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Sr. No.	App. Number	Ref. No./Application No.	Amount Paid	C.B.R. No.	Form Name	Fee Payment	Remarks
1	202531098043	TEMP/E-1/109455/2025-KOL	1600	12602	FORM 1	Full	AI ORCHESTRATED BIOMANUFACTURING SYSTEM FOR CELLULOSE BASED PACKAGING AND ENERGY VALORIZATION FROM HETEROGENEOUS COW DUNG
2	E-12/2031/2025/KOL	202531098043	2500	12602	FORM 9	Full	
3	E-106/2899/2025/KOL	202531098043	0	-1	FORM28	Full	

TransactionID	Payment Mode	Challan Identification Number	Amount Paid	Head of A/C No
N-0001769496	Online Bank Transfer	1010250097159	4100.00	1475001020000001

Total Amount : ₹ 4100.00

Amount in Words: Rupees Four Thousand One Hundred Only

Received from MEENU SHARMA the sum of ₹ 4100.00 on account of Payment of fee for above mentioned Application/Forms.

* This is a computer generated receipt, hence no signature required.

Print

(12) PATENT APPLICATION PUBLICATION

(19) INDIA

(22) Date of filing of Application :10/10/2025

(21) Application No.202531098043 A

(43) Publication Date : 17/10/2025

(54) Title of the invention : AI ORCHESTRATED BIOMANUFACTURING SYSTEM FOR CELLULOSE BASED PACKAGING AND ENERGY VALORIZATION FROM HETEROGENEOUS COW DUNG

(51) International classification	:C12M0001000000, C12M0001107000, C02F0011040000, C12M0001340000, C02F0003280000
(31) Priority Document No	:NA
(32) Priority Date	:NA
(33) Name of priority country	:NA
(86) International Application No Filing Date	: :01/01/1900
(87) International Publication No	: NA
(61) Patent of Addition to Application Number Filing Date	:NA :NA
(62) Divisional to Application Number Filing Date	:NA :NA

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(57) Abstract :
ABSTRACT AI ORCHESTRATED BIOMANUFACTURING SYSTEM FOR CELLULOSE BASED PACKAGING AND ENERGY VALORIZATION FROM HETEROGENEOUS COW DUNG The present invention discloses an AI-orchestrated biomanufacturing system that transforms heterogeneous cow dung into cellulose-based films, meshes, and molded packaging while valorizing residual biomass into energy and fertilizer. At intake, sensorized smart bins perform near-infrared, pH, moisture, ash, microbiological, and vision-based assessments to generate batch signatures used by a digital twin for pre-processing decisions such as screening, de-gritting, pH correction, and pasteurization. A mild extraction and purification line equipped with inline Raman, UV/Vis, torque, and conductivity sensing is continuously optimized by machine-learning controllers to enhance cellulose yield and minimize resource consumption. The resulting cellulose slurry is fed to a pressurized spinning module where nozzle conditions and bath hydrodynamics are closed-loop regulated to achieve target fibre or film morphology. A generative-design engine maps live material properties to product geometries. Residual organics are routed to an AI-controlled anaerobic digester for biogas generation and bio fertilizer recovery, with all process data recorded on a provenance ledger. The said system delivers consistent, low-footprint, traceable packaging and new rural revenue from a problematic waste stream. Fig. 1

No. of Pages : 18 No. of Claims : 10

FORM 2
THE PATENTS ACT, 1970

(39 of 1970)

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THE PATENTS RULES, 2003
COMPLETE SPECIFICATION
(*Refer* Section 10 and Rule 13)

1. TITLE OF THE INVENTION

AI ORCHESTRATED BIOMANUFACTURING SYSTEM FOR CELLULOSE BASED PACKAGING AND ENERGY VALORIZATION FROM HETEROGENEOUS COW DUNG

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PREAMBLE TO THE DESCRIPTION

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

FIELD OF THE INVENTION

[001] The present invention generally relates to the field of biomanufacturing, waste valorization, and sustainable materials engineering, and more particularly to an artificial intelligence (AI)-enabled, sensor-integrated system and method for converting heterogeneous cow dung feedstock into high-performance, biodegradable cellulose-based materials such as films, fibres, meshes, and molded packaging. The invention further pertains to closed-loop process automation, real-time quality control, and by-product valorization through integrated energy and fertilizer recovery, thereby addressing challenges of feedstock variability, process inefficiency, and environmental impact in conventional dung valorization and cellulose production technologies.

BACKGROUND OF THE INVENTION

[002] Globally, the livestock sector generates billions of tons of cow dung annually. Improper management of this waste leads to a range of environmental, public health, and economic issues. Traditional practices such as open dumping and field stockpiling result in the emission of greenhouse gases like methane and nitrous oxide, contamination of water bodies with nutrients and pathogens, and nuisance issues such as odour and pest infestation.

[003] Concurrently, the packaging industry is under increasing pressure to phase out fossil-fuel derived plastics due to their persistence in terrestrial and marine ecosystems. Manufacturers are actively seeking renewable, non-toxic, and traceable alternatives to conventional plastic packaging materials.

[004] Conventional valorization methods for cow dung such as composting, biogas production, and artisanal paper manufacturing are established but suffer from several limitations like fragmented processes that lack integration; high sensitivity to feedstock variability, with dung composition varying hourly based on animal diet, moisture, bedding, and handling; low scalability and inconsistency in achieving manufacturing-grade material outputs; lab-dependent cellulose extraction processes, which assume homogenous plant-based feed stocks and rely on static processing conditions “recipes”, thus lacking robustness in real-world applications. Chemical-intensive and energy-inefficient operations that can offset intended environmental benefits.

[005] Furthermore, farmers lack adequate incentives and infrastructure to sort, store, and deliver dung of a quality suitable for high-value processing. Processors, on the other hand, lack real-time, high-resolution data to predict key performance indicators such as yield, energy consumption, and material quality. This results in operational inefficiencies, reduced throughput, and unpredictable outcomes.

[006] The current state of technology reveals several critical deficiencies like lack of integration across the entire processing value chain, from dung collection to final product fabrication. There is no widely adopted system that dynamically classifies manure, prescribes extraction parameters, and optimizes fibre formation based on real-time input characterization. Absence of continuous sensing and adaptive control mechanisms, resulting in poor reproducibility and quality control. Manual and schedule-based logistics, leading to inefficient transport, spoilage, and increased operational costs. There is no provision for residual management in a closed-loop manner, resulting in waste and unutilized energy/nutrient potential. There is lack of verifiable carbon, water, and toxicity metrics, which are increasingly mandated by environmental regulations and corporate sustainability goals.

[007] These gaps motivate a need for an integrated, circular manufacturing approach that treats cow dung not as a nuisance but as a metered, sensor-characterized feedstock for biodegradable packaging. The technical problem is to stabilize output quality, minimize chemicals and energy, and orchestrate end-to-end operations, from rural collection to fibre formation and product finishing despite heterogeneous inputs.

[008] The present invention arises from the recognition that the integration of machine learning, Internet-of-Things (IoT) sensing, and adaptive control technologies can enable consistent, scalable cellulose fibre fabrication from cow dung, despite its natural variability. By embedding real-time measurement, predictive analytics, and responsive actuation throughout the processing chain, the proposed system not only stabilizes output quality with minimal chemical and energy input, but also valorizes residuals through biogas generation and nutrient recovery.

[009] This integrated, circular manufacturing system of the present invention aims to transform cow dung from a problematic waste product into a traceable, high-value input for biodegradable packaging, thereby offering new revenue streams for farmers and measurable reductions in plastic pollution and greenhouse gas emissions.

SUMMARY OF THE INVENTION

[010] The present invention provides a fully integrated, AI-orchestrated biomanufacturing system for converting heterogeneous cow dung into high-performance, biodegradable cellulose-based films, fibres, meshes, and molded packaging products, while simultaneously valorizing all process by-products into energy and fertilizer.

[011] The present invention addresses longstanding challenges related to feedstock variability, process inconsistency, and environmental inefficiencies in existing dung valorization and cellulose production methods.

[012] The system of the present invention comprises a multi-stage, sensor-enabled, and machine-learning-driven platform that performs end-to-end operations, beginning at waste collection and culminating in finished biodegradable packaging, under a unified supervisory control architecture. The platform's novelty resides in its tightly coupled, closed-loop design that treats cow dung as a sensor-characterized industrial feedstock and applies machine intelligence at every transformation step.

[013] At the intake stage, smart collection bins and intake stations equipped with near-infrared spectroscopy (NIRS), impedance microbiology sensors, and computer-vision modules quantify fibre potential, moisture, ash, grit, pathogens, and contaminants. These data are transmitted to a digital twin that prescribes batch-specific pre-processing, including screening, de-gritting, pH adjustment, and pasteurization, creating a source-aware front end for downstream operations.

[014] A mild chemical extraction and homogenization train is equipped with inline UV-Vis and Raman spectroscopy, conductivity probes, and torque sensors. A reinforcement-learning controller continuously tunes pH, temperature, shear, and residence time to maximize cellulose yield while minimizing chemical use, heat input, and fouling. Recipes are adapted in real time based on feedstock variability, a novel feature absent in prior static systems.

[015] The purified cellulose slurry is processed through a horizontal nozzle pressurized spinning module, where pressure, nozzle RPM, and water-bath hydrodynamics are dynamically adjusted. Computer-vision microscopes and laser micrometers form a self-calibrating metrology stack that enforces statistical process control in real time, ensuring fibre morphology, diameter distribution,

and surface roughness remain within specification. Off-spec material is automatically diverted for reprocessing without halting throughput, representing a novel adaptive fibre-formation loop.

[016] Downstream, a generative-design engine maps live fibre-stream mechanical properties and customer-defined functional constraints, including stacking strength, barrier performance, heat-seal requirements, and end-of-life decomposition, to optimal packaging geometries. Tool paths are emitted to additive manufacturing or thermoforming modules, which consolidate fibres with bio-binders or enzymatic cross linkers to achieve target mechanical and barrier properties without petrochemical coatings, enabling mass customization at the SKU level.

[017] The finishing stage incorporates an intelligent line balancer that schedules drying, calendering, and surface treatments such as hydrophobic plant waxes or mineral-free oxygen scavengers to comply with food-contact and compostability standards. Sanitation cycles (CIP/SIP) are triggered by predictive microbial kinetics rather than fixed schedules, and fail-safe "safe recipes" ensure operational reliability under sensor uncertainty.

[018] Residual biomass, including fines and trimmings, is routed to an AI-controlled anaerobic digester. Predictive machine-learning models regulate feed, agitation, and temperature to stabilize the microbial community and maximize methane production. Biogas is used to supply plant thermal and electrical energy, while surplus energy can be exported. Digestate is processed into standardized bio fertilizer.

[019] A provenance and traceability ledger records batch inputs, process parameters, emissions, water usage, energy consumption, and final product characteristics, enabling compliance with extended producer responsibility (EPR), carbon accounting, and regulatory frameworks, while supporting transparency and traceability across the supply chain.

[020] The novelty of the invention lies in the unified, closed-loop integration of source-aware intake, AI-adaptive extraction, real-time fibre formation control, generative product design, and predictive energy valorization, all managed under a supervisory optimization layer that co-balances material performance, process economics, and environmental footprint. Unlike prior art, the system continuously adapts to variable feedstock, enforces real-time quality control, and dynamically optimizes residual streams and utilities, delivering traceable, high-performance, biodegradable packaging with low environmental impact and new revenue opportunities for farmers.

OBJECTIVES OF THE INVENTION

[021] The primary objective of the present invention is to provide a system and method to convert heterogeneous cow dung into manufacturing-grade cellulose for biodegradable films, meshes, and molded packaging while maintaining consistent and predictable mechanical performance.

[022] Another objective of the present invention is to stabilize the quality of the output material notwithstanding variability in raw feedstock by employing artificial-intelligence-based sensing, batch classification, and adaptive control mechanisms across extraction, spinning, and finishing operations.

[023] Yet another objective of the present invention is to minimize the consumption of chemicals, process water, and energy by utilising real-time optimisation algorithms configured to regulate reagent dosing, processing temperatures, residence times, and heat recovery cycles.

[024] Yet another objective of the present invention is to achieve zero-waste valorization by directing non-cellulosic residues and fines into an anaerobic digestion subsystem that is governed by predictive machine-learning models to produce biogas and standardized bio-fertilizer.

[025] Yet another objective of the present invention is to implement continuous, inline quality assurance using spectroscopic sensors, computer-vision microscopes, and defect-detection modules that trigger immediate, closed-loop corrective actions.

[026] Yet another objective of the present invention is to enable on-demand, generative design of packaging articles that satisfy functional criteria such as strength, barrier properties, and seal compatibility while reducing material usage and cost.

[027] Yet another objective of the present invention is to digitize agricultural participation through IoT-enabled smart collection bins that evaluate manure quality, forecast supply availability, and facilitate transparent, performance-based remuneration for farmers.

[028] Yet another objective of the present invention is to optimize collection logistics, plant scheduling, and inventory management by employing predictive modeling for route planning, load balancing, and spoilage reduction, thereby lowering transport emissions and inefficiencies.

[029] Yet another objective of the present invention is to ensure regulatory compliance and traceability in relation to food-contact safety, compostability requirements, and extended producer responsibility by maintaining a provenance ledger that records batch-level inputs, emissions, and certifications.

[030] Yet another objective of the present invention is to reduce greenhouse-gas emissions and environmental pollution compared with conventional open dumping of manure and petrochemical-based packaging, with support from auditable lifecycle performance metrics.

[031] Yet another objective of the present invention is to provide a modular and scalable system architecture that can be deployed as micro-plants at dairy facilities or expanded to regional hubs, accommodating diverse geographic conditions and production capacities.

[032] Yet another final objective of the present invention is to deliver economically viable unit economics by co-optimizing material properties, throughput, and onsite energy generation, thereby creating new revenue streams and socio-economic benefits for rural communities.

FIGURES OF THE INVENTION

Figure 1 of the present invention represents a schematic Diagram of the AI-Orchestrated Biomanufacturing System for Cellulose-Based Packaging.

Figure 2 of the present invention depicts flowchart of the process workflow of the AI-Orchestrated Biomanufacturing System for Cellulose-Based Packaging and Energy Recovery.

DETAILED DESCRIPTION OF THE INVENTION

[033] The following description describes various features and functions of the disclosed system and method with reference to the accompanying figures. The terminology used herein is provided solely for the purpose of describing particular embodiments only and should not be construed as limiting the scope of the present invention. Variations, modifications, and equivalents that fall within the broader aspects of the disclosed embodiments are also considered part of the invention.

[034] The detailed description is construed as a description of the currently preferred embodiments of the present invention and does not represent the only form in which the present

invention may be practiced. This is to be understood that the same or equivalent functions may be accomplished, in any order unless expressly and necessarily limited to a particular order, by different embodiments that are intended to be encompassed within the scope of the present invention.

[035] The embodiment is chosen and described to provide the best illustration of the principles of the invention and its practical application and to enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated.

[036] The present invention relates to a fully integrated, AI-orchestrated biomanufacturing system for converting heterogeneous cow dung into high-performance, biodegradable cellulose-based packaging products, including films, fibres, meshes, and molded articles, while simultaneously valorizing all process by-products into energy and fertilizer. The invention addresses long-standing challenges of feedstock variability, inconsistent process outputs, and environmental inefficiencies in conventional dung valorization and cellulose production methods.

[037] In one embodiment, the system comprises a network of sensorized intake units installed at participating dairies and a central processing facility coupled over a secure network as shown in Figure 1 of the present invention.

[038] Smart Collection Bins: Each intake unit includes a sealed bin equipped with:

a) Agitation paddles to prevent settling and provide representative sampling;
b) Near-infrared (NIR) spectroscopy for fibre and moisture analysis;
c) pH and conductivity probes;
d) A camera for color and texture analysis; and
e) An impedance microbiology module for pathogen risk assessment.

[039] Upon deposit, the bin assigns a unique batch identifier (Batch ID) and logs time, location, fill level, and temperature. Sensor readings and batch metadata are transmitted in real time to a cloud controller hosting a digital twin of the processing plant. Out-of-spec batches (e.g., high grit or pathogen load) are flagged prior to transport.

[040] Transport & Chain-of-Custody: Batches are transported in tamper-evident, sealed containers with GPS, temperature, and shock logging to preserve hygiene and ensure traceability.

[041] Pre-processing Unit: The pre-processing line removes grit and sand (mechanical screens, hydrocyclones), pasteurizes the slurry to reduce microbial load (heat exchangers), and adjusts pH for optimal extraction. A homogenizer sets the slurry rheology to ensure stable flow and consistent downstream processing. Pre-processing parameters are prescribed by the digital twin based on the sensor vector from the intake bins.

[042] Extraction & Purification: A mild chemical/enzymatic extraction train liberates cellulose fibres under controlled temperature, shear, and reagent dosing. Inline sensors including UV-Vis, Raman spectroscopy, conductivity, torque, and Coriolis mass flow meters feed a reinforcement-learning controller that dynamically tunes solvent/enzyme concentration, temperature, shear, and residence time to maximize cellulose yield while minimizing chemical use, fouling, and energy consumption. Membrane separation (micro-/ultrafiltration) removes fines, salts, and color bodies, followed by optional counter-current washing to achieve product-specific cleanliness thresholds.

[043] Purified Cellulose Dope Storage: The cellulose slurry ("dope") is stored in jacketed, agitated vessels equipped with bio burden monitoring and CIP/SIP ports. Lots deviating from viscosity, particle size, or contamination limits are automatically quarantined or routed to rework.

[044] Fibre Formation Module: A horizontal nozzle pressurized spinning assembly forms fibres, ribbons, or continuous films. Multi-nozzle rotors, pressure manifolds, and water bath hydrodynamics are dynamically adjusted based on rheology estimates. Computer-vision microscopes and laser micrometers regulate fibre diameter, surface smoothness, and morphology in real time, ensuring tight tolerances.

Product Formation:

[045] Molded Packaging (Product Path A): A generative-design engine ingests live fibre mechanical/barrier properties and functional constraints to synthesize minimal-material geometries for trays, clamshells, and mailers. Additive consolidation or thermoforming shapes the parts, and controlled curing locks stiffness and sealability. Final QC verifies mechanical properties, barrier performance, and food-contact compliance.

[046] Films & Meshes (Product Path B): Calendering densifies and smooths films to target grammage and thickness. Infrared drying removes moisture without thermal damage. Optional plant-wax or bio-based barrier coatings are applied, followed by slitting, packaging, and final QC.

[047] Sanitation (CIP/SIP): Automated clean-in-place and steam-in-place cycles are triggered by microbial risk models rather than fixed timers. Sensors verify detergent concentration, contact time, and rinse quality to maintain hygiene with minimal downtime.

[048] Solvent & Water Recovery: Wash waters and benign solvents are captured, filtered, re-circulated, and pre-warmed via heat exchangers to reduce energy and water consumption.

[049] Residuals Handling & Energy Valorization: Non-cellulosic organics, fines, trimmings, and spent wash streams are routed to an anaerobic digester under predictive control (feed rate, agitation, temperature) to stabilize the microbiome and maximize methane yield. Generated biogas powers plant thermal and electrical loads, with surplus energy optionally exported. Digestate is processed into standardized bio fertilizer.

[050] IoT Logistics & Farmer Incentives: Smart bin telemetry drives collection routes and timing, aligning feedstock supply with plant capacity. Quality-indexed pay outs incentivize higher fibre potential, lower grit, and better hygiene at source. Farmers receive periodic reports on fibre quality and earnings.

[051] Provenance Ledger & Compliance: A secure ledger records batch composition, process set points, sensor data, energy/water use, emissions, QC results, and certifications, supporting traceability, EPR reporting, and carbon accounting.

[052] The stepwise process workflow as shown in Figure 2 of the present invention integrates the system architecture modules into an end-to-end biomanufacturing loop:

a) **Smart Collection & Batch ID:** Manure is deposited into sealed smart bins; batch metadata and sensor readings are logged and transmitted.
b) **Sensor Analysis:** Composition vectors are generated for fibre content, moisture, pH, conductivity, color/contaminants, and pathogen risk.
c) **Cloud Classification & Digital Twin:** Batches are tiered, and preprocessing/extraction set points are prescribed. Plant capacity is reserved against live orders.
d) **Transport (Sealed Containers):** Batches move in tamper-evident containers with GPS and temperature logging.
e) **Pre-processing:** De-gritting, pasteurization, pH adjustment, and homogenization prepare slurry for extraction.

f) **Mild Chemical/Enzymatic Extraction:** Reinforcement-learning controllers tune reagent dosing, temperature, shear, and residence time for optimal cellulose yield.

g) **Membrane Separation & Counter-Current Washing:** Fines, salts, and impurities are removed; water and chemical use is minimized.

h) **Purified Cellulose Dope Storage:** Jacketed, agitated tanks hold cellulose dope, with bio burden monitoring and automated quarantine/rework.

i) **Fibre Formation (Horizontal Nozzle Pressurised Spinning):** Dope is extruded into water baths, with real-time diameter and morphology control via computer vision and laser micrometry.

j) **Product Formation:**

- **Molded Packaging:** Generative design, additive consolidation/thermoforming, controlled curing, final QC.
- **Films & Meshes:** Calendering, drying, optional coatings, slitting, packaging, QC.

k) **Sanitation (CIP/SIP):** Triggered by microbial risk; sensors verify cleaning efficacy.

l) **Solvent & Water Recovery:** Recirculation and heat recovery optimize resource use.

m) **Residuals → Anaerobic Digestion → CHP:** Non-cellulosic residues are digested; biogas powers operations, digestate becomes bio fertilizer.

n) **IoT Logistics & Farmer Incentives:** Collection optimized by telemetry; quality-indexed pay outs encourage superior feedstock.

o) **Final QC & Traceability:** Mechanical, barrier, and microbiological testing with batch-level provenance ledger ensures compliance and rapid recalls if needed.

[053] Thus, the disclosed method provides and establishes a closed-loop, sensor-integrated biomanufacturing process that systematically transforms heterogeneous manure feedstock into purified cellulose-based intermediates and end-use products, wherein each stage—from smart collection to final quality control—is digitally orchestrated, resource-optimized, and traceable through a unified data architecture, thereby ensuring consistent product quality, regulatory compliance, and operational sustainability.

[054] The foregoing description of the specific embodiments will so fully reveal the general nature of the objectives herein that others can, by applying current knowledge, readily modify

and/or adapt for various applications such specific objective without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed objectives.

We Claim:

1) An AI-orchestrated biomanufacturing system for converting heterogeneous cow dung into cellulose-based packaging and valorizing residual streams, comprising:

a) a plurality of sensorized intake units at dairy sites, each unit including a sealed collection bin with agitation means, near-infrared spectroscopy, pH and moisture probes, camera-based color and texture analysis, and impedance microbiology sensors for pathogen risk assessment;

b) a cloud-based controller hosting a digital twin, configured to receive batch sensor data, classify the batch, predict cellulose yield and quality, and prescribe pre-processing and extraction set points;

c) a pre-processing unit configured for de-gritting, pasteurization, pH adjustment, and homogenization of the cow dung slurry based on prescribed set points;

d) an extraction and purification train comprising mild chemical and enzymatic treatment, inline sensors (UV-Vis, Raman, conductivity, torque, mass flow), and membrane filtration, controlled via a reinforcement-learning agent to optimize cellulose yield, purity, and chemical consumption;

e) a cellulose dope storage module including jacketed, agitated tanks with bio burden monitoring and automatic rework routing;

f) a fibre formation module comprising a horizontal nozzle pressurized spinning assembly with computer vision and laser micrometry for real-time control of fibre diameter and surface morphology;

g) product formation modules, including (i) a generative-design engine for molded packaging, and (ii) film/mesh calendering and drying units with optional surface treatments;

h) a sanitation subsystem performing CIP/SIP cycles triggered by microbial risk models;

i) a residual management system including an anaerobic digester and combined heat-and-power unit, wherein residual biomass is converted to biogas and standardized bio fertilizer; and

j) a provenance and compliance ledger recording batch composition, set points, utilities, emissions, and quality metrics, enabling traceability, extended producer responsibility, and carbon accounting.

2) The system as claimed in claim 1, wherein the cloud-based controller dynamically adjusts extraction parameters including reagent concentration, temperature, shear, and residence time based on real-time sensor feedback to compensate for feedstock variability.

3) The system as claimed in claim 1 or 2, wherein the fibre formation module adjusts nozzle pressure, rotor speed, and quench bath hydrodynamics to maintain fibre diameter between 8–30 μm and surface roughness within specified tolerances.

4) The system as claimed in claim 1, wherein the residual management system uses predictive machine-learning models to optimize anaerobic digestion, biogas yield, and energy integration with process utilities.

5) The system as claimed in claim 1, wherein IoT-enabled logistics optimize feedstock collection routes and timing and provide quality-indexed farmer incentives.

6) A method for manufacturing cellulose-based packaging and valorizing residual streams from heterogeneous cow dung, comprising the steps of:
   a) collecting cow dung into sealed smart bins at dairy sites, assigning batch identifiers, and recording batch metadata including time, location, temperature, and fill level;
   b) generating a batch composition vector via near-infrared spectroscopy, pH and moisture probes, camera-based analysis, and impedance microbiology;
   c) transmitting the batch data to a cloud-based controller hosting a digital twin, classifying the batch, predicting cellulose yield, energy demand, and quality risks, and prescribing pre-processing and extraction set points;
   d) transporting the batch in tamper-evident, sealed containers with GPS and temperature logging to a central processing facility;
   e) pre-processing the batch via de-gritting, pasteurization, pH adjustment, and homogenization based on prescribed set points;
   f) performing mild chemical and/or enzymatic extraction and purification, with inline sensor feedback controlling reagent dosage, temperature, shear, and residence time to optimize cellulose yield and purity;
   g) storing purified cellulose slurry in jacketed, agitated tanks with bio burden monitoring and diverting off-spec lots to rework;

h) forming fibres, ribbons, or continuous films via horizontal nozzle pressurized spinning with real-time control of fibre diameter and surface morphology using computer vision and laser micrometry;

i) producing packaging products through: (i) a generative-design engine for molded articles, and (ii) calendering, drying, and optional surface treatments for films and meshes;

j) performing CIP/SIP sanitation cycles triggered by microbial risk;

k) recovering wash waters and benign solvents and reclaiming heat from hot streams;

l) diverting residual biomass to an anaerobic digester with predictive control for biogas production and converting digestate into standardized bio fertilizer; and

m) recording all batch compositions, process parameters, utilities, emissions, and QC results in a provenance ledger for traceability, EPR, and carbon accounting.

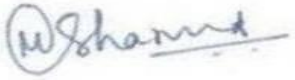
7) The method as claimed in Claim 6, wherein the digital twin dynamically updates pre-processing, extraction, and fibre formation set points to compensate for real-time feedstock variability.

8) The method as claimed in Claim 6, wherein packaging product geometry is generated based on live mechanical and barrier properties of the fibre stream to minimize material usage.

9) The method as claimed in Claim 6, wherein farmer incentives are provided based on fibre quality, grit content, and hygiene metrics collected from smart bins.

10) The method as claimed in Claim 6, wherein residual biogas is used to power plant operations and surplus energy is exported to the grid.

Dated this 10th day of October, 2025



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ABSTRACT

AI ORCHESTRATED BIOMANUFACTURING SYSTEM FOR CELLULOSE BASED PACKAGING AND ENERGY VALORIZATION FROM HETEROGENEOUS COW DUNG

The present invention discloses an AI-orchestrated biomanufacturing system that transforms heterogeneous cow dung into cellulose-based films, meshes, and molded packaging while valorizing residual biomass into energy and fertilizer. At intake, sensorized smart bins perform near-infrared, pH, moisture, ash, microbiological, and vision-based assessments to generate batch signatures used by a digital twin for pre-processing decisions such as screening, de-gritting, pH correction, and pasteurization. A mild extraction and purification line equipped with inline Raman, UV/Vis, torque, and conductivity sensing is continuously optimized by machine-learning controllers to enhance cellulose yield and minimize resource consumption. The resulting cellulose slurry is fed to a pressurized spinning module where nozzle conditions and bath hydrodynamics are closed-loop regulated to achieve target fibre or film morphology. A generative-design engine maps live material properties to product geometries. Residual organics are routed to an AI-controlled anaerobic digester for biogas generation and bio fertilizer recovery, with all process data recorded on a provenance ledger. The said system delivers consistent, low-footprint, traceable packaging and new rural revenue from a problematic waste stream.

Fig. 1

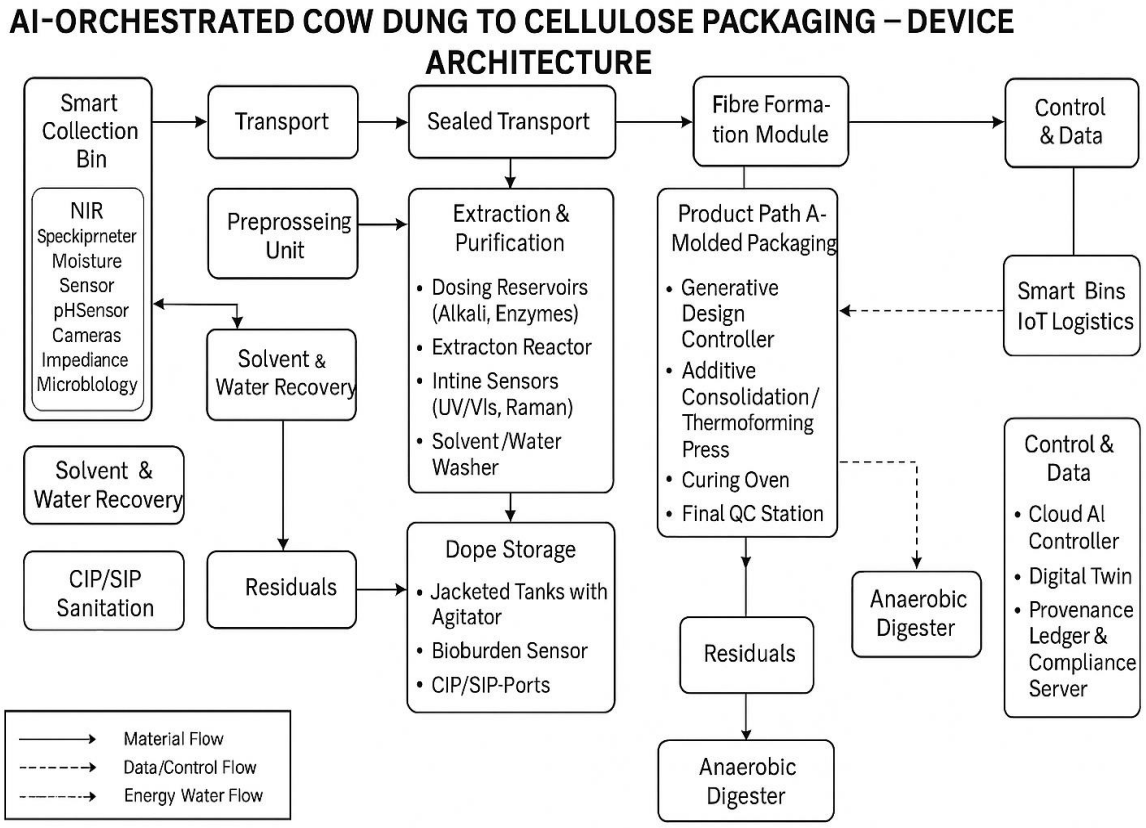

Figure 1: System Architecture

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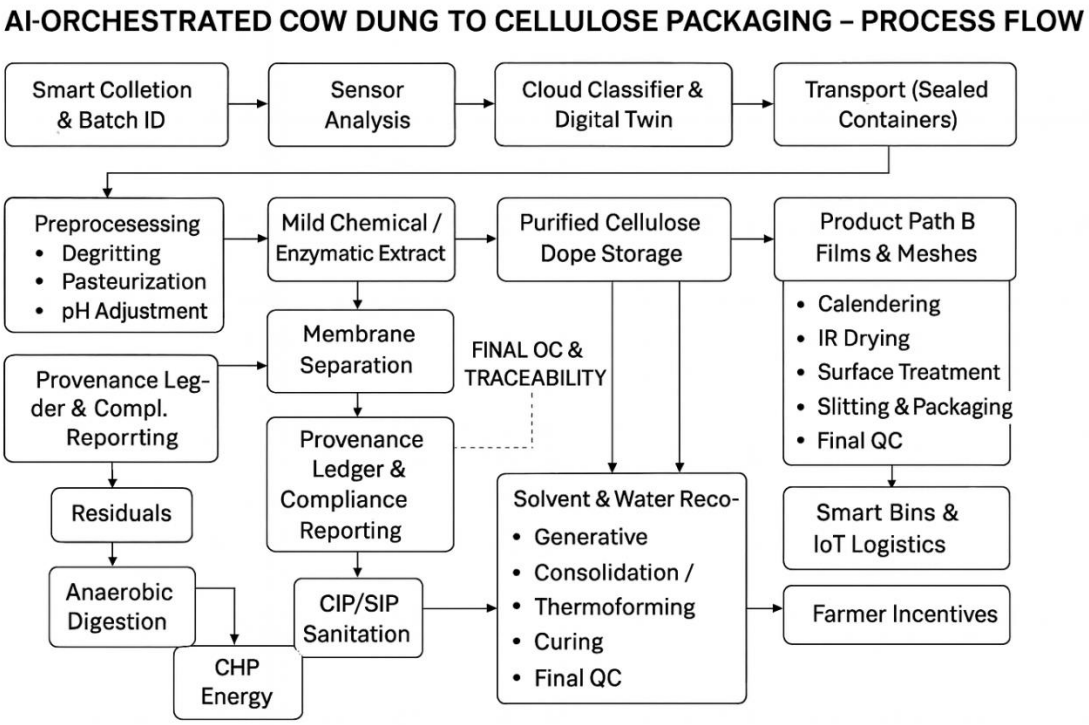

Figure 2: Process flow of the system

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FORM 5

THE PATENTS ACT, 1970

(39 of 1970)

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THE PATENTS RULES, 2003

DECLARATION AS TO INVENTORSHIP

[See Section 10(6) and Rule 13(6)]

1. NAME OF APPLICANT:

SRJX RESEARCH AND INNOVATION LAB LLP

hereby declare that the true and first inventors of the invention disclosed in the complete specification filed in pursuance of our application numbered_____dated October 10, 2025 is as under:-

2. INVENTOR(S)

a) **DR. DILEEP KUMAR MOHANACHANDRAN**
b) Indian;
c) International Research Fellow, SEGi University, 47810 Petaling Jaya, Selangor Darul Ehsan, Malaysia

a) **DR. SOUMYA RANJAN JENA**
b) Indian;
c) Plot No - 3E/474, Sector-9, CDA, Post- Markat Nagar, Cuttack-753014, Odisha, India; and

a) **DR. NORMALA SUBRAMANIAM GOVINDARAJO**
b) Indian;
c) E 305, Vaishnavi Ratnam Apartment, Jalahalli Cross, Bangalore, Karnataka-560057, India

3. DECLARATION TO BE GIVEN WHEN THE APPLICATION IN INDIA IS FILED BY THE APPLICANT IN THE CONVENTION COUNTRY:

We, the applicant in the convention country hereby declare that our right to apply for a patent in India is by way of assignment from the true and first inventor. **NA**

Dated this 10th day of October, 2025

MEENU SHARMA
(IN/PA-2856)
Patent Agent for the Applicant
SRJX RESEARCH AND INNOVATION LAB LLP

To,
The Controller of Patents,
The Patent Office,
at New Delhi

Signature Not Verified
Digitally Signed.
Name: MEENU SHARMA
Date: 10-Oct-2025 20:28:21
Reason: Patent Efiling
Location: DELHI

UDYAM REGISTRATION CERTIFICATE

UDYAM REGISTRATION NUMBER	**UDYAM-OD-07-0095836**
NAME OF ENTERPRISE	**SRJX RESEARCH AND INNOVATION LAB LLP**

TYPE OF ENTERPRISE *

SNo.	Classification Year	Enterprise Type	Classification Date
1	2025-26	Micro	16/08/2025

MAJOR ACTIVITY — **SERVICES**

SOCIAL CATEGORY OF ENTREPRENEUR — **GENERAL**

NAME OF UNIT(S)

S.No.	Name of Unit(s)
1	SRJX RESEARCH AND INNOVATION LAB LLP

OFFICAL ADDRESS OF ENTERPRISE

Flat/Door/Block No.	PLOT NO-3E/474	Name of Premises/ Building	SECTOR-9
Village/Town	CDA CUTTACK	Block	NA
Road/Street/Lane	Avinab Bidanasi	City	Cuttack Sadar
State	ODISHA	District	CUTTACK , Pin 753014
Mobile	9090255155	Email:	soumyajena1989@gmail.com

DATE OF INCORPORATION / REGISTRATION OF ENTERPRISE	**05/05/2025**
DATE OF COMMENCEMENT OF PRODUCTION/BUSINESS	**05/05/2025**

NATIONAL INDUSTRY CLASSIFICATION CODE(S)

SNo.	NIC 2 Digit	NIC 4 Digit	NIC 5 Digit	Activity
1	72 - Scientific research and development	7210 - Research and experimental development on natural sciences and engineering	72100 - Research and experimental development on natural sciences and engineering	Services

DATE OF UDYAM REGISTRATION	**16/08/2025**

* **In case of graduation (upward/reverse) of status of an enterprise, the benefit of the Government Schemes will be availed as per the provisions of Notification No. S.O. 2119(E) dated 26.06.2020 issued by the M/o MSME.**

For any assistance, you may contact:

1. District Industries Centre: CUTTACK (ODISHA)

2. MSME-DFO: CUTTACK (ODISHA)

Udyam Registration Number : UDYAM-OD-07-0095836

Type of Enterprise	MICRO	**Major Activity**	Services
Type of Organisation	Limited Liability Partnership	**Name of Enterprise**	SRJX RESEARCH AND INNOVATION LAB LLP
Owner Name	SRJX RESEARCH AND INNOVATION LAB LLP	**PAN**	AFPFS4480L
Do you have GSTIN	No	**Mobile No.**	9090255155
Email Id	soumyajena1989@gmail.com	**Social Category**	General
Gender	Male	**Specially Abled(DIVYANG)**	No
Date of Incorporation	05/05/2025	**Date of Commencement of Production/Business**	05/05/2025

Bank Details

Bank Name	IFS Code	Bank Account Number
Punjab national bank	PUNB0787800	7878002100002490

Employment Details

Male	Female	Other	Total
3	2	0	5

Investment in Plant and Machinery OR Equipment (in Rs.)

S.No.	Financial Year	Enterprise Type	Written Down Value (WDV)	Exclusion of cost of Pollution Control, Research & Development and Industrial Safety Devices	Net Investment in Plant and Machinery OR Equipment[(A)-(B)]	Total Turnover (A)	Export Turnover (B)	Net Turnover [(A)-(B)]	Is ITR Filled?	ITR Type
1	2023-24	Micro	0.00	0.00	0.00	0.00	0.00	0.00	No	NA

Unit(s) Details

SN	Unit Name	Flat	Building	Village/Town	Block	Road	City	Pin	State	District
1	SRJX RESEARCH AND INNOVATION LAB LLP	PLOT NO-3E/474	SECTOR-9	CDA CUTTACK	NA	Avinab Bidanasi	Cuttack Sadar	753014	ODISHA	CUTTACK

Official address of Enterprise

Flat/Door/Block No.	PLOT NO-3E/474	**Name of Premises/ Building**	SECTOR-9
Village/Town	CDA CUTTACK	**Block**	NA
Road/Street/Lane	Avinab Bidanasi	**City**	Cuttack Sadar
State	ODISHA	**District**	CUTTACK , **Pin :** 753014
Mobile	9090255155	**Email:**	soumyajena1989@gmail.com
Latitude	20.5021859203546	**Longitude:**	85.88860428847029

National Industry Classification Code(S)

SNo.	Nic 2 Digit	Nic 4 Digit	Nic 5 Digit	Activity
1	72 - Scientific research and development	7210 - Research and experimental development on natural sciences and engineering	72100 - Research and experimental development on natural sciences and engineering	Services

Are you interested to get registered on Government e-Market (GeM) Portal	No
Are you interested to get registered on TReDS Portals(one or more)	No
Are you interested to get registered on National Career Service(NCS) Portal	No
Are you interested to get registered on NSIC B2B Portal	No
Are you interested in availing Free .IN Domain and a business email ID	N/A
Are you interested in getting registered on Skill India Digital Portal	No
District Industries Centre	CUTTACK (ODISHA)
MSME-DFO	CUTTACK (ODISHA)
Date of Udyam Registration	16/08/2025
Date of Printing	16/08/2025

IEC Details	
IEC Number	
IEC Status	Inactive
IEC Registration Date	
IEC Modification Date	

FORM 1 THE PATENTS ACT, 1970 (39 of 1970) and THE PATENTS RULES, 2003 **APPLICATION FOR GRANT OF PATENT** (See Section 7, 54 & 135 and sub-rule (1) of Rule 20)				(FOR OFFICE USE ONLY)	
				Application No.	
				Filing date:	
				Amount of Fee paid:	
				CBR No:	
				Signature:	
1. APPLICANT'S REFERENCE/ IDENTIFICATION NO. (AS ALLOTTED BY OFFICE)					
2. TYPE OF APPLICATION [Please tick () at the appropriate category]					
Ordinary (✓)		Convention ( )		PCT-NP ()	
Divisional ( )	Patent of Addition ( )	Divisional ( )	Patent of Addition ( )	Divisional ( )	Patent of Addition( )
3A. APPLICANT					
Name in Full		Nationality	Country of Residence	Address of the Applicant	
SRJX RESEARCH AND INNOVATION LAB LLP		Indian	India	SRJX RESEARCH AND INNOVATION LAB LLP, Plot No - 3E/474, Sector-9, CDA, Post- Markat Nagar, Cuttack-753014, Odisha, India	
3B. CATEGORY OF APPLICANT [Please tick (✓) at the appropriate category]					
Natural Person ()		Other than Natural Person			
		Small Entity (✓)	Startup ( )	Country	
4. INVENTOR(S) [Please tick (✓) at the appropriate category]					
Are all the inventor(s) same as the applicant(s) named above?		Yes ( )		No (✓)	
If "No" , furnish the details of the inventors					
Name in Full		Nationality	Country of Residence	Address of the Inventors	
DR. DILEEP KUMAR MOHANACHANDRAN		Indian	Malaysia	International Research Fellow, SEGi University, 47810 Petaling Jaya, Selangor Darul Ehsan, Malaysia	
DR. SOUMYA RANJAN JENA		Indian	India	Plot No - 3E/474, Sector-9, CDA, Post-Markat Nagar, Cuttack-753014, Odisha, India	

DR. NORMALA SUBRAMANIAM GOVINDARAJO	Indian	India	E 305, Vaishnavi Ratnam Apartment, Jalahalli Cross, Bangalore, Karnataka-560057, India

5. TITLE OF THE INVENTION

AI ORCHESTRATED BIOMANUFACTURING SYSTEM FOR CELLULOSE BASED PACKAGING AND ENERGY VALORIZATION FROM HETEROGENEOUS COW DUNG

6. AUTHORISED REGISTERED PATENT AGENT(S)	IN/PA No.	2856
	Name	Meenu Sharma
	Mobile No.	9953170519
7. ADDRESS FOR SERVICE OF APPLICANT IN INDIA	Name	**MEENU SHARMA**
	Postal Address	Ground Floor, S-456, LGF, Greater Kailash – II, New Delhi – 110048, India
	Telephone No.	NA
	Mobile No.	9953170519
	Fax No.	NA
	E-mail ID	meenusharma345@gmail.com

8. IN CASE OF APPLICATION CLAIMING PRIORITY OF APPLICATION FILED IN CONVENTION COUNTRY, PARTICULARS OF CONVENTION APPLICATION

Country	Application Number	Filing date	Name of the applicant	Title of the invention	IPC (as classified in the convention country)

9. IN CASE OF PCT NATIONAL PHASE APPLICATION, PARTICULARS OF INTERNATIONAL APPLICATION FILED UNDER PATENT CO-OPERATION TREATY(PCT)

International application number	**International filing date**

10. IN CASE OF DIVISIONAL APPLICATION FILED UNDER SECTION 16, PARTICULARS OF ORIGINAL (FIRST) APPLICATION

Original (first) application No.	Date of filing of original (first) application
NIL	NIL

11. IN CASE OF PATENT OF ADDITION FILED UNDER SECTION 54, PARTICULARS OF MAIN APPLICATION OR PATENT

Main application /patent No.	Date of filing of main application
NIL	NIL

12. DECLARATIONS

(i) Declaration by the inventor(s)

(In case the applicant is an assignee: the inventors may sign herein below or the applicant(s) may upload the assignment or enclose the assignment with this application for patent or send the assignment by post /electronic transmission duly authenticated within the prescribed period).

We, the above named inventors are the true & first inventors for this invention and declare that the applicant herein is my assignee or legal representative.

(a) Date:

(b) Signature:

(c) Name: Dr. Dileep Kumar Mohanachandran

(a) Date:

(b) Signature:

(c) Name: Dr. Soumya Ranjan Jena

and

(a) Date:

(b) Signature:

(c) Name: Dr. Normala Subramaniam Govindarajo

(ii) Declaration by the applicant(s) in the convention country

(In case the applicant in India is different than the applicant in the convention country: the applicant in the convention country may sign herein below or applicant in India may upload the assignment from the applicant in the convention country or enclose the said assignment with this application for patent or send the assignment by post /electronic transmission duly authenticated within the prescribed period).

I/We, the applicant(s) in the convention country declare that the applicant(s) herein is/are/my/our assignee or legal representative. **N.A.**

(a) Date

(b) Signature:

(c) Name:

(iii) Declaration by the applicant

We, the applicant hereby declare that: -

☑ We are in possession of the above-mentioned invention.
☑ The complete specification relating to the invention is filed with this application.
☐ ~~The invention as disclosed in the specification uses the biological material from India and the necessary permission from the competent authority shall be submitted by us before the grant of patent to us.~~
☑ There is no lawful ground of objections to the grant of the Patent to us.
☐ ~~We are the true & first inventor.~~
☑ We are the assignee or legal representative of true & first inventors.
☐ ~~The application or each of the applications, particulars of which are given in Paragraph 8, was the first application in convention country in respect of our invention.~~
☐ ~~We claim the priority from the above mentioned application filed in convention Country/Countries and state that no application for protection in respect of the invention had been made in a convention country before that date by us or by any person from which we derive the title.~~
☐ ~~Our application in India is based on international application under Patent Cooperation Treaty (PCT) as mentioned in Paragraph 9.~~
☐ ~~The application is divided out of our application particulars of which are given in Paragraph 10 and pray that this application may be treated as deemed to have been filed on ……under Section 16 of the act.~~
☐ ~~The said invention is an improvement in or modification of the invention particulars of which are given in Paragraph 11.~~

13. FOLLOWING ARE THE ATTACHMENTS WITH THE APPLICATION

(a) Form 2

Item	*Details*	*Fee*	*Remarks*
Complete specification	No. of pages: 18	**1600**	**Including claims, abstract and drawings**
No. of Claims	No. of Claims: 10 and No. of pages: 03		
Abstract	No. of page: 01	-	-
No. of Drawings	No. of drawing: 0 2 and No. of pages: 02	-	-

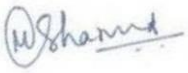
(b) Complete specification along with drawing;
(c) Statement and undertaking on Form 3;
(d) Declaration as to Inventorship on Form 5;
(e) Form 28;
(f) Form 9; and
(g) General Power of Authority.

Total fee INR 1600/- submitted online through electronic portal of State Bank of India.

We hereby declare that to the best of our knowledge, information and belief the fact and matters stated herein are correct and we request that a patent may be granted to us for the said invention.

Dated this 10th day of October, 2025

Name: Meenu Sharma



Signature:
To,
The Controller of Patents,
New Delhi

FORM 28
THE PATENTS ACT, 1970
(39 of 1970)
AND
THE PATENTS RULES, 2003
TO BE SUBMITTED BY A SMALL ENTITY
[See rules 2 (fa), 2(fb), 2(ca) and 7]

We,

a) **SRJX RESEARCH AND INNOVATION LAB LLP**

b) Indian;

c) SRJX RESEARCH AND INNOVATION LAB LLP, Plot No - 3E/474, Sector-9, CDA, Post-Markat Nagar, Cuttack-753014, Odisha, India

applicant in respect of the patent application no._____ dated October 10, 2025 hereby declare that we are a small entity in accordance with rule 2(fa) and submit following document as a proof:

For claiming the status of a small entity: - Evidence of registration under the Micro, Small and Medium Enterprises Act, 2006 (27 of 2006).

The information provided herein is correct to the best of our knowledge and belief.

Dated this 10th day of October, 2025

Meenu Sharma
IN/PA-2856
Agent for the Applicant
SRJX RESEARCH AND INNOVATION LAB LLP

To,
The Controller of Patents,
The Patent Office,
At New Delhi

FORM 9
THE PATENTS ACT,
1970 (39 of 1970)
&
The Patent Rules, 2003
REQUEST FOR PUBLICATION
(See Section 11A (2); rule 24A)

We, **SRJX RESEARCH AND INNOVATION LAB LLP**, Indian, of the address SRJX RESEARCH AND INNOVATION LAB LLP, Plot No - 3E/474, Sector-9, CDA, Post- Markat Nagar, Cuttack-753014, Odisha, India hereby request for early publication of our patent application……dated **October 10, 2025** titled "**AI ORCHESTRATED BIOMANUFACTURING SYSTEM FOR CELLULOSE BASED PACKAGING AND ENERGY VALORIZATION FROM HETEROGENEOUS COW DUNG**" under section 11A(2) of the Act.

Dated this 10th day of October, 2025

MEENU SHARMA
(IN/PA-2856)
Patent Agent for the Applicant
SRJX RESEARCH AND INNOVATION LAB LLP

To,
The Controller of Patents,
The Patent Office,
New Delhi

Signature Not Verified
Digitally Signed.
Name: MEENU SHARMA
Date: 10-Oct-2025 20:32:05
Reason: Patent Efiling
Location: DELHI

सत्यमेव जयते

INDIA NON JUDICIAL

Government of National Capital Territory of Delhi

₹100

e-Stamp

₹100₹100₹100₹100

Certificate No.	:	IN-DL35961746213944X
Certificate Issued Date	:	16-Aug-2025 11:10 AM
Account Reference	:	IMPACC (IV)/ dl962703/ DELHI/ DL-ESD
Unique Doc. Reference	:	SUBIN-DLDL96270305293890128756X
Purchased by	:	SRJX RESEARCH AND INNOVATION LAB LLP
Description of Document	:	Article 48(c) Power of attorney - GPA
Property Description	:	Not Applicable
Consideration Price (Rs.)	:	0 (Zero)
First Party	:	SRJX RESEARCH AND INNOVATION LAB LLP
Second Party	:	ZAINAB SYED AND ASSOCIATES
Stamp Duty Paid By	:	SRJX RESEARCH AND INNOVATION LAB LLP
Stamp Duty Amount(Rs.)	:	100 (One Hundred only)

NOTARY R.V. Singh Advocate Reg. No.2262 Commission Expire On 24-10-2027 Area-Delhi GOVT. OF INDIA

Please write or type below this line IN-DL35961746213944X

NOTARY R.V. Singh Advocate Reg. No.2262 Commission Expire On 24-10-2027 Area-Delhi GOVT. OF INDIA

Statutory Alert:

1. The authenticity of this Stamp certificate should be verified at 'www.shcilestamp.com' or using e-Stamp Mobile App of Stock Holding Any discrepancy in the details on this Certificate and as available on the website / Mobile App renders it invalid.
2. The onus of checking the legitimacy is on the users of the certificate
3. In case of any discrepancy please inform the Competent Authority.

Signature Not Verified
Digitally Signed
Name: MEENU SHARMA
Date: 10-Oct-2025 20:28:21
Reason: Patent Filing
Location: DELHI

FORM-26
The Patents Act, 1970
(39 of 1970)
FORM FOR AUTHORIZATION OF A PATENT AGENT/OR ANY PERSON IN A MATTER OR PROCEEDING UNDER THE ACT
[See Sections 127 and 132; Rule 135]

I, **SRJX RESEARCH AND INNOVATION LAB LLP**, Indian, of the address SRJX RESEARCH AND INNOVATION LAB LLP, Plot No - 3E/474, Sector-9, CDA, Post- Markat Nagar, Cuttack-753014, Odisha, India, hereby authorize **Zainab Syed & Associates** having address 3E, Nawab Bhagwanpora, Lal Bazar, Srinagar, Jammu & Kashmir, 190023, India **(Mobile No.: +91 9748818235, Email: bandyopadhyay.sudarshana@gmail.com)** through **Ms. Sudarshana Bandyopadhyay (IN/PA 2802)** and **Ms. Meenu Sharma (IN/PA-2856),** registered Indian Patent Agents, to act on our behalf and to further appoint attorney(s)/agent(s) in connection with the filing and prosecution of our patent applications for grant of Letters Patent, filing of request for examination, filing request for amendment, recordal of change of name and address, ownership, change of address of service in India, renewal of patent, recordal of assignments, filing and defending oppositions and infringement actions, restoration of patents, registration of documents and such other actions and all proceedings under the Patents Act, 1970 and the Patent Rules, 2003 and all such proceedings before the Patent Office or the Government of India or any Court in India and all acts and things as the said attorney may deem necessary or expedient in connection therewith or incidental thereto.

We further request that all notices, requisitions and communication relating thereto may be sent to such person/s at the corresponding address mentioned below:

Ground Floor, S-456, LGF, Greater Kailash – II, New Delhi – 110048, India,

(Contact No.: +91 9748818235; Email: bandyopadhyay.sudarshana@gmail.com)

We, hereby, revoke all previous authorizations, if any, in respect of the proceedings.

NOTARY
R.V. Singh
Advocate
Reg. No.2282
Commission
Expire On
24-10-2027
Area-Delhi
GOVT. OF INDIA

We, hereby, assent to the action already taken by the said person/s in the above matter.

Dated this **14th day of August, 2025**

SRJX RESEARCH AND INNOVATION LAB LLP
Through:

Signature: Soumya Ranjan Jena

Name: Dr. Soumya Ranjan Jena

Company Seal: SRJX Research and Innovation Lab LLP
LLPIN: ACO-1435

To,
The Controller of Patents,
The Patent Office,
Kolkata

NOTARY
R.V. Singh
Advocate
Reg. No.2282
Commission
Expire On
24-10-2027
Area-Delhi
GOVT. OF INDIA

ATTESTED
Notary Public Delhi

16 AUG 2025

FORM 9
THE PATENTS ACT,
1970 (39 of 1970)
&
The Patent Rules, 2003
REQUEST FOR PUBLICATION
(See Section 11A (2); rule 24A)

We, **SRJX RESEARCH AND INNOVATION LAB LLP**, Indian, of the address SRJX RESEARCH AND INNOVATION LAB LLP, Plot No - 3E/474, Sector-9, CDA, Post- Markat Nagar, Cuttack-753014, Odisha, India hereby request for early publication of our patent application……dated **October 10, 2025** titled "**AI ORCHESTRATED BIOMANUFACTURING SYSTEM FOR CELLULOSE BASED PACKAGING AND ENERGY VALORIZATION FROM HETEROGENEOUS COW DUNG**" under section 11A(2) of the Act.

Dated this 10th day of October, 2025

MEENU SHARMA
(IN/PA-2856)
Patent Agent for the Applicant
SRJX RESEARCH AND INNOVATION LAB LLP

To,
The Controller of Patents,
The Patent Office,
New Delhi

Signature Not Verified
Digitally Signed.
Name: MEENU SHARMA
Date: 10-Oct-2025 19:29:30
Reason: Patent Efiling
Location: DELHI

FORM 3

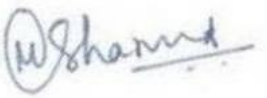
THE PATENTS ACT, 1970
(39 of 1970)
&
THE PATENTS RULES, 2003

STATEMENT AND UNDERTAKING UNDER SECTION 8

(See section 8, rule 12)

Name of the Applicant	We, a) **SRJX RESEARCH AND INNOVATION LAB LLP** b) Indian; c) SRJX RESEARCH AND INNOVATION LAB LLP, Plot No - 3E/474, Sector-9, CDA, Post- Markat Nagar, Cuttack-753014, Odisha, India hereby declare:
Name, address and nationality of the joint applicant.	(i) that we have not made any application for the same / substantially the same invention outside India

Name of the Country	**Date of application**	**Application No.**	**Status of the application**	**Date of publication**	**Date of grant**
NIL	NIL	NIL	NIL	NIL	NIL

Name and address of the assignee	(iii) that the rights in the application have been assigned to: a) **SRJX RESEARCH AND INNOVATION LAB LLP** b) Indian; c) SRJX RESEARCH AND INNOVATION LAB LLP, Plot No - 3E/474, Sector-9, CDA, Post- Markat Nagar, Cuttack-753014, Odisha, India that we undertake that up to the date of grant of the patent by the Controller, we would keep him informed in writing the details regarding corresponding applications for patents filed outside India within six months from the date of filing of such application. **Dated this 10th day of October, 2025**
To be signed by applicant or his authorized registered patent agent.	
Name of the natural person who has signed.	**Meenu Sharma** **(IN/PA-2856)** **Patent Agent for the Applicant**
	To, The Controller of Patents, The Patent Office, at New Delhi

Signature Not Verified

Digitally Signed.
Name: MEENU SHARMA
Date: 10-Oct-2025 20:28:21
Reason: Patent Efiling
Location: DELHI