Creation of recirculation micro-currents by vector magnetic microswimmers

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During an ischemic stroke, blood clots form which blocks the cerebral blood flow, preventing the supply of oxygen to areas of the brain that depends on the replaced vessels through angiogenesis. The success of the effective treatment in the first hours after the accident depends entirely on the effectiveness of delivery of the active principle (tissue plasminogen activator t-PA) allowing the clots to dissolve as quickly as possible. Intravenous or intraarterial administration of the active ingredient does not allow rapid diffusion of the drug to the clot due to stagnation of blood in the clogged vessels. The use of magnetic iron oxide nanoparticles can be very effective in accelerating drug transport even in completely clogged vessels. The idea consists in rotating magnetic nanoparticles (advantage of elongated shape) by an oscillating magnetic field applied via electric coils placed outside near the affected area. Nowadays, iron oxide nanoparticles are commonly used as a contrast agent in magnetic resonance imaging (MRI) and are not found to be dangerous to the human body.

We study the aggregation under rotating fields of individual magnetic nanoparticles self-assembled into elongated micron-sized aggregates whose final length is inversely proportional to the square root of the field frequency.

The synchronous rotation of the aggregates with the field is essential to generate macroscopic recirculating flow in a closed microfluidic channel with a characteristic speed on the order of 10µm/s in the presence of a weak magnetic field gradient[1]. The created flow has been shown to considerably enhance the dissolution of a sodium alginate bead placed into the microfluidic channel thanks to accelerated convection of the dissolution agent (sodium citrate). These results constitute a physical ground for further research on clot lysis in a real biological environment.