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Porous silica-coated magnetic nanoparticles for molecular diagnostics of virus infection

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Magnetic separation is one of the most efficient and rapid methods currently used for nucleic acid isolation and was used during the COVID-19 pandemic. Magnetic nanoparticles can easily separate viral RNA and DNA from complex clinical samples without the need for centrifugation steps and laborious traditional organic extraction or column separation techniques. Using an external magnetic field, nucleic acids are easily separated and recovered after binding to magnetic nanoparticles. Silica-coated MNPs are widely used to extract biological molecules, including nucleic acids. To increase the yield of nucleic acid separation, MNPs are functionalised by covalently binding various ligands and polymers to their surface, such as amines, aldehydes, polyacrylic acid or APTES (3-aminopropyltriethoxysilane).
At the beginning of the pandemic in 2019, there was a severe shortage of many reagents and consumables, especially RNA isolation kits, required for testing for SARS-CoV-2, due to high demand worldwide. Here, we describe the synthetic procedures for the surface functionalisation of the magnetic core of magnetic nanoparticles to assess their efficacy in isolating viral RNA in diagnostic RT-qPCR. The core is iron oxide Fe3O4 and the shell is a porous layer of silica. The nanoparticle beads were characterised by HRTEM, SEM, FT-IR, XRD and magnetic measurements. The quality of the prepared nanoparticles was verified by isolation of viral RNA from tissue samples infected with hepatitis E virus - HEV and from biofluid samples from SARS-CoV-2 positive patients. The efficiency of RNA isolation was quantified by RT-qPCR. Our results clearly indicate the organisation of a mesoporous structure on the nanoparticle surface. Due to the pores, the specific surface area SBET of amorphous silica has increased to the order of magnitude comparable to the regular mesoporous structures SBA-15 or SBA-16. The potential benefit of this modification is straightforward. The increased surface area provides more silane groups available to bind RNA, improving the efficiency of the particles.

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