the anode to the cathode through the strong state electrolyte, as shown by the situation. This cycle is additionally reversible. [6]-[7] The electrolyte conditions for strong state electrolytes feature the critical job of the strong state material in working with particle transport and keeping up with charge nonpartisanship inside the battery. Compared to organic electrolytes, solid-state electrolytes offer a number of advantages, including improved safety, lower flammability, and higher thermal stability. In any case, strong state electrolytes frequently experience the ill effects of lower ionic conductivity and restricted similarity with anode materials, which can restrict their exhibition.

2.8 Preferred Electrolyte

Because of its solid ionic conductivity, expansive electrochemical strength window, and low softening point, favored electrolyte sodium bis (trifluoro methyl sulfonyl)imide (NaTFSI) is generally viewed as the most encouraging for sodium particle batteries.[4]-[7]. It has been demonstrated that NaTFSI makes it possible for Na-ion batteries to have a high stability cycle and good rate capability.

The electrolyte equation for an organic electrolyte used in a sodium-ion battery can be represented as follows:



where NaX addresses the sodium salt, like NaPF_6 , NaCF_3SO_3 , or NaTFSI, and X^- addresses the comparing anion[22]-[24] During the activity of the battery, the salt breaks up in the natural dissolvable, for example, a combination of propylene carbonate, ethylene carbonate and dimethyl carbonate, to shape the electrolyte arrangement. The sodium particles (Na^+) and the comparing anions (X^-) are allowed to move inside the arrangement, while the electrons (e^-) are communicated between the cathode and the anode through the outside circuit [7]. The electrolyte condition mirrors the reversible course of the sodium particle (Na^+) being diminished to sodium metal (Na) at the anode during the

release of the battery and afterward oxidized back to Na^+ at the cathode during the charging of the battery. The anions (X^-) don't take part straightforwardly in the electrochemical response however assume a significant part in keeping up with charge lack of bias and working with particle transport inside the electrolyte arrangement.

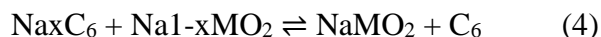
3. Working Principle

The Na-particle battery functions similarly to the Lithium-particle battery, but sodium compounds are used instead of lithium compounds.[1][2][23] It has two terminals—a cathode and an anode—an electrolyte and a separator. Hard Carbon should make up the anode since it is an endless resource, dependable, sensible, and has a high unambiguous cutoff. Hard carbon misses the mark on clear cut gem structure and is for the most part comprised of little, emphatically cross-connected glasslike spaces that are incredibly immobilized and can't be revised into very much adjusted structures.[22][24]

Hard carbon has an extraordinary microstructure that permits it to intercalate sodium particles, making it simple to store and delivery sodium particles. Hard carbon additionally performs well because of its high electrical conductivity and capacity to move electrons proficiently during charging and releasing cycles.[16][21]

Na-particle battery terminal materials vary so remarkably from their Li-particle partners in science and electrochemistry that useful battery-prepared competitors have as of late become available.[22][24] Hard-carbon anodes and cathodes comprising of layered progress metal oxides, change metal fluorophosphates, and Prussian blue, as well as their counterparts, have been worked as test cells in research centers and agent model cells, and their exhibition has been assessed. Layered change metal dioxides, NaMO_2 , can be found in O_3 and P_2 crystallographic structures, where M can be Fe, Ni, Mn, CO, or other elements.[21][22] In the O_3 - NaMO_2 stage, Na is found in octahedral destinations, though in the P_2 -stage, it is tracked down in kaleidoscopic locales.

The released terminals can be tracked down in a Na-particle battery with a hard-carbon (C_6) anode and a layered change metal oxide, NaMO_2 , as the cathode, in the cathode responses.



Likewise, to LiCoO_2 , the NaCoO_2 cathode is first added to the released Na-particle cell, and the cell is then enacted by charging first to frame the Na intercalated anode and Na deintercalation cathode in the completely energized cell [7].

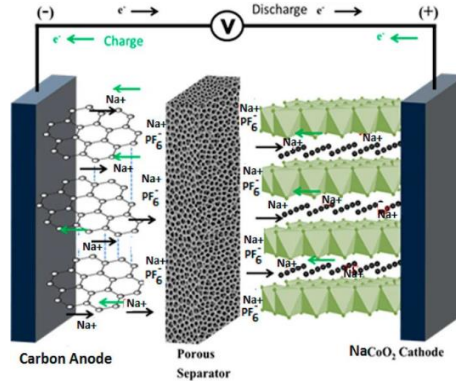


Figure 1. Representation of Electron transition [25][26]

3.1 Prussian blue Analogues

Prussian Blue Analogs (PBAs) have arisen as alluring anode materials for Na-particle batteries because of their solid electrochemical exhibition and underlying stability.[17][21] Prussian blue (PB) is the most read up PBA for Na-particle batteries. It is cubic in shape and theoretically has a higher capacity of 120 mAh/g. Moreover, PB shows stable cycling and great rate capacity. Prussian Blue (PB) and Prussian Blue Analogues (PBAs) had been broadly investigated as cathode materials for Sodium-particle Batteries (SIBs). PB and PBAs are invaluable cathode materials because of their unmistakable designs, high hypothetical limits, and fantastic underlying steadiness during charge/release cycles. [12] During the release cycle in Sib's, Sodium-particles are drawn from anode and conveyed to the cathode, going about as the positive terminal. To make $\text{Na}_x\text{PB}/\text{Na}_x\text{PBA}$, PB/PBAs can reversibly intercalate sodium particles into their precious stone grid. The intercalation process is driven by the reduction of PB/PBAs, which results in the release of electrons that are utilized by the reduction of sodium ions into sodium metal. NA-particles are deintercalated from the cathode and moved back to the anode during charging, while electrons are utilized to oxidize sodium metal to sodium particles and to reestablish PB/PBAs to their unique condition. [21]With solid cycle strength and limit maintenance, sodium particles' intercalation and deintercalation processes in PB/PBAs are profoundly reversible. In general, by permitting reversible sodium particle

intercalation/deintercalation during charge/release cycles, PB and PBAs serve a huge job as cathode materials in SIBs. They give intriguing conceivable outcomes to cutting edge SIBs with high energy thickness and expanded cycle lives in light of their higher Functional limit and great primary security.

3.2 P2-type layered oxide

O3-type layered oxides, some of the time alluded to as P2-type layered oxides, have become perceived as potential cathode materials for Na-particle batteries as a result of their minimal expense, high limit and brilliant underlying stability.[28] These substances have a layered gem structure with soluble base metal oxide and progress metal oxide layers mixed.

P2-type layered oxides are utilized as cathode materials in Na-particle batteries incorporate: $\text{Na}_{0.66}\text{CoO}_2$: One of the most researched P2-type layered oxides for sodium-ion battery applications, it has a high theoretical capacity of 150 mAh/g and strong structural stability.

$\text{Na}_{0.5}\text{Ni}_{0.25}\text{CO}_{0.25}\text{O}_2$: This substance has a lesser theoretical capacity than $\text{Na}_{0.66}\text{CoO}_2$, but thanks to the presence of Ni and Co ions, it has greater cycling stability and rate capability. $\text{Na}_{0.67}\text{Mn}_{0.67}\text{O}_2$: This material has a low rate capability and poor cycle stability due to the Jahn-Teller distortion of Mn ions, while having a high theoretical capacity of 240 mAh/g and great structural stability. $\text{Na}_{0.75}\text{Ni}_{0.23}\text{Mn}_{0.52}\text{O}_2$: This material is an excellent alternative for high-performance sodium-ion batteries because to its high capacity, excellent structural stability, high cycle stability, and rate capability.

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3.4 Poly-anion compounds

Due to their stable crystal structures and strong redox potential, poly anion compounds have been found as Cathode materials for Na-ion batteries.[3][30] The materials have large capacity and strong cycle stability because they are built on poly anion frameworks that can accept sodium ions.

$\text{NaTi}_2(\text{PO}_4)_3$: Although this material has a high theoretical capacity of 140 mAh/g and strong structural stability, its rate capability is constrained by its weak electrical conductivity.

NaFeSO_4F : This material has a great rate capability and a high theoretical capacity of 139 mAh/g. It also has strong structural stability and good electrical conductivity.

Poly anion builds, as a general rule, give various advantages as cathode materials for Na-particle batteries, including stable gem structures, high redox potential, and solid cycle stability.[28][30] These materials can work at a specific rate, yet some of them have poor electronic conductivity. Analysts are examining strategies like doping and Nano organizing to build the electrical conductivity of poly anion compounds and work on their electrochemical execution in sodium-particle batteries to get around this limitation.

4. Comparison of lithium-ion and sodium-ion battery

Following an inside and out study into cathode materials persuaded by research on Li-particle materials, numerous Na-based addition compounds are found to impart primary qualities to their Li-particle partners. [1][2][23]These are gotten from similar synthetic families as the layered oxides or polyanionic

compounds utilized in the (+) positive anode and the intermetallic amalgams or carbonaceous materials for the (-) negative electrode. [4,5]. These discoveries additionally consider the utilization of Na-based electrolytes with solvents like Li-particle electrolytes. Negative anodes built of hard carbon (HC) with limits of around 300 mAh/g were utilized in the two frameworks as opposed to alloying (Na_xM) or transformation cathodes, which have enormous volume development, unfortunate reversibility, and serious voltage hysteresis. In addition, HC's Na⁺ absorption is mediated by a low-voltage plateau followed by a sloping voltage area, which corresponds to Na⁺ insertion into disordered layers and Na⁺ filling of nanopores. [1]-[30] This allows it to take up Li⁺ at higher rates into graphite without using Na-plating. Due to the demonstrated preference of multilayer oxides over poly anionic ones in the current company Li-particle batteries, many researchers rushed to pursue the improvement of the previous, despite the fact that selecting the Na-particle positive terminals was not as simple.

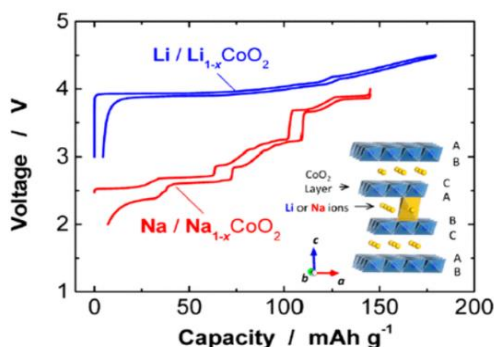


Figure 2. The comparison of Li ion battery vs Sodium Ion battery [25] [26].

4.1. Poly-anionic compounds

The change from Li-to Na-particle innovation builds the last option's power advantage over the previous. In light of a drop in the redox capability of sodium layered oxide, the huge lift in energy thickness that layered skeletons give over polyanionic ones is significantly diminished.[3][30]This brings about a lower yield cell voltage, yet it likewise recommends that the terminal be dealt with and handled in a dry climate. A portion of these dampness challenges can be settled by manufacturing O3-P2 composites or accurately embedding O3 skeletons at the punishment of lower limit

execution. In spite of the way that sodium might live in both octahedral (O) and kaleidoscopic (P) conditions, dissimilar to Li's particle, Na-based layered oxides have more convoluted gem science than Li-particle ones.[28] To conquer the limit limitation of P-type layered oxides attributable to sodium non-stoichiometry (0.7-0.8 per equation unit), research has focused on the adjustment of stoichiometric O3-Na1MO2 deliberately works by alterations in the nature and grouping of the change metals. The penultimate stage towards high limit is the arrangement of an anionic redox-dynamic O3 NaLi1/3M2/3O2 stage. [10] Like its Li-rich sibling, this phase may have intermediate kinetics. Faradion created Na-particle pocket cells with O3 or O3-P2 intermixture of NaNi(1xyz)MnxMgyTizO2 stages, guaranteeing a particular energy of 150 Wh/kg for the total cell weight at C/3 rate with a typical voltage of 3.2 V. Next to layered structures, three-layered (3D) Na-based polyanionic stages like phosphates (NaFePO₄), sulfates Na₂Fe₂(SO₄)₃, and fluorophosphates (NaVPO₄F) have moreover been completely investigated. The Na₃V₂(PO₄)₂F₃ (NVPF) compound, with its particular gem structure consisting of open channels for quick Na⁺ particles diffusion and a typical capability of 3.9V, emerges as the most practical terminal when investigating the vast boundary space enrolling the material basic creation and precious stone electronic construction that determines the cathode's electrochemical exhibitions.[30] At a material-level explicit energy of 507 Wh/kg, it is comparable to LiFePO₄ (LFP In the 18,650 model cells used by Tiamat, the NVPF/HC research transmitted 122 Wh/kg at a 1C rate.

The cells have a strong rate limit (90% at 1C) and a long cycling life (>4,000 cycles); Prussian blue stages, which have been known for a very long time and were recently thought to be cathodes for uncommercialized electrochromic devices, are now distinguished as reversible host positive terminals for Na-particle batteries.[17][21] They utilize a three-layered primary system whose creations, as shown by Novosis, are the most appealing for Na-particle batteries.[7] The advantages of Prussian blue stages include their non-poisonous To deal with this issue, a sans water Prussian blue terminal with 140 mAh/g at 1C rate and a normal voltage of 3.4 V was actually reported.[22] This cathode has a low material thickness (1.8 g/cm³ instead of 5.1 and 3.5 g/cm³ for LiCoO₂ and LiFePO₄, independently), which achieves an unpretentious energy thickness (volumetric from the beginning, Basically by subbing LiPF₆ with NaPF₆, scientists exchanged the extensively used Li-molecule electrolytes over totally to Na-molecule electrolytes.[7] This current situation was learned about our hidden 18,650 models, which had high electrochemical execution at 25°C anyway fair execution at 55°C in regards

to self-delivery and breaking point upkeep. In EC-DMC/HC science, these models depend on NVPF//1M NaPF₆. This was anticipated on the grounds that Na-based carbonates are more solvent than their Li partners because of Na⁺'s milder Lewis acidity, which brings about unfortunate steadiness of the defensive SEI layer on the C anode. [14] The direct carbonate component of the electrolyte (DMC) is every now and again utilized in Li-particle batteries. [21] in light of these upgrades including either certain or negative anodes and electrolytes, Na-molecule batteries have been worked as 18650 or Pocket cells, and associations like Faradion, Tiamat, and Novasis working with the NVPF, layered oxide, and Prussian blue science, separately, have been spread out.

4.1.1 Electrolyte Stability

The electrolyte's stability is another important aspect of a SIB's stability. To stay away from holes, decay, or other unfortunate results on the battery's presentation, the electrolyte should stay consistent over the battery's life expectancy. Normally, a natural fluid electrolyte or a strong state electrolyte are been utilized as the electrolyte in SIBs. [7][22] In light of the fact that they are less inclined to release or spill, strong state electrolytes give more noteworthy security and wellbeing than fluid electrolytes. They are additionally more thermally steady, which empowers them to oppose higher temperatures without debasing. Despite the fact that their conductivity is every now and again lower than that of fluid electrolytes, strong state electrolytes can be challenging to make. Conversely, fluid electrolytes have a higher conductivity and might be less difficult to deliver. They are less safe than solid-state electrolytes because they are more prone to deterioration over time and may be combustible. [23]

4.1.2 Thermal Stability

For a SIB to work securely under shifted conditions, its warm solidness is fundamental. The battery should be fit for enduring a wide temperature range without failing or becoming unsound. The warm soundness of SIBs is habitually connected with the material security of the anode and electrolyte. [7] One of its benefits is that SIBs use materials that are more thermally stable than those in lithium-ion batteries. For example, NaFePO₄ has a more noteworthy dissolving point than lithium iron phosphate (LiFePO₄), which empowers it to oppose higher temperatures without

debasement. Similar to this, solid-state electrolytes outperform liquid electrolytes in terms of their thermal stability.

5. Conclusions

The change to maintainable energy sources has turned into a significant issue for researchers, technologists, and lawmakers the same. As a result, research into alternative energy technologies like Na-ion batteries as a potential solution to the energy storage needs of electric vehicles has increased. In this survey, we took a gander at the capability of Na-particle batteries for electric vehicle applications, their advantages and downsides, and the current degree of innovative work in this subject. One of the main advantages of Na-ion batteries over lithium-ion ones is that they are plentiful and inexpensive. As a result, Na-ion batteries might be an appealing alternative. Moreover, sodium-particle batteries have shown fantastic execution concerning energy thickness, soundness, and security, making them a reasonable choice for electric vehicle applications. Na-particle batteries, then again, have various deterrents, including lower energy thickness than lithium-particle batteries and an absence of business accessibility because of the present status of improvement. Regardless of these difficulties, scholastics and industry pioneers are endeavoring to improve the exhibition and feasibility of Na-particle batteries for use in electric vehicles. New cathode materials, electrolytes, and cell plans are being explored and tried to expand the energy thickness, cycle life, and security of these batteries. Sodium-particle batteries, then again, have showed huge potential as a lithium-particle battery substitute for electric vehicle applications, in spite of the fact that they face various difficulties. More innovative work is expected to work on the exhibition and monetary practicality of sodium-particle batteries, yet progress has previously been made. The progress to manageable energy sources will require joint effort among scholastics, industry, and policymakers, with continuous investigation into elective energy innovations, for example, sodium-particle batteries assuming a basic part.

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Authors' biographies



Vishal RAVI SRIDEVI is currently pursuing his final year of B.E. in Mechatronics Engineering and is a Student of Mechatronics department at Rajalakshmi engineering College, Chennai, India. His areas of interest and projects include Automotives, Energy distribution, Industrial Automation, Sustainable Development, Automobiles, Control Systems, Design of Mechatronics system.

Email: 201201059@rajalakshmi.edu.in



Prakash ELANGO VAN is an Assistant Professor of Mechatronics Engineering Department at Rajalakshmi engineering College, Chennai, India and currently pursuing Ph.D. in the domain of Mechanical Engineering. His areas of interest and projects include Fuel Cell, Battery Management Systems and Internal Combustion Engines.

Email: prakasrajes@rajalakshmi.edu.in



Sivakandhan CHINNASAMY is a Professor of Mechanical Engineering at Nadar Saraswathy College of Engineering and Technology, India and holds Ph.D. in Mechanical Engineering His research topics include Renewable Energy, Composite Materials and Internal Combustion Engines.

Email: kandhansiva69@gmail.com



Sanjay Kumar SRINIVASAN is currently pursuing his final year of B.E. in Mechatronics Engineering and is a Student of Mechatronics department at Rajalakshmi engineering College, Chennai, India. His areas of interest and projects include Industrial Automation, Robotics, Industry 4.0, Control, Design of Mechatronics system, Energy Conservation.

Email: 201201504@rajalakshmi.edu.in



Sanjay Mohan SUJATHA is currently pursuing his final year of B.E. in Mechatronics Engineering and is a Student of Mechatronics department at Rajalakshmi engineering College, Chennai, India. His areas of interest and projects include Industrial Automation, Sustainable Development, Control Systems, Design of Mechatronics system, Automotives.

Email: 201201046@rajalakshmi.edu.in



Kanagaraj VENUSAMY holds a M.E. in Mechatronics Engineering and is an Assistant Professor of Mechatronics department at Rajalakshmi engineering College, Chennai, India. His research topics include Industrial Automation, Sustainable Development, Industry 5.0, Control Systems, Design of Mechatronics system, Entrepreneurship.

Email: kanagaraj.v@rajalakshmi.edu.in



Ramnat Venkataramanan is currently pursuing his final year of B.E. in Mechatronics Engineering and is a Student of Mechatronics department at Rajalakshmi engineering College, Chennai, India. His areas of interest and projects include Industrial Automation, Sustainable Development, Industry 4.0, Design of Mechatronics system, Sensors Interfacing, Microcontrollers.

Email: 201201042@rajalakshmi.edu.in