

# Theranostic Applications in Breast Cancer

## 1. Introduction

Breast cancer is the most common malignancy among women worldwide and remains a major cause of morbidity and mortality. Despite significant advances in diagnosis and treatment, challenges persist due to tumor heterogeneity, late-stage diagnosis, and resistance to therapy. Traditional methods often require separate steps for diagnosis and treatment, resulting in delays and less effective care.

Theranostics, a portmanteau of "therapy" and "diagnostics," represents a paradigm shift in personalized cancer care. It integrates diagnostic imaging and targeted therapy into a single platform, enabling real-time monitoring of therapeutic response and enhancing treatment precision. Theranostic systems can significantly improve outcomes by allowing early detection, targeted drug delivery, reduction in systemic toxicity, and adaptation of therapy based on real-time feedback.

This research proposes the development and evaluation of multifunctional theranostic agents for breast cancer using nanotechnology, molecular imaging, and targeted therapies to enable personalized management of the disease.

## 2. Research Objectives

- To design and synthesize multifunctional nanoplateforms for simultaneous imaging and therapy of breast cancer.
- To functionalize nanoparticles with ligands specific to breast cancer biomarkers (e.g., HER2, ER, PR).
- To evaluate in vitro and in vivo diagnostic efficacy using imaging modalities such as MRI, PET, or fluorescence imaging.
- To assess therapeutic efficacy through targeted delivery of chemotherapeutic or photothermal agents.
- To analyze the pharmacokinetics, biodistribution, and biocompatibility of developed theranostic agents.

## 3. Problem Identification

- Late Diagnosis and Poor Prognosis
- Lack of Integration Between Diagnosis and Therapy
- Resistance to Standard Treatments:
- Inefficient Drug Delivery Systems:
- Inadequate Real-Time Monitoring of Treatment Response:

#### **4. Literature Review Summary**

Theranostics in Breast Cancer. *Frontiers in Nuclear Medicine*, 2023. This review provides an overview of promising current and future theranostic approaches in breast cancer, discussing pre-clinical and clinical data on successful targets like HER2, GRPR, PSMA, and CXCR-4.

Nanotheranostics in Breast Cancer Bone Metastasis, *Pharmaceutics*, 2024. This article reviews recent advancements in nanodrug delivery systems for breast cancer bone metastasis, exploring innovative applications and future directions in nanotheranostics.

Recent Advancements in Nanoconstructs for the Theranostics of Triple-Negative Breast Cancer, *Comptes Rendus Chimie*, 2024. This review discusses types and subtypes of TNBC, challenges with standard therapies, mechanisms of drug resistance, and highlights recent advancements in nanoconstructs for theranostic applications.

Current Status of Cancer Nanotheranostics: Emerging Strategies for Targeted Therapy and Imaging, *Frontiers in Molecular Biosciences*, 2023. This review focuses on various agents currently being studied as cancer theranostics, including redox-sensitive micelles targeting the tumor microenvironment.

Nanotechnology-Based Drug Delivery for Breast Cancer Treatment, *Nano Today*, 2025. This article discusses recent developments in nanotechnology-based drug delivery systems for breast cancer treatment, including manganese-based hypericin-loaded polyester dendrimer nanoparticles as theranostic nanoplatfoms.

#### **5. Expected Outcomes**

- A novel platform capable of targeted diagnosis and therapy of breast cancer.
- Improved imaging contrast and accuracy in identifying breast tumors.