

Engineering safer ZnO quantum dots for fast-tracking healthcare applications – From lab innovation to pilot scale production

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Zinc oxide quantum dots (ZnO QDs) with a robust defect chemistry play a pivotal role in energy, agriculture, and healthcare. Predominantly, singly ionized oxygen vacancies (VO•) on the ZnO surface contribute to its unique characteristics. Size and concentration control, achieved through precise fabrication techniques, endow QDs with diverse physiochemical, optical, and biological attributes.

While traditional batch synthesis methods prevail, advancements in the past two decades have prompted adaptations to meet the growing demand for high-quality ZnO QDs. This has led to the prominence of environmentally conscious continuous flow synthesis platforms, aiming to bridge the gap between laboratory-scale and pilot-scale production. This study introduces an innovative, sustainable continuous flow synthesis approach for defect-engineered ZnO QDs (E-ZnO), guided by nucleation-growth kinetics in reactor design. The unique geometry and aspect ratio of the reactor induce Dean vortices, optimizing mixing efficiency.

A systematic analysis demonstrates the successful production of monodispersed E-ZnO with a stable hydrodynamic size of 7.6 nm over six months. Notably, E-ZnO exhibits superior photoluminescence quantum yield (PLQY) of 0.89 and sustained photostability, even under 72 hours of UV radiation exposure. Mechanistic evaluations, employing photoluminescence studies and electron paramagnetic resonance spectroscopy (EPR), validate the prolonged stability and absence of VO• quenching over time.

Furthermore, E-ZnO showcases superior bioactivity, particularly in anti-cancer properties against the MCF-7 human breast cancer cell line. The MTT assay reveals a substantial reduction in cell viability with increasing E-ZnO concentration, reaching near-z at 500 μg/mL. Consequently, E-ZnO emerges as a promising candidate for cancer therapy and various healthcare applications, underscoring its versatility and potential across diverse domains.

**Biography**

Dr. Kulkarni obtained his Ph.D. in Materials Science in  1984  from  the [Indian Institute of Technology-Kharagpur](http://www.uiuc.edu/), post-doctoral research in Purdue University  He joined IIT Bombay as a Faculty Member in 1987, and recently superannuated after 35 years’ involvement in Teaching, research and administration. Dr. Kulkarni was awarded prestigious Alexander von Humboldt Research Fellowship. His group has engineered defect ZnO quantum dots for biological applications in general and skin UV protection in particular. Continuous flow process for quantum dot production was designed, developed, fabricated and validated for inexpensive production. Both D –Zno and Nano Ceria for cancer theranostics.