On-Demand Release of Drug from Magnetic Nanoparticle-Loaded Alginate Beads

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Magnetic nanoparticles are of great interest for targeted delivery and controlled release of drugs because of their action-at-a-distance behavior with an applied magnetic field. In our research, superparamagnetic Fe3O4 nanoparticles with an average diameter of 10 nm were successfully synthesized via a simple coprecipitation process. The magnetic nanoparticles were then loaded with berberine as a drug model in alginate beads as drug carriers for controlled drug release application. Our investigation found that an on-demand drug release via on-off operation of a static magnetic field could be achieved. It was observed that the ‘on’ cycle of the static magnetic field reduced the amount of drug released approximately ten times in comparison with the amount of drug released during the ‘off’ cycle. We suggested that the static magnetic field magnetized the Fe3O4 nanoparticles and subsequently generated magnetic force which induced the nanoparticles to aggregate instantly, leading to a rapid decrease in porosity of the alginate beads. The drug molecules were, therefore, restrictedly confined within the beads, causing a significant reduction in the diffusion of the drug to the surrounding environment. By removing the static magnetic field, the magnetic nanoparticles inside the beads were subjected to zero magnetization due to their superparamagnetic properties. Without the magnetic force, the beads swelled and then allowed the drug molecules to diffuse outward of the beads at a relatively higher rate. The on-off operation of a static magnetic field exhibited an interesting approach to control the release of drugs for better treatment efficiency and fewer side effects.