# SERS detection of anticancer drugs using a composite nanostructure based on porous silicon and gold nanoparticles

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Over the recent years, Raman spectroscopy (RS) methods have been largely employed in biomedical analysis. Generally, it is based on the detection of molecular vibrations which are activated by laser radiation and subsequent inelastic light scattering. Resulting spectra constitutes a distinctive "fingerprint" that contains detailed molecular information. Cells, microorganisms, metabolites, small molecules and etc can be detected through RS. Furthermore, the combination of RS and confocal microscopy leads to both spectroscopic monitoring and imaging which is beneficial in the research of nanocontainers for drug delivery. Although Raman scattering is initially weak, its intensity can be enhanced up to 15 orders of magnitude by exciting surface plasmon resonances on the nanorough surfaces of noble metals. This effect, surface-enhanced Raman scattering (SERS), has opened novel opportunities for biomedical analytics, and different metal nanostructures may serve as SERS substrate.

Porous silicon nanoparticles (pSiNPs) are promising nanocontainers for drug delivery due to their high drug-loading capacity, biocompatibility and degradation into non-toxic silicic acid in the living body environment [1]. Notably, it is well known that crystalline silicon has a specific Raman band at 520.5 $cm^{-1}$ that allows monitoring of the uptake, intracellular localisation, and dissolution of pSiNPs in cells. For the first time, Raman studies of the biodegradation of doxorubicin-loaded pSiNPs and drug release kinetics inside cancer cells were successfully demonstrated in [2]. Also, the cellular uptake and biodistribution of pSiNPs loaded with sunitinib, another anticancer drug, were studied by RS in [3]. However, the modification of pSiNPs surface with Au nanoparticles (AuNPs) is expected to achieve the considerable enhancement of the Raman signal of the loaded drug due to SERS effect.

In this work, a method of the fabrication of a new composite nanomaterial Au-pSi NPs was developed. Au-pSi NPs were characterized using RS, infrared (IR) spectroscopy, dynamic light scattering (DLS), transmission electron microscopy (TEM), scanning electron microscopy (SEM). Doxorubicin and sunitinib were loaded into Au-pSi NPs and the drugs releases were measured using spectrophotometry and SERS.

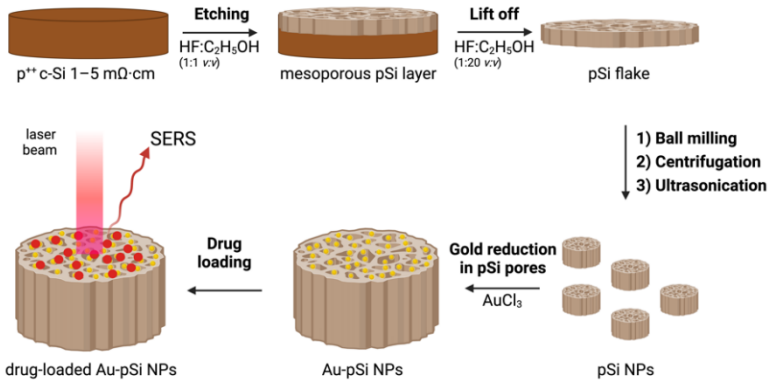


Figure 1. – Schematic illustration of Au-pSi NPs nanocontainers fabrication.

The obtained results emphasise future applications of composite nanostructures based on porous silicon and gold nanoparticles for controlling drug release from nanocontainers using SERS.

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[1] J.-H. Park, et al, Biodegradable luminescent porous silicon nanoparticles for in vivo applications, Nat. Mater., vol. 8, pp. 331–336, (2009).
[2] P.V. Maximchik, et al, Biodegradable Porous Silicon Nanocontainers as an Effective Drug Carrier for Regulation of the Tumor Cell Death Pathways, ACS Biomater., Sci. Eng., vol. 5 (11), pp. 6063-6071, (2019).
[3] E. Tolstik, et al, Raman and fluorescence micro-spectroscopy applied for the monitoring of sunitinib-loaded porous silicon nanocontainers in cardiac cells, Front. pharmacol., vol. 13, pp. 962763, (2022).