NED University of Engineering and Technology

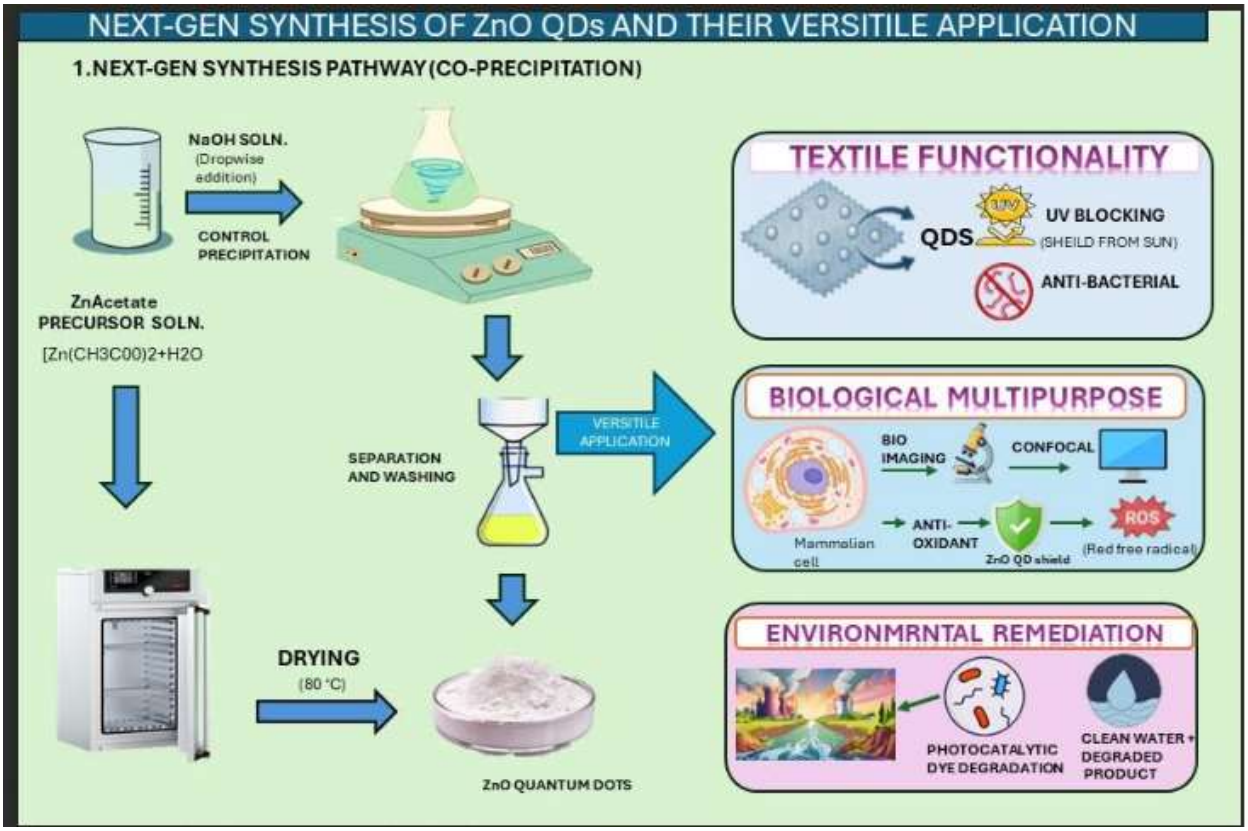
Final Year Design Project Showcase
Batch-2025-26
Year 2025-26

	Department: Chemistry Programme: Chemistry
1	**Project Title** Next-Gen Synthesis of ZnO QDs and their Versatile Applications
2	**Project Idea** Nanomaterial Chemistry and Environmental/Biochemical Applications
3	**Process** Development of an advanced, aqueous co-precipitation strategy to synthesize highly stable, mono-disperse spherical zinc oxide quantum dots (1.8 $\pm$0.2 nm) using a novel organic stabilizer, 2-amino-6-benzoyl-5-hydroxy-4-(4-nitrophenyl)-4H-chromene-3-carbonitrile (BHNC), to overcome rapid aggregation and thermodynamic instability.
4	**Outcome** High-Efficiency Heterogeneous Catalysis: The as-prepared BHNC-stabilized zinc oxide quantum dots serve as a potent catalyst for the rapid degradation and reduction of hazardous industrial dyes (including PNP, Methylene Blue, Congo Red, Rhodamine, Safranine, and Fuchsin). Potent Biological Agents: They also act as effective antioxidant and anti-urease agents for biomedical and pharmaceutical applications. Advanced Functional Textiles: This enables the fabrication of durable, wash-resistant UV-blocking coatings for smart fabrics utilizing the BHNC-stabilized zinc oxide quantum dot matrix
5	**Evidence (Theoretical Basis)** Bare ZnO quantum dots suffer from high surface energy and rapid aggregation, leading to poor size distribution and quantum confinement loss. Passivating particle boundaries with the BHNC organic capping agent suppresses surface energy, controls nanoparticles growth at room temperature, and ensures long-term colloidal stability verified via UV-Vis spectroscopy, AFM, and FTIR.
6	**Competitive Advantage or Unique Selling Proposition** The project directly addresses clean water, environmental protection, and industrial innovation by providing a sustainable, low-cost method to neutralize hazardous industrial waste streams and toxic dyes. Furthermore, it replaces expensive and energy-intensive synthesis methods with a room-temperature co-precipitation route, making eco-friendly UV-blocking textiles and advanced water treatment commercially viable.
a	**Attainment of any SDG** Based on the focus on clean water, environmental protection, and green synthesis protocols for managing heavy industrial dye effluents, the primary United Nations Sustainable Development Goals (SDGs) addressed are: • **SDG 6:** Clean Water and Sanitation *(Ensuring availability and sustainable management of water by reducing pollution and treating wastewater)* • **SDG 9:** Industry, Innovation and Infrastructure *(Promoting sustainable industrialization and fostering green technological innovation)* • **SDG 12:** Responsible Consumption and Production *(Ensuring sustainable production patterns and minimizing chemical waste generation)*

b	**Any Environmental Aspect** **Energy-Efficient Synthesis:** Utilizes a green, room-temperature co-precipitation method that significantly reduces energy consumption compared to conventional, high-temperature manufacturing processes. **Pollution Reduction:** Combines resource-efficient fabrication with high-performance catalytic degradation of organic water pollutants, effectively minimizing industrial chemical footprints and environmental impact.
c	**Cost Reduction of Existing Product** The project significantly reduces production expenses by substituting costly, energy-intensive high-temperature manufacturing routes with a straightforward, room-temperature aqueous co-precipitation method utilizing accessible laboratory reagents like zinc acetate dihydrate and sodium hydroxide. Additionally, the incorporation of the novel BHNC organic stabilizer optimizes the yield and long-term stability of the zinc oxide quantum dots without requiring expensive specialized capping agents or sophisticated vacuum equipment, making large-scale commercialization economically viable for wastewater treatment and functional textile manufacturing.
d	**Process Improvement, which leads to Superior Products or Cost Reduction, Efficiency Improvement of the Whole Process Eliminates the severe aggregation issues of traditional,** **Elimination of Nanoparticle Aggregation:** Traditional un-stabilized nanoparticle fabrication suffers from severe particle agglomeration due to high surface energy, resulting in poor size distribution and loss of quantum confinement performance. This process integrates a precise, reproducible capping agent mechanism using the novel organic stabilizer BHNC, which successfully passivates particle boundaries and prevents clustering during synthesis. **Enhanced Product Homogeneity and Longevity:** The controlled room-temperature aqueous co-precipitation route yields highly mono-disperse spherical zinc oxide quantum dots (1.8 ± 0.2 nm). This structural uniformity significantly improves catalytic longevity and stability when deployed for industrial dye degradation and functional textile coatings. **Operational Efficiency and Cost Optimization:** By bypassing complex, energy-intensive, and high-temperature manufacturing techniques, the streamlined method utilizes simple laboratory equipment and accessible precursors (such as zinc acetate dihydrate and sodium hydroxide). This increases overall process efficiency, ensures high reproducibility, and makes large-scale production economically viable for commercial environmental and textile applications.
e	**Expanding of Market share** (e.g. how it expand and what is the problem with the current market **Market Expansion Strategy:** The project expands market share by replacing conventional, high-cost, and less durable UV-blocking and wastewater treatment agents with highly efficient, eco-friendly BHNC-stabilized zinc oxide quantum dots. **Current Market Limitations:** Existing commercial solutions often suffer from poor durability against repeated water washing in textiles, high energy requirements during synthesis, and limited effectiveness in neutralizing complex industrial dye effluents. **Competitive Edge:** By introducing a low-cost, room-temperature synthesis route that yields mono-disperse quantum dots with dual functionality (catalytic dye degradation and durable UV-protection), the project captures unaddressed segments within the sustainable textile and industrial wastewater management sectors.

f	**Capture New Market** (e.g. Niche market or unaddressed segment) **Capture New Market (Niche/Unaddressed Segment):** The project targets an unaddressed niche market at the intersection of sustainable textiles and advanced environmental remediation by introducing dual-functional BHNC-stabilized zinc oxide quantum dots. **Addressing Unmet Needs:** Traditional commercial sectors generally treat UV-blocking fabric treatments and industrial wastewater dye degradation as entirely separate manufacturing and chemical supply chains. **Commercial Penetration:** By delivering a single, low-cost, room-temperature synthesized nanomaterial that simultaneously provides wash-durable UV protection for smart fabrics and high-efficiency heterogeneous catalysis for complex dye effluents (such as PNP, Methylene Blue, and Congo Red), the project opens up a novel, high-value commercial segment for multifunctional, eco-friendly chemical products.	
g	**Any Other Aspect** Beyond industrial wastewater treatment and smart textiles, the synthesized BHNC-stabilized zinc oxide quantum dots demonstrate potent biological properties, serving effectively as antioxidant and anti-urease agents for pharmaceutical applications.	
7	**Target Market** (Industries, Groups, Individuals, Families, Students, etc) Please provide some detail about the end-user of the product, process, or service **Textile Manufacturing and Apparel Industries:** End-users include textile finishing plants and apparel brands utilizing wash-durable, UV-blocking smart fabric coatings for high-performance consumer clothing and outdoor gear. **Environmental and Wastewater Treatment Sectors:** Municipal and industrial wastewater treatment facilities that require efficient heterogeneous catalysts to neutralize hazardous organic dye effluents (such as PNP, Methylene Blue, Congo Red, Rhodamine, Safranine, and Fuchsin) before discharge. **Biomedical and Pharmaceutical Industries:** Research and development groups utilizing potent antioxidant and anti-urease agents for advanced medical and pharmaceutical applications. **Academic and Scientific Research Institutions:** Chemistry and chemical engineering researchers, laboratories, and universities seeking reliable, low-cost precursors and protocols for synthesizing mono-disperse zinc oxide quantum dots.	
8	**Team Members** (Names along with email address)	**Syed Azaz CY-22014 syedaizazali95@gmail.com** **Muhammad Ali CY-22012 muhalii.2810@gmail.com** **Uzair Ansari CY-22033 uzairansari2243@gmail.com** **Syed Inamullah CY-22044 inamullahj744@gmail.com**
10	**Supervisor Name** (along with email address)	Dr. Rafia Usman Khan. e mail : rkhan@neduet.edu.pk
11	**Video (If any)**	NA

Pictures (to be pasted below


NEXT-GEN SYNTHESIS OF ZnO QDs AND THEIR VERSITILE APPLICATION
1.NEXT-GEN SYNTHESIS PATHWAY(CO-PRECIPITATION)
NaOH SOLN.
(Dropwise addition)
CONTROL PRECIPITATION
ZnAcetate PRECURSOR SOLN.
[Zn(CH3C00)2+H2O
SEPARATION AND WASHING
VERSITILE APPLICATION
DRYING
(80 °C)
ZnO QUANTUM DOTS
TEXTILE FUNCTIONALITY
QDS
UV BLOCKING
(SHEILD FROM SUN)
ANTI-BACTERIAL
BIOLOGICAL MULTIPURPOSE
BIO IMAGING
CONFOCAL
Mammalian cell
ANTI-OXIDANT
ZnO QD shield
ROS
(Red free radical)
ENVIRONMRNTAL REMEDIATION
PHOTOCATALYTIC DYE DEGRADATION
CLEAN WATER + DEGRADED PRODUCT