# Pd single-atom heterogeneous catalyst for sustainable Sonogashira cross-coupling on scale

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Among the transition-metal catalyzed cross-coupling reactions, the Sonogashira-Hagihara reaction presents a cornerstone in today's synthetic chemists toolbox to access complex arylalkynes and enynes.[1] Attempts to replace homogeneous palladium catalysts with solid-supported, mostly nanoparticle-based counterparts have failed to compensate for inferior activity or severe metal leaching. Single-atom heterogeneous catalysts (SAHC) are promising approach to maximize the control over the palladium site, while displaying favorable metal-efficiency and facile recoverability.[2] Herein, we report Pd single-atoms supported on nitrogen doped carbon (**Fig. 1a**) as a sustainable catalyst for the Sonogashira cross-coupling. Advanced characterization techniques are used to relate structure properties with catalyst activity and stability. Although lower activity was observed compared to homogeneous benchmarks the SAC stands out with its stable performance. A more holistic and process-centered assessment of the investigated catalysts is obtained through life cycle analysis (LCA), unveiling the sustainability of heterogeneously catalyzed Sonogashira coupling (**Fig. 1b**).

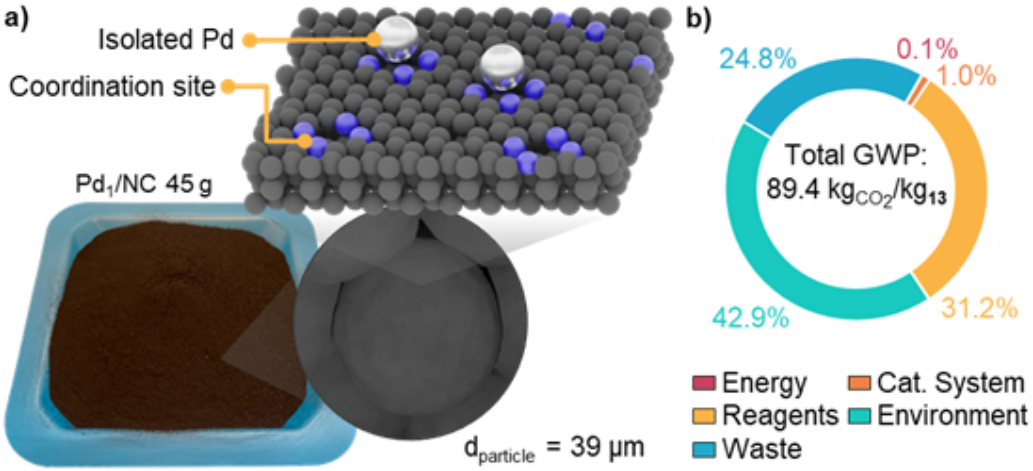


**Fig. 1 a)** Photography of the $Pd_1$/NC and schematic representation of its structure at particle and nanometer scale. Color code: blue, nitrogen; black, carbon; gray, palladium. **b)** Donut chart expressing the component classes' shares of the Sonogashira reaction´s total GWP. $Pd_1$/NC is assumed to be used for 10 consecutive batch reactions. *Energy*: Electricity and heat; *Cat. System*: $Pd_1$/NC, CuI and $PPh_3$; *Reagents*: Aniline **11** and Ethin **12**; *Environment*: MeCN and $NEt_3$; *Waste*: Incineration of generated waste.

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