Title: *Microfluidic methods for creation of emulsions and new materials*

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Abstract

Over the last few decades, miniaturization was one of the more important goals in the development of analytical techniques of both chemical and biological nature. The interest in this aspect roots in the prospects for benefits that come with minimization of the amount of reagents and therefore the reduction of the waste products. The ability of microfluidic systems to handle small volumes of fluid controllably, especially when combined with versatile vistas of precise detection of the outcomes of reactions creates a potential for new sophisticated applications and for reduction of the cost of existing assays.

In the diversity of studies on microfluidic systems within the last 20 years, a considerable interest has been dedicated to microfluidic techniques that rely on biphasic flow. This interest resulted in a wide range of applications of emulsion generators for both: i) screening analyses (where single droplets serve as a individual micro reactors), which is particularly useful in microbiology, biochemistry as well as diagnostics, and ii) preparative purposes.

Production of polymeric capsules and gel microparticles of well defined size and content is pertinent when it comes to potential use in pharmaceutical, cosmetic or food industries. Such entities might be successfully employed as carriers of active substances.

There is a variety of simple microfluidic generators of emulsions that have been introduced to systems devoted to high throughput production of polymeric particles. The state of art, however, did not present a solution to the challenge of constructing a system capable of simultaneous formation of numerous streams of uniform droplets and controlling a strictly defined spectrum of their chemical content. Preparation of polymeric carriers in the manner presented in this thesis may be as fast as is generation of simple droplets, and at the same time offers the opportunity of generation of streams differing in content, which, in turn, might become useful in controlling the profile of slow release of entrapped active substances.

The present thesis is based on a set of experiments covering design, fabrication and precise analysis of operation of microfluidic systems dedicated to simultaneous generation of a well defined number of streams of droplets each of which corresponds to a different predetermined concentration of input soluble sub-streams. The thesis includes also the description of the process of optimization of the bonding procedure used in fabrication of the microfluidic systems, and characterization of the working range of the systems dedicated to generation of micro-droplets with varied chemical content. An important aspect of the thesis is the characterization of the influence of

viscosities of liquids and of the details of the order of delivery of these liquids to the microfluidic junction on the process of generation of droplets and on the fidelity of operation of the system, including the preservation of the requested gradation of the content of the drops. Additionally, the thesis contains an exemplary practical application of the proposed systems in formation of microgels of polysaccharide blends enriched with a model active substance (gold nanoparticles), under strict control of the droplet size, and further the investigation of the influence of the 'alginate to pectin' proportion on the rates of release of the nanoparticles.

The introduction explains both the variety as well as the versatility of microfluidic systems. Then I proceed to presentation of a set of experiments dedicated to development of a tool that supports a high throughput of manufacturing of monodisperse microdroplets of varied chemical content. Finally, I introduce the application of one of such systems to the production of hydrogel microparticles enabling prolonged release of the encapsulated model active substance.