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Potential integration of osmotic pumps and magnetic nanoparticles in the development of novel drug delivery systems

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Noncommunicable diseases (NCDs) are long-term conditions influenced by a variety of genetic, physiological, environmental and behavioural factors. NCD-related deaths have surged to approximately 40 million annually, accounting for 74% of all deaths worldwide, especially in low-income countries. This health crisis underlines the necessity to overcome the limitations of conventional drug delivery systems, as they are unable to effectively regulate the release of drugs at the target site, resulting in suboptimal drug concentrations in bloodstream and, consequently, treatment inefficacy and potential adverse effects. In contrast, controlled drug delivery systems, such as osmotic pumps, offer significant advantages, including zero-order kinetics and predictable drug release independent of external factors. Since osmotic pumps are based on the osmosis phenomenon, the selection of high osmolality draw solutions (DS) and the regeneration stage is critical for the viability of the drug delivery process. Conventional DS exhibit several disadvantages as the difficulty of regeneration and concentration polarization phenomena. Recently, functionalized magnetic nanoparticles (MNPs) have received particular attention over traditional DS due to several advantages: (i) high water flux, (ii) low energy requirements, (iii) biocompatibility, (iv) high surface area/volume ratio, (v) low toxicity, (vi) easy recovery due to superparamagnetic behaviour, and (vii) potential for reuse. Despite the promising potential, the integration of MNPs and osmotic pump-based drug delivery systems has not been explored yet. This combination could offer a number of attractive advantages, including: (i) design of external and implanted medical devices, (ii) controlled and constant drug delivery, (iii) elimination of the need for batteries, (iv) reduced dosing frequency and medical interventions, (v) simultaneous drug delivery, and (vi) device reusability of the device after its lifetime. Therefore, this proposed drug delivery system holds immense potential for developing novel controlled drug delivery devices with exceptional properties. By harnessing this technology, it could be possible to create affordable NCD treatments, particularly benefiting low-income countries, representing a significant step towards the achievement of the Sustainable Development Goals 3 “Good health and well-being” and 10 “Reduced inequalities” included in the 2030 Agenda.

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