Hybrid nanostructures comprised of multiple materials that function in concert exhibit properties that cannot be achieved by single-element nanoparticles. Today, such systems can be made by colloidal synthesis. However, there are not adequate strategies for the crafting of a large number of arrays of size- and shape-controlled core-shell structures. Here, we present a generic nanofabrication strategy for the production of a library of large-area of core-shell nanostructures with a high number of material combinations in terms of all constituents. We locally grow different dielectric or semiconducting shell layers encapsulating plasmonic nanoantenna cores decorated with up to seven varieties of composition-tunable transition-metal nanoparticles, many of which have precedence in plasmonics and catalysis. To demonstrate the opportunities that now become available, we craft our library for the scrutiny of plasmon-assisted enhanced light absorption engineering with application in photocatalysis. Selecting the best structure our library in terms of absorption enhancement, we investigate its photocatalytic efficiency during CO oxidation varying a wide parameter space of reaction conditions. Our studies demonstrate that chemical reactivity cannot be accessed with thermal energy only. Thus, we propose an interplay between light-induced photothermal energy and photoexcitation of carriers the core-shell antenna activating the CO adsorbed species over the metal catalyst allowing to enhance the CO$_2$ photocatalytic reaction rate. The material combinations and presented application make our core-shell nanoantennas a promising platform for high throughput screening of new materials for plasmon driven photocatalysis.

**Keywords:** Nanofabrication, Plasmonics, Catalysis

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**Presenting author's email:** arturosusarce@gmail.com