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Review article

Microfluidics as a cutting-edge technique for drug delivery applications

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ABSTRACT

The need for new and more advanced drug delivery systems (DDS) is currently in demand for efficient delivery of the therapeutics to the desirable tissues/cells, improved drug formulations, and industrial scale production. The newly developed drugs often present poor biopharmaceutical properties, therefore suffering from poor patient compliance, as well as deleterious side effects. Emulsion-based formulations gained attention as potential DDS for the delivery of single or combined small drug molecules with different physicochemical properties. However, the conventional fabrication methods often yield heterogeneous drug formulations. The microfluidics technique offers several advantages over conventional methods for the synthesis of DDS. The highly monodisperse droplets obtained with this technique are useful templates in the preparation of several DDS, such as microcapsules, microspheres, polymersomes, and liposomes. In this review, we will discuss and provide an overview of the microfluidics techniques based on glass capillary as a tool for the fabrication of advanced DDS. In particular, we will focus on the production of droplet-based systems by single, double, and multiple emulsion microfluidic techniques. Finally, the future prospects and potentials of the microfluidics technique are also elucidated.

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1. Introduction

Tremendous technological progresses in the biomedical field have been continuously emerging in recent years, mainly as a consequence of the noteworthy advancements in diverse areas, such as electronics, biological and material sciences, physics, chemistry and nanotechnology [1,2]. In particular, the development of miniaturized systems to replace or overcome the disadvantages of conventional macrosized systems is under continuous research for different applications in the biomedical field, one of them being the fabrication of novel drug delivery systems (DDS) [3].

In the last years, researchers have been working in the

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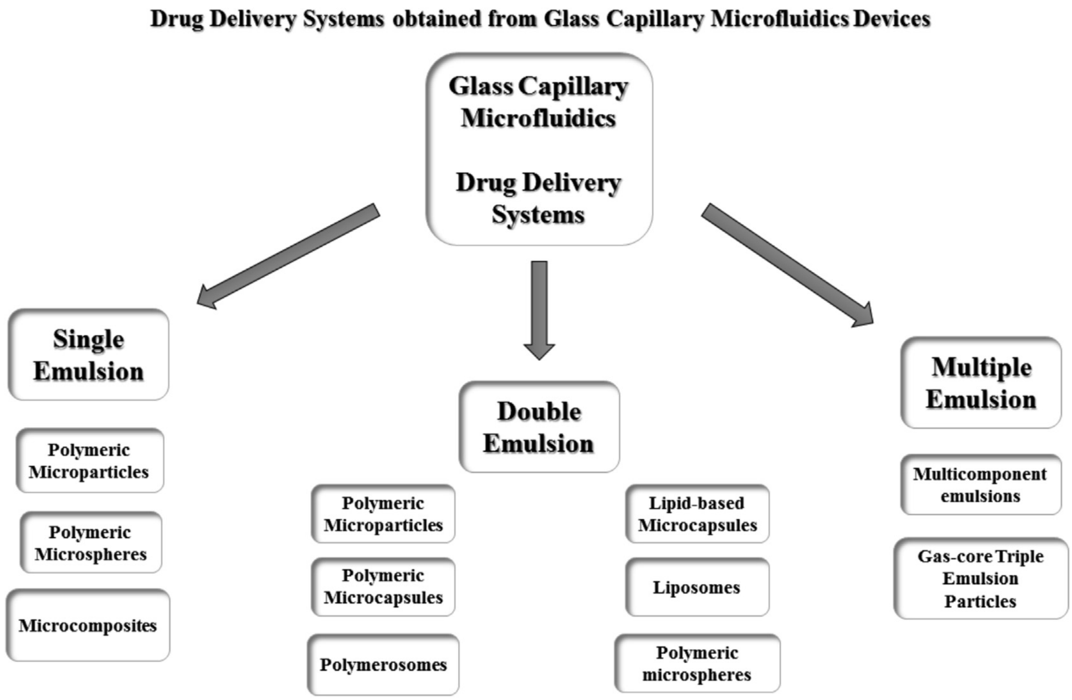

Fig. 1. Overview of the microfluidic-based techniques used to prepare advanced DDS presented and discussed in this review.

development of "smart" drug formulations, with the aim of strategically deliver therapeutics to the disease sites in a controllable and targeted manner, in order to improve the drug's therapeutic effectiveness [4]. The increasing efforts to develop more advanced DDS bring along several advantages, such as lower adverse effects of the administered drugs, by prolonging the release at a lower systemic dosage, by targeting the drugs to the desired cells, as well as by increasing the solubility of poorly water-soluble drugs. These advantages ultimately will lead to a decrease in the treatment costs, due to a higher efficacy of the drugs and lower drug dosage needed, improving the patient's compliance by reducing the drug's administration frequency and decreasing its potential side effects [5].

Among the diverse existent DDS, emulsion-based formulations gained particular attention as potential DDS for the delivery of poorly water-soluble molecules, which are nowadays a big part of the newly developed chemical entities with potential biomedical relevance [6,7]. The versatility of an emulsion system translates into an adaptable integration of a variety of functional materials in the aqueous and organic phases, resulting into microsized droplets that are able to carry and deliver more efficiently different cargos, bringing along potential economic impacts in drug development

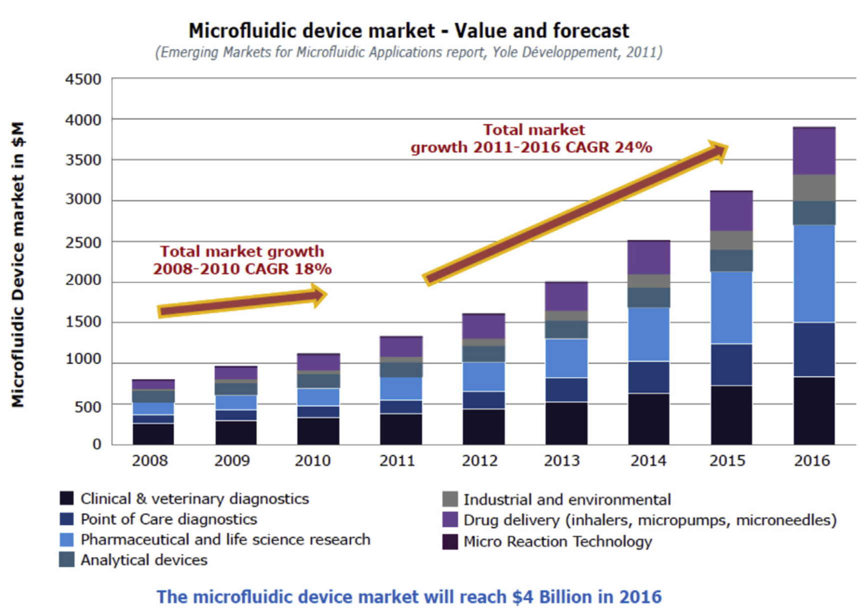

Fig. 2. Microfluidic device market – value and forecast. Reprinted from ref. [11].