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Cancer theranostic applications of lipid-based nanoparticles

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Highlights

- LNPs can be doped with multiple components for theranostics.
- LNPs allow versatile multimodal imaging and therapy of cancer.
- LNPs empower image-guided drug targeting.
- Feasibility of multifunctional LNPs in scale-up manufacturing must be considered.

Abstract

A variety of nanoplatforms have been developed and applied for cancer therapy, imaging, or the combination thereof. These nanoplatforms, combined with therapeutic and imaging functionalities, display great potential to enhance medical care. In particular, lipid-based nanoparticles (LNPs) are among the most-studied platforms that have resulted in many encouraging advances in theranostics. LNPs are biodegradable and biocompatible, and their formulation can be tailored for various applications. Here, we provide an overview of recent developments of four representative LNP platforms for theranostics: stealth liposomes, triggered-release liposomes, porphysomes, and lipid-coated calcium phosphate NPs (LCPs). We discuss their potential, limitations, and potential applications for cancer care and highlight perspectives and future directions for the nanotheranostics field.

Keywords: **lipid-based nanoparticles; nanotheranostics; image-guided drug delivery; cancer; personalized medicine**

Introduction

Cancer is the second leading cause of death around the world, accounting for 8.8 million deaths in 2015 [1]. Early detection, precise diagnosis, and effective treatment of cancer are key to improving the cure rate of this disease. Current treatments face challenges including the ineffectiveness of drug treatments and lack of reliable diagnostic and monitoring techniques. Ineffective treatment can be attributed to poor drug delivery, development of drug resistance, and significant adverse effects. 'Nanotheranostics' refers to a new class of breakthroughs, capable of simultaneously providing diagnosis and therapy to patients through nanotechnologies. Most chemotherapeutic or imaging agents exhibit a low molecular weight that cannot be effectively retained in blood circulation, and are characterized by a narrow therapeutic index because of the lack of specificity [2,3]. These drawbacks greatly compromise their therapeutic efficacy [4]. Therefore, a variety of nanoplatforms have been developed to target small-molecule drugs for enhanced therapy in cancer and autoimmune diseases [5,6]. In general, NPs (<200 nm) selectively extravasate and accumulate in cancerous regions via the enhanced permeability and retention (EPR) effect [7]. This occurs because tumor tissues often exhibit leaky vasculature and poor lymphatic drainage [8]. Given that multiple agents can be incorporated into a single NP, many of these nanoplatform systems have been further optimized for the co-delivery of a therapeutic drug and an imaging agent to simultaneously perform treatment and disease NPs and report therapeutic outcomes.

Among these theranostic nanoplatforms, LNPs are the most extensively studied, with many encouraging results (Figure 1). Here, we focus on recent progress over the past 5 years in lipid-based nanotheranostics. For other types of

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