Bionanocatalysts

Bionanocatalysts are a class of catalysts that incorporate biological molecules or entities at the nanoscale for catalyzing various chemical reactions. These catalysts typically exploit the high specificity and efficiency of biological molecules such as enzymes, proteins, or nucleic acids, combined with the unique properties of nanomaterials.

The integration of biological molecules with nanomaterials offers several advantages:

Enhanced Catalytic Activity: The high surface area-to-volume ratio of nanomaterials provides ample sites for catalytic activity, while the biological molecules contribute high specificity and efficiency.

Increased Stability: Biological molecules, when immobilized on nanomaterials, often exhibit enhanced stability against denaturation or degradation, thereby prolonging the catalyst's lifespan.

Tunable Properties: The properties of bionanocatalysts can be fine-tuned by modifying the nanomaterial's characteristics or engineering the biological component, allowing for precise control over catalytic activity and selectivity.

Biocompatibility: Bionanocatalysts are often biocompatible, making them suitable for applications in biotechnology, biomedicine, and environmental remediation.

Green Chemistry: Many bionanocatalysts operate under mild reaction conditions, reducing energy consumption and minimizing the generation of hazardous byproducts, thus aligning with the principles of green chemistry.

Applications of bionanocatalysts span various fields, including organic synthesis, pharmaceuticals, environmental remediation, and energy conversion. For instance, they are employed in the synthesis of fine chemicals, production of biofuels, degradation of pollutants, and design of biosensors.

However, challenges such as scalability, reproducibility, and cost-effectiveness still need to be addressed to realize the full potential of bionanocatalysts for industrial applications. Nonetheless, ongoing research and advancements in nanotechnology and biotechnology continue to drive progress in this field.

Bionanocatalysts for glioblastoma

Catalytic Nanomedicine has achieved important advances in developing bionanocatalysts, brain-tissue-biocompatible catalytic nanostructures capable of destabilizing the genetic material of malignant cells, causing their apoptosis. Previous work has demonstrated the efficacy of bionanocatalysts and their selectivity for cancer cells without affecting surrounding healthy tissue cells.

A review provides a detailed description of these nanoparticles and their potential mechanisms of action as antineoplastic agents, covering the most recent research and hypotheses from their incorporation into the tumor bed, internalization via endocytosis, specific chemotaxis by mitochondrial and nuclear genetic material, and activation of programmed cell death. In addition, a case report of a patient with GBM treated with the bionanocatalysts following tumor removal surgery is described. Finally, the gaps in knowledge that must be bridged before the clinical translation of these compounds with such a promising future are detailed [1)]

Recent cutting-edge research has unveiled bionanocatalysts with 1% Pt (platinum), demonstrating unparalleled selectivity in cleaving C-C, C-N, and C-O bonds within DNA in malignant cells. The application of these nanoparticles has yielded promising outcomes.

The objective of a study was to employ bionanocatalysts for the treatment of Glioblastoma (GBM) in a patient, followed by the evaluation of obtained tissues through electronic microscopy.

Bionanocatalysts were synthesized using established protocols. These catalysts were then surgically implanted into the GBM tissue through stereotaxic procedures. Subsequently, tissue samples were extracted from the patient and meticulously examined using Scanning Electron Microscopy (SEM).

Detailed examination of biopsies via SEM unveiled a complex network of small capillaries branching from a central vessel, accompanied by a significant presence of solid carbonate formations. Remarkably, the patient subjected to this innovative approach exhibited a three-year extension in survival, highlighting the potential efficacy of bionanocatalysts in combating GBM and its metastases.

Bionanocatalysts demonstrate promise as a viable treatment option for severe cases of GBM. Additionally, the identification of solid calcium carbonate formations may serve as a diagnostic marker not only for GBM but also for other CNS pathologies [2)].

1)
López-Goerne T, Padilla-Godínez FJ. Catalytic Nanomedicine as a Therapeutic Approach to Brain Tumors: Main Hypotheses for Mechanisms of Action. Nanomaterials (Basel). 2023 May 4;13(9):1541. doi: 10.3390/nano13091541. PMID: 37177086; PMCID: PMC10180296.
2)
López-Goerne T, Arellano A, Padilla-Godínez FJ, Magaña C, González-Bondani A, Valiente R. Solid CaCO3 Formation in Glioblastoma Multiforme and its Treatment with Ultra-Nanoparticulated NPt-Bionanocatalysts. Curr Cancer Drug Targets. 2024 Mar 28. doi: 10.2174/0115680096289012240311023133. Epub ahead of print. PMID: 38561623.