

# INNOVATION SCIENCE AND TECHNOLOGY

**ISSUE 10, PART I / OCTOBER 2026**

 **Acceptance of papers**



**Acceptance of  
papers**

Published monthly



**Topics**

economics,  
technology, social  
sciences



**EDITOR-IN-CHIEF:**

Mirzaliyev Sanjar Makhamatjon ugli

**DEPUTY EDITOR-IN-CHIEF:**

Makhmudov Nosir Makhmudovich  
DSc., Prof., Academician

**DEPUTY EDITOR-IN-CHIEF:**

Ochilov Bobur Bakhtiyor ugli – Senior  
lecturer at TSUI

THE SCIENTIFIC-POPULAR ELECTRONIC  
JOURNAL **"INNOVATION SCIENCE AND  
TECHNOLOGY"** HAS BEEN REGISTERED  
UNDER THE NUMBER **C-5669633** BY THE  
AGENCY FOR INFORMATION AND MASS  
COMMUNICATIONS (AOKA) OF THE  
REPUBLIC OF UZBEKISTAN, EFFECTIVE  
FROM OCTOBER 9, 2024.

**CONTACTS**

Phone: **+998 50 737 87 88**

Website: <https://ist-journal.uz>

Email: [innovationist2025@gmail.com](mailto:innovationist2025@gmail.com)

The scientific electronic journal "Innovation Science and Technology" has been included in the list of scientific publications recommended for the publication of main scientific results of dissertations for the award of PhD and DSc degrees in economics and technical sciences, in accordance with the Resolution No. 370 of the Presidium of the Higher Attestation Commission of the Republic of Uzbekistan, dated May 8, 2025.

**Editorial board:**



**Sharipov Kongiratbay Avezimbetovich,**  
Doctor of Technical Sciences (DSc), Professor



**Abdurakhmanova Gulnora Kalandarovna,** Doctor of  
Economic Sciences (DSc), Professor



**Cham Tat Huei,**  
Doctor of Philosophy (PhD), Professor (Malaysia)



**Muhammad Imran Sadiq**  
Doctor of Philosophy in Economics (PhD), Professor,  
Malaysia



**Ahmed Aziz Ismail**  
Doctor of Technical Sciences (DSc),  
Professor (Egypt)



**Lee Chin**  
Doctor of Philosophy in Economics (PhD), (Malaysia)



**Asongu Simplicie**  
Doctor of Philosophy in Economics (PhD), Cameroon



**Rui Dang**  
Doctor of Chemistry (DSc), Professor, China



**Zahoor Ahmed**  
Doctor of Philosophy in Economics (PhD), Turkey



**Shujaat Abbas**  
Doctor of Philosophy in Economics (PhD), Russia



**Tina A Coffelt**  
Doctor of Philosophy in Educational Sciences (PhD),  
USA



**Abdikarimova Dinara Rustamxanovna**  
Doctor of Economic Sciences (DSc), Professor

**Kurbonbekova Mohichehra Turobjonovna**  
Doctor of Economic Sciences (DSc), Professor

**Alimardonov Ilkhom Muzrabshokovich**  
Doctor of Economic Sciences (DSc), Professor



**Razakova Barno Sayfieva**  
Doctor of Philosophy in Economics (PhD)



**Khasanov Sarvar Ulugbek ugli**  
Doctor of Philosophy in Economics (PhD)



**Kholikova Rukhsora Sanjarovna**  
Associate Professor (PhD)



**Xoliyorova Shoxista Qahramon qizi**  
PhD in Economics, Assistant Lecturer at the Department TSUE

**Nasiba G'anjon qizi Sattorova**  
PhD, Senior Lecturer at the Department of Banking

# CONTENTS

|                                                                                                                                                           |    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| IMPLEMENTATION OF THE IMPROVED METHODOLOGY IN PRACTICE AND ASSESSMENT OF ITS ECONOMIC EFFICIENCY .....                                                    | 8  |
| Eshniyazova Yulduz Yuldashbayevna                                                                                                                         |    |
| EXPERIMENTAL OPTIMIZATION OF DESIGN AND ENERGY PARAMETERS OF A GARLAND-TURBINE MOBILE MICRO HYDROPOWER PLANT FOR FREE-FLOWING WATER .....                 | 13 |
| Sultonov Sanjarbe, Zokirov Islomjon, Nurillaev Ahadullo, Abdullaev Shavkat                                                                                |    |
| METHODOLOGY FOR INCREASING THE EFFICIENCY OF CREDIT OPERATIONS IN COMMERCIAL BANKS .....                                                                  | 19 |
| Djumaniyazov Ikram Karimbaevich                                                                                                                           |    |
| COMPARATIVE ANALYSIS OF A COMPACT RESIDUAL CONVOLUTIONAL MODEL AND LINEAR REGRESSION FOR IMAGE SUPER-RESOLUTION .....                                     | 27 |
| Husan Arziqulov Normurod o'g'li                                                                                                                           |    |
| COMPARATIVE EVALUATION OF MACHINE LEARNING ALGORITHMS AND CLASS IMBALANCE HANDLING STRATEGIES FOR CREDIT CARD FRAUD DETECTION .....                       | 33 |
| Mahmudova Dilnoza Avaz qizi                                                                                                                               |    |
| DIGITAL TRANSFORMATION OF FINANCIAL RESOURCE MANAGEMENT IN PUBLIC SOCIAL SECTOR INSTITUTIONS .....                                                        | 39 |
| Khasanov Tulkin Axmatovich                                                                                                                                |    |
| WAYS TO ENSURE THE STABILITY OF THE CAPITAL BASE OF COMMERCIAL BANKS .....                                                                                | 45 |
| Isakov Isobek Janabay's son                                                                                                                               |    |
| CROSS-DAY EXPERIMENTAL EVIDENCE OF THERMAL-LOAD SHIFTING IN A SOLAR-DRIVEN HYDRONIC RADIANT FLOOR WITH MACROENCAPSULATED RT52 PHASE CHANGE MATERIAL ..... | 50 |
| Jurabek Kamolov, Sokhib Temirov, Marjona Makhmudova                                                                                                       |    |
| STUDY OF THE TRACTION DYNAMICS OF AN AGGREGATE CONSISTING OF A FRUIT-HARVESTING MACHINE AND ITS TWO-AXLE CONTAINER-CARRYING TRAILER PLATFORM .....        | 59 |
| Norchayev Davron, Sardor Nigmatjonov, Norchayev Jaloliddin, Norchayev Rustam                                                                              |    |
| PRIORITY DIRECTIONS FOR STRENGTHENING THE FINANCIAL STABILITY OF AGRICULTURAL ENTERPRISES .....                                                           | 67 |
| Kulmatov Zafar Jumanazarovich                                                                                                                             |    |
| METHODOLOGICAL APPROACHES TO DEVELOPING UNIVERSITY STUDENTS' DIGITAL COMMUNICATIVE COMPETENCE BASED ON EMOTIONAL INTELLIGENCE .....                       | 73 |
| Malikakhon Kamiljanova                                                                                                                                    |    |
| SIMULTANEOUS REMOVAL CHARACTERISTICS OF OIL AND HEAVY METAL IONS BY BIOFLOCCULANTS BASED ON THE CELLULOSE-DMAEMA/PEPA COMPOSITE .....                     | 80 |
| Xayitboeva Dilshoda, Ibragimov Nasrilla, Jumaev Anvarbek                                                                                                  |    |
| ECONOMIC ANALYSIS AND DEVELOPMENT STRATEGY OF THE WOOD-POLYMER COMPOSITES MARKET .....                                                                    | 84 |
| Abdumalikova Zarnigor, Ayubova Indira, Jumaev Anvarbek                                                                                                    |    |
| ENERGY UTILIZATION ANALYSIS OF AGRICULTURAL DRYING BASED ON INTEGRATED SOLAR THERMAL AND PHOTOVOLTAIC ENERGY SUPPLY .....                                 | 89 |
| Ibragimov Umidjon, Mirzayarova Sevara, Khujayorova Aziza                                                                                                  |    |
| RECENT ADVANCES IN THE SYNTHESIS OF NANOSTRUCTURED MATERIALS FOR ZINC-ION BATTERIES .....                                                                 | 96 |
| Diyorbek Absattorov, Dilnoza Erimbatova, Murodjon Samadiy                                                                                                 |    |

# RECENT ADVANCES IN THE SYNTHESIS OF NANOSTRUCTURED MATERIALS FOR ZINC-ION BATTERIES

**Diyorbek Absattorov**

Laboratory Assistant, Department of Metrology and Materials Science Engineering at Karshi State Technical University

**Dilnoza Erimbatova**

PhD student at Karakalpak State University

**Murodjon Samadiy**

Professor at Karshi State Technical University

**Abstract:** Zinc-ion batteries are a safe and low-cost option for storing renewable energy, but their performance depends heavily on the electrode materials. This article reviews recent progress in making nanostructured materials for these batteries, with a focus on manganese oxides, vanadium oxides, and carbon-based composites. We compare common synthesis routes, including hydrothermal growth, electrospinning, and template-assisted methods, and explain how each one shapes particle size, crystal structure, and ion transport. Studies show that nanorods, nanosheets, and nanowires usually store more zinc and last longer than bulk powders. Still, scale-up, material cost, and unclear reaction mechanisms remain open problems for future work.

**Keywords:** zinc-ion batteries; nanostructured materials; hydrothermal synthesis; manganese oxide; vanadium oxide; energy storage.

**Annotatsiya:** Rux-ionli batareyalar qayta tiklanuvchi energiyani saqlash uchun xavfsiz va arzon yechim hisoblanadi, biroq ularning samaradorligi ko'p jihatdan elektrod materiallariga bog'liq. Mazkur maqolada ushbu batareyalar uchun nanostrukturallangan materiallarni ishlab chiqish borasidagi so'nggi yutuqlar, xususan, marganes oksidlari, vanadiy oksidlari va uglerod asosidagi kompozit materiallarga e'tibor qaratilgan holda ko'rib chiqiladi. Gidrotermal sintez, elektrospinning va shablon yordamida sintez qilish kabi keng tarqalgan usullar taqqoslanib, ularning har biri zarracha o'lchami, kristall tuzilma va ionlarning harakatlanish xususiyatlarini qanday shakllantirishi tushuntiriladi. Tadqiqotlar nanostepjenlar, nano-sahifalar va nanovoloknolar hajmi kukunlarga nisbatan odatda ko'proq rux ionlarini saqlashi va uzoqroq xizmat qilishini ko'rsatmoqda. Shunga qaramay, ishlab chiqarishni keng miqyosga olib chiqish, materiallar tannarxi va reaksiyalar mex-anizmlarining yetarlicha aniqlanmaganligi kelgusidagi tadqiqotlar uchun dolzarb masalalar bo'lib qolmoqda.

**Kalit so'zlar:** rux-ionli batareyalar; nanostrukturallangan materiallar; gidrotermal sintez; marganes oksidi; vanadiy oksidi; energiyani saqlash.

**Аннотация:** Цинк-ионные батареи являются безопасным и недорогим решением для хранения возобновляемой энергии, однако их эксплуатационные характеристики во многом зависят от материалов электродов. В данной статье рассматриваются последние достижения в разработке наноструктурированных материалов для таких батарей с акцентом на оксиды марганца, оксиды ванадия и композиты на основе углерода. Сравниваются распространённые методы синтеза, включая гидротермальный синтез, электроspinning и шаблонно-ориентированные методы, а также объясняется, как каждый из них влияет на размер частиц, кристаллическую структуру и транспорт ионов. Исследования показывают, что наностержни, нанослои и нанопроволоки, как правило, обеспечивают более высокую способность к накоплению цинка и более длительный срок службы по сравнению с объемными порошковыми материалами. Тем не менее масштабирование производства, стоимость материалов и недостаточная ясность механизмов протекающих реакций остаются актуальными проблемами для дальнейших исследований.

Ключевые слова: цинк-ионные батареи; наноструктурированные материалы; гидротермальный синтез; оксид марганца; оксид ванадия; хранение энергии.

## INTRODUCTION

Wind and solar power are growing fast, but they do not produce electricity on demand. Large batteries are needed to smooth out this gap between supply and use. Lithium-ion batteries dominate the market today, yet their cost, limited resources, and flammable organic electrolytes make them a difficult choice for grid-scale storage. Aqueous zinc-ion batteries (ZIBs) have therefore attracted growing attention. Zinc is abundant and cheap, it can be handled in air, and water-based electrolytes are far safer than the organic liquids used in lithium-ion cells [1,2].

A ZIB works by moving  $\text{Zn}^{2+}$  ions back and forth between a zinc metal anode and a host cathode, usually in a mildly acidic or neutral zinc-salt solution. The idea is simple, but the practice is not. Zinc ions carry two charges and are comparatively heavy, so they interact strongly with the crystal lattice and move slowly through it [1]. Cathodes also change structure while they are charged and discharged, and the reaction mechanisms inside them are still argued about in the literature [1,2,5]. Together these facts explain why finding a good cathode is considered the main bottleneck of the field.

Two families of inorganic cathodes receive most of the attention. Manganese oxides are cheap and exist in many crystal forms, and several of them accept zinc reversibly [3,5,7]. Vanadium oxides have layered structures with wide gaps between the layers, which gives zinc ions room to enter [4,8,10]. Both families, however, suffer from slow ion diffusion, poor electrical conductivity, or structural damage during cycling. Much of the recent work tries to fix these problems by changing how the material is built rather than what it is made of.

Nanostructuring is the most common way to do this. When a material is shaped into rods, sheets, wires, or fibers, the distance that ions must travel inside each particle becomes short, the contact area with the electrolyte becomes large, and the structure can better tolerate the strain of repeated insertion and removal. The idea has been tested in many forms: hydrothermal  $\alpha\text{-MnO}_2$  nanorods [3], flexible  $\text{V}_2\text{O}_5$  fiber papers [4], manganese oxide nanowires on graphene [7], iron-doped  $\text{V}_2\text{O}_5$  nanorods made from electrospun templates [9], and  $\text{V}_2\text{O}_5$  particles split into nanosized pieces by electrochemical activation [10]. A further study showed that hydrothermal conditions can change the phase and composition of a vanadium oxide and with it the zinc-storage capacity [6].

Several good reviews already describe cathode chemistry and reaction mechanisms [1,2,5,8]. In this article we look at the question from the side of synthesis. We ask which preparation routes are used, what nanostructures they produce, and how those structures affect zinc storage. The article is organized as follows. Section 2 discusses representative studies on manganese and vanadium nanomaterials. Section 3 explains how the literature was selected and summarizes the main synthesis routes and testing methods. Section 4 gives conclusions and suggestions for future work.

## REVIEW OF LITERATURE ON THE SUBJECT

This section looks at five representative studies [3,4,6,7,10]. They were chosen because each one reports both a clear synthesis route and the resulting battery behavior, and together they cover manganese oxides, vanadium oxides, and carbon composites.

An early and often cited example of nanostructured manganese oxide is the  $\alpha\text{-MnO}_2$  nanorod electrode of Alfuruqi and co-workers, made by a simple hydrothermal reaction. The cell delivered an initial discharge capacity of  $233 \text{ mAh g}^{-1}$  at  $83 \text{ mA g}^{-1}$ , and its Coulombic efficiency stayed close to 100% during long cycling. The authors used synchrotron X-ray methods to follow what happens inside the electrode. They found that zinc insertion into the tunnels of  $\alpha\text{-MnO}_2$  was reversible and that the unit cell expanded by only about 3%, a small change that explains why the structure survived cycling [3]. The study is useful because it connects a cheap synthesis route directly to a measured structural benefit.

A more recent approach is to pair manganese oxide with a conductive support. Antony et al. grew  $\text{MnO}_2$  nanowires on reduced graphene oxide and screen-printed the composite into interdigitated electrodes for a prismatic cell. The device kept a Coulombic efficiency of 99.59% after 300 cycles at a fairly high current rate [7]. The nanowires supply a large surface, while the graphene sheets carry electrons, which pure  $\text{MnO}_2$  conducts poorly. The printing step also shows that nanomaterials can be adapted to practical electrode formats and not only to coin cells.

Li et al. mixed  $\text{V}_2\text{O}_5$  nanofibers with carbon nanotubes to form a flexible “nanopaper” that serves as a cathode without a separate binder. The paper delivered a capacity of  $375 \text{ mAh g}^{-1}$  and ran for 500 cycles. The authors explained this result by the short diffusion paths of the thin fibers and by the open spaces between the vanadium oxide layers, which act as two-dimensional channels for zinc ions [4].

Triosod et al. took a different view and asked what a hydrothermal treatment does to the chemical identity of the product. By changing the phase and composition of  $\text{V}_2\text{O}_5$ , they obtained a sodium vanadate hydrate that reached about  $296 \text{ mAh g}^{-1}$  at  $50 \text{ mA g}^{-1}$  in  $2 \text{ M ZnSO}_4$ . Pure  $\text{V}_2\text{O}_5$  gave only about  $103 \text{ mAh g}^{-1}$  under the same conditions [6]. Their work is a reminder that “synthesis” controls composition as well as shape.

Yoo and co-workers followed a third path. Instead of building a better structure during synthesis, they created

it during use. Their nano-sized split  $V_2O_5$  with water-containing interfaces was prepared by an electrochemical activation step. A normal  $V_2O_5$  cathode needs several initial cycles, called the aging process, during which the volume changes and cracks appear. The activated material avoided this stage, reached  $457 \text{ mAh g}^{-1}$  at  $0.1 \text{ A g}^{-1}$ , and kept 91% of its capacity after 200 cycles at a higher current. The authors also built an all-solid-state cell with it [10].

Placed side by side, the five studies show how strongly the synthesis route decides the outcome. Hydrothermal reactions gave tunnel-structured nanorods in one case [3] and a new vanadate phase in another [6]. Fiber-based assembly produced a freestanding electrode [4]. Growth on graphene solved the conductivity problem [7], and electrochemical activation removed the aging stage [10]. In every case the benefit came from the same basic principles: shorter ion paths, easier access for the electrolyte, and a structure that tolerates volume change.

The studies also share limits. Capacities and lifetimes were measured mostly in small laboratory cells, and the test conditions differ from paper to paper, so the numbers cannot be compared directly [3,4,6,7,10]. Reaction mechanisms are explained in some detail only for a few materials [3,10]. Finally, the synthesis steps are usually described at laboratory scale, and it is rarely discussed whether the same shapes could be produced cheaply in kilogram batches. These gaps point to the research needs listed in the conclusion.

Three questions come up repeatedly when the five studies are read together. The first is stability over time. The  $\alpha\text{-MnO}_2$  nanorods and the activated  $V_2O_5$  both showed good retention, but the cycling tests ran for hundreds of cycles at most [3,10], while a grid battery would be expected to run for many years. The second is the role of water. In the activated  $V_2O_5$ , water between the layers is part of the design [10], and in the sodium vanadate hydrate it is part of the formula [6], so the amount and location of water clearly matter, yet it is hard to control and to measure. The third is the choice of conductive additive. Carbon nanotubes and graphene help in the nanopaper and in the printed electrode [4,7], but they add cost and weight, and their share in the electrode is not always reported in a way that allows fair comparison.

None of these questions argues against nanostructuring. They show that a high capacity in a first report is only the starting point. A material becomes useful for batteries only if its synthesis is repeatable, its structure remains stable during long operation, and its extra components can be justified in terms of cost.

## RESEARCH METHODOLOGY

This work is a narrative review, and no new experiments were carried out. We searched for studies on nanostructured cathode materials for zinc-ion batteries, using search terms such as “zinc-ion battery”, “nanostructured cathode”, “hydrothermal synthesis”, “ $\text{MnO}_2$ ”, and “ $V_2O_5$ ”. The search covered mainly the period from 2015 to 2024. To keep the source base consistent, only papers published in Elsevier journals were kept, and the DOI of every paper was checked against the publisher record.

A paper was included if it met three conditions: it dealt with zinc-ion storage, it described how the material was made, and it reported electrochemical results. Ten papers were finally selected. Four are review articles on cell design, cathode mechanisms, and materials preparation [1,2,5,8]. Six are experimental studies, of which two concern manganese oxides [3,7] and four concern vanadium oxides [4,6,9,10].

From each paper we recorded the material, the synthesis route, the resulting shape and size, the electrolyte, the reported capacity, and the cycling behavior. Because the studies used different currents and electrolytes, the values were not merged into one statistic. Instead, they were compared qualitatively and grouped by synthesis route. Numbers quoted in this article are given exactly as the original authors reported them.

Table 1 summarizes the main routes found in the selected papers. The routes are described in more detail below (Table 1).

**Table 1. Main synthesis routes for nanostructured zinc-ion battery cathodes found in the reviewed studies<sup>1</sup>**

| Synthesis route                     | Typical procedure                                                         | Typical morphology                           | Example from the literature                                          |
|-------------------------------------|---------------------------------------------------------------------------|----------------------------------------------|----------------------------------------------------------------------|
| Hydrothermal                        | Precursor solution sealed in an autoclave and heated for several hours    | Nanorods, nanosheets, phase-tuned vanadates  | $\alpha\text{-MnO}_2$ nanorods [3]; sodium vanadate hydrate [6]      |
| Electrospinning with heat treatment | Polymer fibers loaded with metal salts, then heated to remove the polymer | Nanofibers, nanorods, doped rods             | Fe-doped $V_2O_5$ nanorods [9]                                       |
| Growth on a conductive support      | Active oxide grown on, or mixed with, a carbon support                    | Nanowires on graphene, fiber–nanotube papers | $\text{MnO}_2$ on reduced graphene oxide [7]; $V_2O_5$ nanopaper [4] |

<sup>1</sup> Source: Author's own work.

|                            |                                                                   |                                                             |                                          |
|----------------------------|-------------------------------------------------------------------|-------------------------------------------------------------|------------------------------------------|
| Electrochemical activation | Electrode is pre-cycled so that particles split and take up water | Nano-sized split particles with water-containing interfaces | Split V <sub>2</sub> O <sub>5</sub> [10] |
|----------------------------|-------------------------------------------------------------------|-------------------------------------------------------------|------------------------------------------|

Hydrothermal synthesis. Metal salts and, where needed, an oxidant are dissolved in water, sealed in a Teflon-lined steel autoclave, and heated for several hours, usually at about 120–200 °C. The solid product is then washed and dried. Reaction time, temperature, and precursor ratio decide whether rods, sheets, or other shapes form, and in some cases they decide the crystal phase as well [3,6]. The method is popular because the equipment is simple and the reaction can be scaled by using larger vessels.

Electrospinning with heat treatment. A polymer solution that contains metal precursors is pulled into thin fibers by a strong electric field. The fibers are then heated in air, which burns off the polymer and leaves oxide nanofibers or short nanorods. Doping elements can be added to the solution before spinning, which is how iron-doped V<sub>2</sub>O<sub>5</sub> nanorods were obtained [9]. The method gives very uniform fibers, but the equipment is more specialized and the output is lower than in a batch reaction.

Growth on conductive supports and composites. Active particles are grown on, or mixed with, carbon materials such as graphene or carbon nanotubes. The carbon provides an electron path and keeps the nanoparticles from clumping [4,7]. Electrodes can then be shaped by filtration, as in the nanopaper [4], or by printing, as in the screen-printed cell [7].

Electrochemical activation. In this less common route, a prepared electrode is cycled under controlled conditions so that the particles break into nano-sized pieces and take up water between the layers. The material that results performs well from the first cycles [10].

Authors in this field usually confirm the crystal phase by X-ray diffraction and study the shape and size of particles by scanning and transmission electron microscopy. Gas adsorption gives the surface area, and spectroscopic methods follow changes in the oxidation state of vanadium or manganese. Synchrotron methods were used to follow zinc insertion in  $\alpha$ -MnO<sub>2</sub> [3].

Battery performance is typically tested in coin cells or small prismatic cells with a zinc foil anode and a zinc-sulfate electrolyte. Three standard electrochemical tests appear again and again. Cyclic voltammetry shows at what voltages the redox reactions occur. Galvanostatic charge–discharge tests give capacity, efficiency, and cycle life. Electrochemical impedance spectroscopy reveals resistance inside the cell [3,7]. Readers who compare results between papers should always check the current density, the electrolyte, and the active-material loading, because these three factors can change reported capacities greatly.

## CONCLUSIONS AND SUGGESTIONS

Nanostructured materials have clearly improved zinc-ion batteries. Shaping manganese and vanadium oxides into rods, sheets, and fibers shortens the path zinc ions must travel and gives them more places to react. Hydrothermal synthesis remains the most popular route because it is simple and flexible, while electrospinning and template methods give finer control.

However, many results come from small laboratory cells, and the reaction mechanisms are still debated. Future work should test materials in larger cells, use cheaper precursors, and study structural changes during cycling. Progress on these points will decide whether nanostructured zinc-ion batteries can move beyond the laboratory stage.

### References:

1. L.E. Blanc, D. Kundu, L.F. Nazar, Scientific challenges for the implementation of Zn-ion batteries, *Joule* 4 (2020) 771–799. <https://doi.org/10.1016/j.joule.2020.03.002>
2. J. Ming, J. Guo, C. Xia, W. Wang, H.N. Alshareef, Zinc-ion batteries: Materials, mechanisms, and applications, *Mater. Sci. Eng. R* 135 (2019) 58–84. <https://doi.org/10.1016/j.mser.2018.10.002>
3. M.H. Alfaruqi et al., Enhanced reversible divalent zinc storage in a structurally stable  $\alpha$ -MnO<sub>2</sub> nanorod electrode, *J. Power Sources* 288 (2015) 320–327. <https://doi.org/10.1016/j.jpowsour.2015.04.140>
4. Y. Li, Z. Huang, P.K. Kalambate, Y. Zhong, Z. Huang, M. Xie, Y. Shen, Y. Huang, V<sub>2</sub>O<sub>5</sub> nanopaper as a cathode material with high capacity and long cycle life for rechargeable aqueous zinc-ion battery, *Nano Energy* (2019). <https://doi.org/10.1016/j.nanoen.2019.04.009>
5. X. Ke, L. Li, S. Wang, A. Wang, Z. Jiang, F.R. Wang, C. Kuai, Mn-oxide cathode material for aqueous Zn-ion battery: structure, mechanism, and performance, *Next Energy* 2 (2024) 100095. <https://doi.org/10.1016/j.nxener.2023.100095>
6. S. Triosod et al., Hydrothermal transforming phase structure and chemical composition of V<sub>2</sub>O<sub>5</sub> for elevating electrochemical property of zinc ion batteries, *Appl. Surf. Sci.* (2024) 159468. <https://doi.org/10.1016/j.apsusc.2024.159468>
7. M. Inigo Antony et al., MnO<sub>2</sub> nanowires modified reduced graphene oxide thick film cathode for aqueous zinc-ion

- prismatic battery, *J. Energy Storage* 103 (2024) 114283. <https://doi.org/10.1016/j.est.2024.114283>
8. T. Zhou, G. Gao, V2O5-based cathodes for aqueous zinc ion batteries: Mechanisms, preparations, modifications, and electrochemistry, *Nano Energy* 127 (2024) 109691. <https://doi.org/10.1016/j.nanoen.2024.109691>
  9. G. Yoo, B.-R. Koo, H.-R. An, C. Huang, G.-H. An, Enhanced and stabilized charge transport boosting by Fe-doping effect of V2O5 nanorod for rechargeable Zn-ion battery, *J. Ind. Eng. Chem.* (2021). <https://doi.org/10.1016/j.jiec.2021.04.041>
  10. G. Yoo, B.-R. Koo, et al., Nano-sized split V2O5 with H2O-intercalated interfaces as a stable cathode for zinc ion batteries without an aging process, *Chem. Eng. J.* 434 (2022) 134738. <https://doi.org/10.1016/j.cej.2022.134738>

**Proofreader:** Zokir ALIBEKOV

**Layout and Designer:** Oloviddin Sobir ugli

---

## **2026. № 10**

---

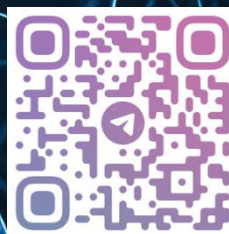
© When materials are reproduced, the INNOVATION SCIENCE AND TECHNOLOGY journal must be cited as the source. Authors are responsible for the accuracy of the information in materials and advertisements published in the journal. Editorial opinions may not always align with those of the authors. Submitted materials will not be returned to the editorial office.

To publish articles in this journal, you may submit articles, advertisements, stories, and other creative materials through the following links. Materials and advertisements are published on a paid basis.

You may subscribe to the journal at any time using the following details. Once subscribed, please send a screenshot or photo of your payment confirmation to our Telegram page @iqtisodiyot\_77. Based on this, we will send the latest issue of the journal to your address each month.

“The journal “INNOVATION SCIENCE AND TECHNOLOGY” has been registered by the Agency for Information and Mass Communications under the Administration of the President of the Republic of Uzbekistan from 09.10.2024 under the registration number №390637. License number: C-5669633. PNFL: 30407832680027

**Our address:** Tashkent city, Yunusobod district, 19th block,  
House 17.



### Acceptance of articles

Published every  
monthly



### Directions

Social, economic, political,  
technological, scientific



Scopus || Scientific electronic journal specializing in Scopus

**CERTIFICATE NUMBER: №390637**

**ORDER NUMBER ACCORDING TO  
THE LICENSE REGISTER: C-5669633**

### CONTACT:



Contact us  
**+998 50 737 87 88**



Telegram channel  
**t.me/scopus\_IST2100**



Journal official website  
**<https://ist-journal.uz/index.php/IST>**