A Practical Microfluidic Device for Synthesis of Purified Monodisperse Micro-Alginate Beads (MABs) as Microcarriers of Gold Nanoparticles.

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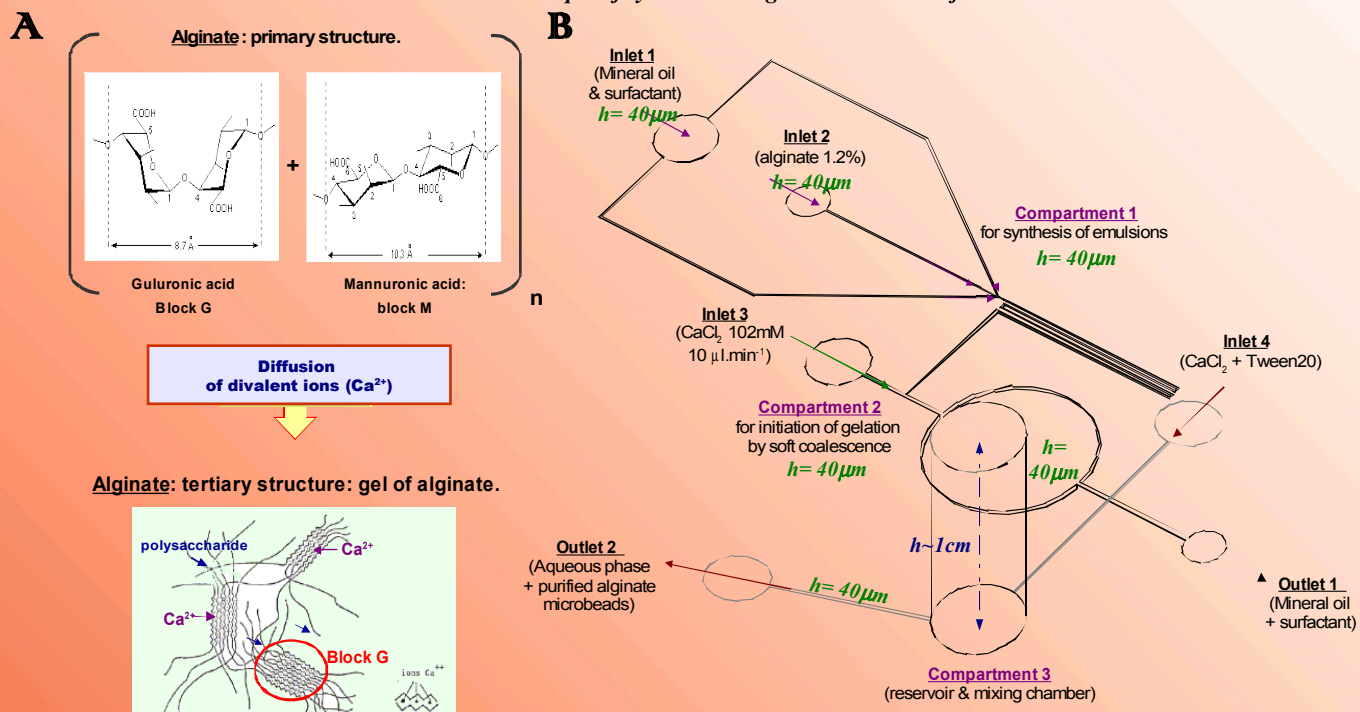
1. Abstract:

Size-controlled small complex gel beads are desired for wide-spread applications in the field of medical engineering and drug delivery. Therefore, we developed a novel microfluidic device that perform the 'lab-on-chip' for encapsulating gold nanoparticles in Micro-Alginate Beads (MABs). The proposed device is three platforms in one. Compartment 1 is dedicated to synthesis of oil-alginate emulsions. Compartment 2 is designed to initiate polymerization by coalescence. Compartment 3 is a mixing/reservoir compartment to complete polymerization, wash and collect purified MABs and the "oil-surfactant" phase from the bottom and the top outlet ports, respectively. The size and the gap of monodisperse alginate droplets were successfully controlled by adjusting the relative "oil phase/sample" flow rate ratio in compartment 1. Coalescence of the droplets was successfully realized without clogging the system. Droplets containing gold nanoparticles react with calcium ion at the interface between oil phase and aqueous phase so that microbeads precipitate spontaneously from the bottom of oil to the bottom of compartment 3 and undergo complete gelation. After 3 washes by gentle mixing in compartment 3, purified microcarriers with predictable sizes were successfully collected from the outlet port of the bottom stage of the device and observed by fluorescence microscopy.

2. Design & principle of the microfluidic PDMS device:

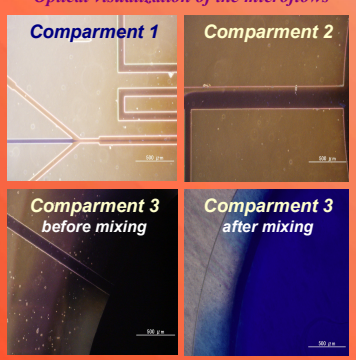
Schematic drawing of the microfluidic device & principle of production of MABs.
A: Chemical reaction. B: Principle of synthesis using the PDMS microfluidic device.



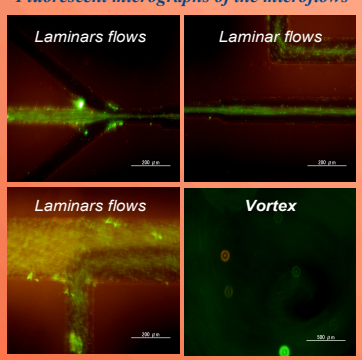
3. Performances: visualization of the microflows & MAB synthesis accuracy:

Visual observation of the microflows

Optical visualization of the microflows



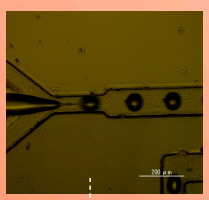
Fluorescent micrographs of the microflows



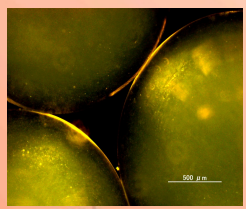
Accurate microflows (laminar flows & vortex) have been observed without any problem of pressure and backward flows from comparment 3 to compartment 1.

Oil-alginate emulsion & visual observation of purified MABs

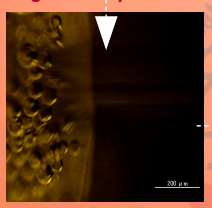
Monodisperse emulsions



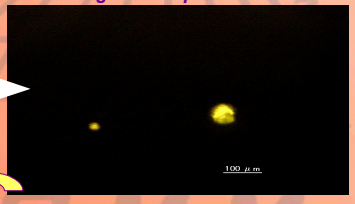
3mm macro alginate beads obtained by conventional method



Gelation & sedimentation of MABs containing 10 nm gold nanoparticles



Fluorescent micrograph of ~20µm & 80µm MABs as microcarriers of gold nanoparticles



Performances regarding the size of the alginate microcarrier, down to 20µm in diameter, can be obtained using the present microfluidic system.

4. Conclusions:

We developed a practical microfluidic device capable of generating monodisperse and purified MABs of ~ 20µm in diameter in the best case, in order to handle gold nanoparticles of ~ 10nm in diameter and has the advantages of accurate control of diameter as well as simple and low cost process. The approach in manipulation of such microspheres will provide promising uses for tissue engineering (cell handling), drug delivery and other cell-based pharmaceutical applications.