ABSTRACT

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Silica-based nanomaterials: design and optimization of in-batch and in-flow processes

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Among the variety of nanomaterials, silica-based nanoparticles (SiO_2 NPs) are promising delivery systems for biomedical applications. To date, conventional NPs syntheses hinder the potential translation of nanocarriers into clinical applications mainly due to low batch-to-batch reproducibility and limited scalability. Microfluidics has emerged as a potential tool for the in-flow production of NPs, providing platforms for highly reproducible syntheses. The aim of the present work is the design of inorganic nanomaterials, i.e., mesoporous bioactive glass (MBG NPs) and SiO_2 NPs, through the optimization of in-batch and in-flow syntheses. In the first case, MBG NPs were synthesized via traditional sol-gel reaction based on a hydrothermal approach. Meanwhile, the in- flow synthesis was performed in a microfluidic chip, which was conceived as sol-gel reaction device. The resulting MBG and SiO_2 nanomaterials were physically characterized in terms of size, polydispersity index and morphology through dynamic light scattering (DLS), transmission electron microscopy (TEM) and scanning electron microscopy (SEM). The obtained MBG NPs showed a size distribution below 200 nm, with good polydispersity index (PDI=0.2), and the presence of a porous structure, which is a desirable feature for nanomaterials in clinical and biomedical applications. In contrast, the in-flow SiO_2 NPs were found to be of a larger dimension (size>μm) but with a narrower size distribution and with a smooth shape. In conclusion, the tested processes ensured the production of silica-based nanomaterials with favorable characteristics, in terms of size and PDI. Moreover, the microfluidic approach has demonstrated great potential due to its ease of control and versatility in the implementation of different synthesis conditions, which give great expectations for its future development as one of the leading technologies in the production of bio-nanomaterials.