IIT MADRAS
Indian Institute of Technology Madras

Technology Transfer Office
TTO - IPM Cell

Industrial Consultancy & Sponsored Research (IC&SR)

METHOD FOR PREPARING LUMINESCENT SILICON NANOPARTICLES FROM RICE HUSK USING MICROWAVE IRRADIATION

IITM Technology Available for Licensing

Problem Statement

- Inks based on silicon are used to **print thin silicon films** for semiconductor applications.
- Silicon inks contain **Silicon nano-particles**; which are particularly useful to create stable and solvent compatible suspensions. They are also useful due to their inherent changes in the electronic structure.
- However, production of silicon nano-particles **requires high energy** (ΔH=169.7 kcal/mol at 1900 K) reduction of naturally found SiO_2 to Silicon (Si).
- There is a **need for sustainable manufacturing of silicon inks** as well as silicon nanoparticles for energy efficient and affordable technologies

Intellectual Property

- IITM IDF Ref. **1493**
- **IN 369130- Patent Granted**

TRL (Technology Readiness Level)

TRL - 5: Technology validated in relevant environment

Technology Category/ Market

Category- Micro & Nano Technologies
Industry Classification:

- **NIC (2008)- 10619-** Other grain milling and processing (grain milling residues); **26105-** Manufacture of display components (plasma, polymer, LCD, LED); **26102-** Manufacture of electron tubes, diodes, transistors and related discrete devices
- **NAICS (2022)- 115114-** Postharvest Crop Activities; **335139**- Electric Lamp Bulb and Other Lighting Equipment Manufacturing; **334413-** Semiconductor and Related Device Manufacturing

Applications- LEDs, printable electronics, photovoltaics, biocompatible devices, sensing devices.

Market Drivers-
LED market- Projected to grow from $87.10 billion in 2023 to $298.38 billion by 2030 with a GAGR of 19.2 %; **Photovoltaic market-** valued at $ 96.4 Billion in 2023 and is expected to grow to $ 155 Billion by 2028 with a CAGR of 10.1%

Research Lab

Prof. T Pradeep,
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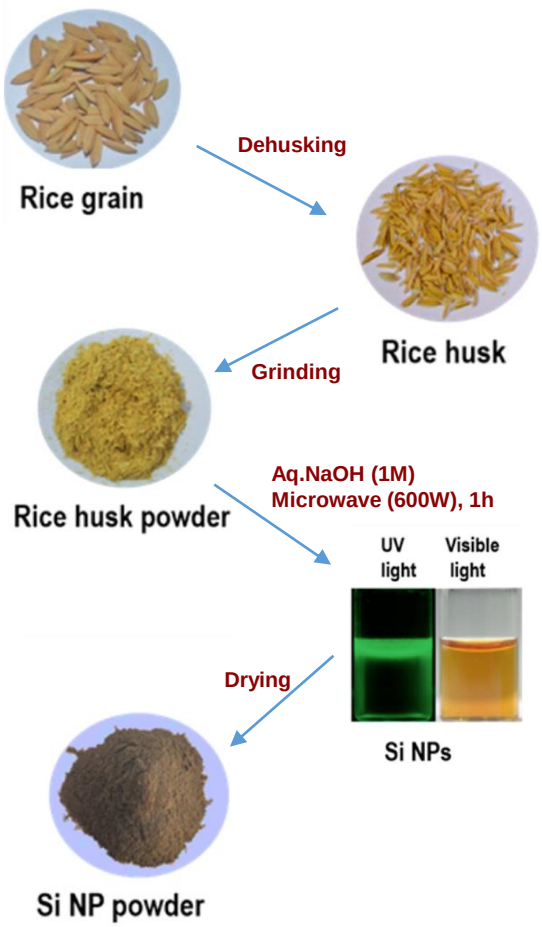

Figure: Procedures involved in the synthesis of green luminescent Si Nano-Particles (NPs)

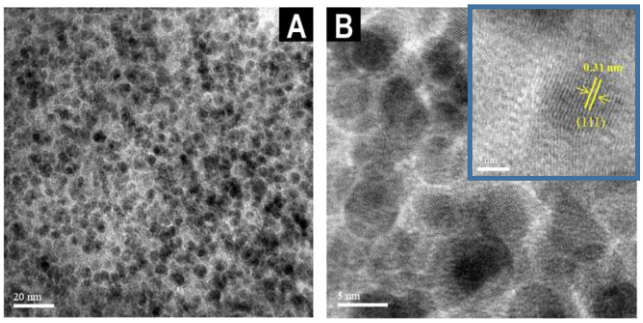

Figure: (A) Large area TEM image of the rice husk synthesized Si NPs (B) HRTEM image of the Si NPs and the inset shows a lattice spacing of 0.31 nm arising from the (111) plane of silicon.

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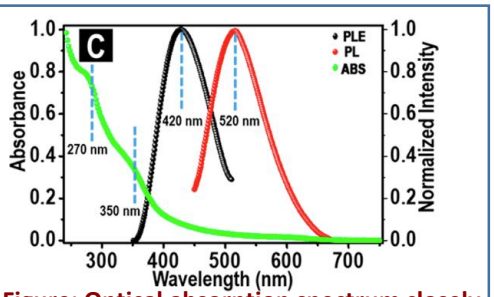

Figure: Optical absorption spectrum closely resembles peaks shown by Si particles in known literature (270 nm and 340 nm)

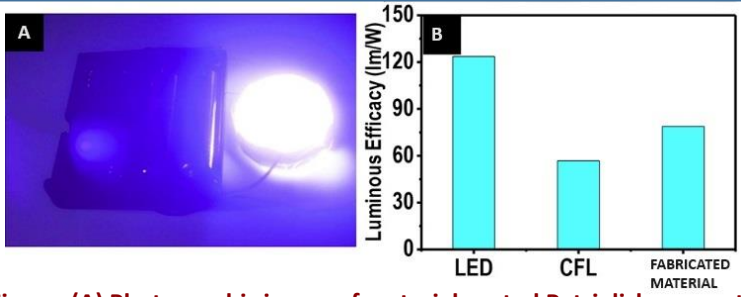

Figure: (A) Photographic image of material coated Petri dish connected to 3 W, 3V UV LED emitting white light (B) Luminous efficacy comparison of the fabricated material with a commercial WLED and CFL

Technology

1. The invention relates to a method of preparing monodisperse, visibly luminescent silicon nanoparticles in solution starting from a widely available and cheap starting material, namely rice husk using microwave irradiation
2. NaOH solution is used to dissolve silica from the rice husk powder. The microwaved rice husk powder yields a brown powder. Water was added to make a suspension and pH was adjusted to get a stable solution.
3. Microwave reduction at a temperature 200 °C results in reduction of Silicon precursors by carbon precursors and enables a controlled growth of silicon which leads to the formation of nanoparticles.
4. Size distribution of the silicon nanoparticles found using Dynamic Light Scattering (DLS) shows an average size of 6.5 nm.
5. Color characteristics of luminescent materials were observed. The materials used for the production of white light were silicon nanoparticles(green), silicon nanoparticles(blue) and Au@BSA cluster (red)

Key Features / Value Proposition

- The silicon particles made using the **sustainable and affordable process** are **stable for extended period** allowing them to be useful for applications.
- These silicon nanoparticles are conjugated with **biocompatible** molecules to enable them useful in biological applications.
- The quantum yield of the silicon nanoparticle is as high as 0.60 which is indicative of the **high brightness and mono dispersity** of the nanoparticles as these particles give size dependent emission properties.
- Compared to its luminescent counterparts such as dyes, quantum dots, silicon nanoparticles have **superior photo stability and lower toxicity**.
- The stability of Si NPs upon changing the pH of the solution allows it to be used for several bio-imaging and sensing applications.

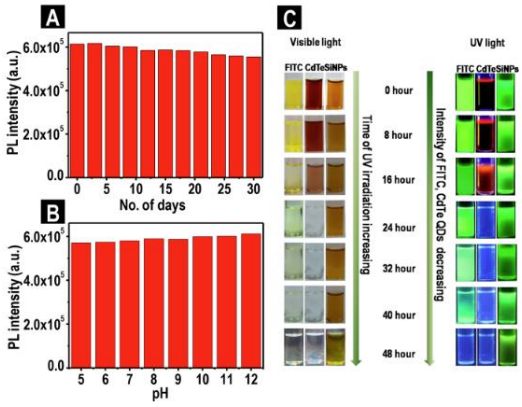

Figure: (A) Variation of Photo Luminescence (PL) intensity of Si NPs as a function of time. (B) Variation of PL intensity as a function of pH. (C) Photo stability comparison and photograph of FITC, CdTe Quantum Dots (QDs), and Si NPs under continuous UV irradiation up to 48 h.

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