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Chemical Swarm Robots: Design, Synthesis and Functionality

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Most currently produced pharmaceutical formulations are based on a single molecular entity – the active pharmaceutical ingredient (API) – that is synthesised in a dedicated (bio)chemical plant and then has to be stable throughout the supply chain all the way to the patient. However, many pathogens that the API is supposed to fight use a different strategy: they produce toxins locally within the host and the timing, quantity and even composition of the toxins can vary from host to host and depending on local conditions.

The aim of our work is to design and synthesise structured microparticles called chemical robots that are inspired by the structure and function of single-cell organisms. A chemical robot consists of an outer semi-permeable shell and several internal separate compartments able to store and release chemical reagents on demand. A predefined set of chemical or enzymatic reactions take place within the body of the chemical robot and the reaction product is released to the outside environment at a predefined rate. The chemical robot can therefore be thought of as a miniature chemical reactor with internal supply of reactants and a mechanism for triggering their release.

The synthesis of chemical robots follows a bottom-up strategy. In the first step, the internal compartments (either based on liposomes or on hollow mesoporous silica particles) are synthesised and pre-filled with the required reagents. Compartments containing different reagents are then mixed in a colloidal suspension called “roboplasma” (like cytoplasm), which is then encapsulated into the external membrane by means of either inkjet printing technology [1] or interfacial polymerisation [2]. Finally, the outer surface of the chemical robots can be functionalised by attaching the desired functional groups e.g. for specific ligand-receptor binding. In this presentation the current status of chemical robot synthesis and functionality will be reviewed and some challenges for further research in this area will be outlined.

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