LTCC MICROFLUIDIC DEVICES APPLIED ON SYNTHESIS AND FUNCTIONALIZATION OF NANOPARTICLES

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Abstract: *Microfluidics has brought diverse advantages on chemical processes allowing higher control of reactions and economy of reagents and energy. Low temperature co-fired ceramics (LTCC) have additional advantages as material for microfluidics devices fabrication such as high compatibility with chemical reagents, low roughness and easy scaling and microfabrication. The conjugation of LTCC technology with microfluidics allows the development of micrometric sized channels and reactors exploiting the advantages of fast and controlled mixing and heat transfer processes, essential for the synthesis and surface functionalization of nanoparticles. Therefore, a cooperation has been established between Laboratory of Supramolecular Chemistry and Nanotechnology of Institute of Chemistry of the University of São Paulo (LQSN-IQUSP) and the Laboratory of Micromanufacture of Institute for Technological Research (LMI/BIONANO-IPT) aiming the development of new microfluidic devices applied on synthesis and functionalization of gold and iron oxide nanoparticles that enables the development of nanomaterials with new and advanced functionalities.*

Key-Words*: LTCC technology; gold nanoparticles; miniaturization; synthesis of nanoparticles*

Introduction: Nanotechnology is a branch of science that objectives the development of materials with unique properties. Nanomaterials are composed of particles with at least one dimension sized from 1 to 100 nanometers and have different properties than their macrometric analog which guarantees great success in several areas such as optical, sensors, electronics, catalysts, energy conversion and medicine. However, there is a huge problem associated with controlling several parameters that define synthesis and other reactions of these materials which can lead to polydispersed and low-quality nanoparticles.

Miniaturization permits faster, controlled and reproducible chemical processes. There are several advantages in using microfluidics devices such as high heat and mass transfer of reagents with guarantees main control of process, low reagent and energy consumption, safety, portability of reactors, etc. However microfluidic devices currently employed in the synthesis of nanomaterials have a high manufacturing cost (e.g. silicon) or are not compatible with several reagents (e.g., steel, polymer, etc.).

One of the technologies used in microfabrication is called low-temperature co-fired ceramics (LTCC), which consists of easy-to-process hybrid ceramics with physical-chemical properties suitable for fabrication of microreactors applied on synthesis and modification of nanoparticles. LTCC devices are designed using multiple layers of green ceramics and allows the fabrication of microfluidic systems using multiple layers of green tapes, which will generate 3D structures after aligning them and applying heat and pressure to the lamination. After sintering green ceramics are compatible with organic solvents, strong acids and reducing reagents, that is, its application leads to a wide range of reactions using LTCC devices.

Accordingly, we are focused on the development, test and optimization of microfluidic systems design for synthesis of gold nanoparticles, and multifunctionalization of magnetic and gold nanoparticles, in order to obtain monodispersed and multifunctional nanoparticles in highly reproducible processes. We are employing Turkevich Method which consists in the reduction of a gold salt with citrate at high temperature once this particle is water-dispersible, biocompatible and reactive, so they are excellent for modification and application on posterior biological studies.

Experimental: LTCC microfluidic devices consisted of 21 ceramic sheets with thickness corresponded to 254 µm each one. Microchannels are design on AutoCAD 2016© and CircuitCAM© software and cut on ceramic sheets using LPFK laser. After cutting, Ceramic layers were aligned in order to form a 3D structure, pressed and sintered. All connections and hoses are compatible with the reagents used in Turkevich method. Microfluidics essays are performed with PHD2000 Harvard Apparatus syringe pumps while microreactor were heated by a water bath.

Results and discussion: It was possible to obtain gold nanoparticles of various diameters by modulating operating parameters of microfluidic device (reagent concentration, flow rate, etc.). The nanoparticles obtained were characterized by Electronic Spectroscopy, Dynamic Light Dispersion (DLS) and Total Reflection X Ray Fluorescence Spectroscopy (TXRF). Currently operation parameters are being optimized in order to obtain reproducible and size-tunable product. Devices responsible for functionalization are also been developed.

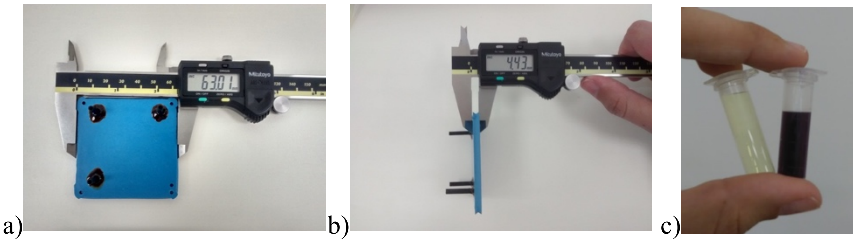

Figure 1. A,B) Microfluidic device fabricated with LTCC technology employed on synthesis of gold nanoparticles. C) Gold (III) salt used in nanoparticles synthesis and gold nanoparticles obtained through flow conditions.

Conclusion: LTCC technology showed to be highly promising since the material is chemically very inert and ensures good control of the nucleation and multifunctionalization reactions. The next stage of the project is to complete the tests with the first devices designed for synthesis and modification of nanomaterials. The gold nanoparticles will also be functionalized with bioactive binders in order to obtain multifunctional and anisotropic nanoparticle.

References and acknowledgements:

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