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Improved Magneto-Microfluidic Separation of Nanoparticles through Formation of the β-Cyclodextrin−Curcumin Inclusion Complex

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Molecular adsorption to the nanoparticle surface may switch the colloidal interactions from repulsive to attractive and promote nanoparticle agglomeration. If the nanoparticles are magnetic, then their agglomerates exhibit a much stronger response to external magnetic fields than individual nanoparticles. Coupling between adsorption, agglomeration, and magnetism allows a synergy between the high specific area of nanoparticles (∼100 m2/g) and their easy guidance or separation by magnetic fields. This yet poorly explored concept is believed to overcome severe restrictions for several biomedical applications of magnetic nanoparticles related to their poor magnetic remote control. In this presentation, we test this concept using curcumin (CUR) binding (adsorption) to β-cyclodextrin (βCD)-coated iron oxide nanoparticles (IONP). CUR adsorption is governed by host−guest hydrophobic interactions with βCD through the formation of 1:1 and, possibly, 2:1 βCD:CUR inclusion complexes on the IONP surface. A 2:1 stoichiometry is supposed to promote IONP primary agglomeration, facilitating the formation of the secondary needle-like agglomerates under external magnetic fields and their magneto-microfluidic separation. The efficiency of these field-induced processes increases with CUR concentration and βCD surface density, while their relatively short timescale (<5 min) is compatible with magnetic drug delivery application.

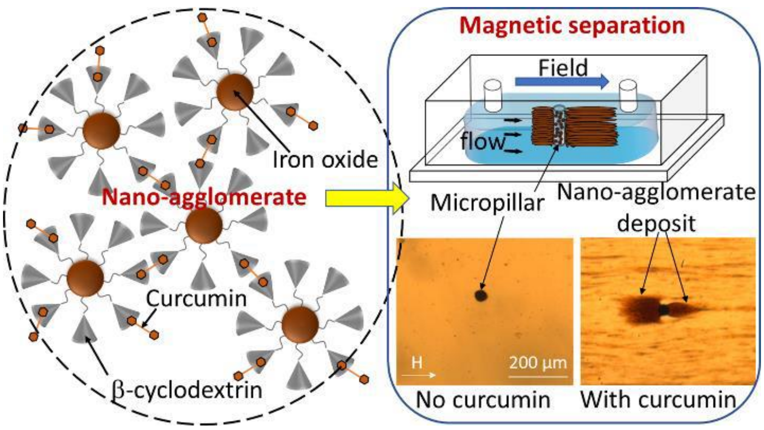

Fig. Mechanism of primary agglomeration of βCD-coated IONP through the formation of a 2:1 βCD:CUR inclusion complex. The addition of CUR to the nanoparticle solution is expected to promote both 1:1 and 2:1 βCD:CUR inclusion complexes on the IONP surface with sketch and results of the experimental setup with microfluidic channel (represented in an enlarged scale) with a micropillar used for the magnetic separation when the field-induced aggregates accumulate around the magnetized micropillar and are separated from the suspending liquid under flow.