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Nano-copper catalyzed three-component reaction to construct 1,4-substituted 1,2,3-triazoles

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ABSTRACT

Three-component reaction of alkyl halides, sodium azide with terminal alkynes can be catalyzed by nano-copper particles under ambient conditions. A series of 1,4-disubstituted-1,2,3-triazoles were obtained regioselectively by this one-pot strategy. Nano copper can be reused at least three times without significant deactivation.

At the dawn of the 21st century, green catalysis, including using highly efficient catalyst, clean solvent, multicomponent reaction, and recoverable reaction system, has become a hot topic in chemical transformations and has been paid more attention by researchers.[1,2]

In many transition metals, copper has been used as catalyst in organic synthesis for many decades.[3–6] The discovery of Cu(I)-catalyzed azide–alkyne cycloaddition yielding selectively 1,4-disubstituted-1,2,3-triazoles is a very important advance in the chemistry of triazoles.[7,8] As we know, 1,2,3-triazoles are important building blocks of nitrogen heterocyclic compounds and have been widely used in pharmaceuticals, agro chemicals, dyes, photographic materials, corrosion inhibition, etc.[9] 1,2,3-Triazoles are also associated with a wide range of biological properties such as magnetic resonance imaging, drug delivery, and biomolecular sensors.[10] Two routes are generally adopted for the synthesis of substituted 1,2,3-triazoles. One is copper catalyzed [3+2] cycloaddition of organoazides with alkynes. However, methods for the preparation of organic azides are rather limited.[11] Moreover, it needs two-step reactions, special reagents, even strictly oxygen, and water-free conditions to obtain the aimed products via organic azides.[12–15] In order to overcome the disadvantages of the above two-step reactions, one pot, three-component reaction of alkyl halides, sodium azide, and alkynes is developed recently by using copper catalysts such as Cu_2O,[16] CuI,[17,18] $CuSO_4$,[19–21] $CuBr(PPh_3)_3$,[22] $CuFe_2O_4$ nanoparticles,[1] and polymeric imidazole-Cu(II).[23] Supported Cu(0) nanoparticles were also used as a catalyst in this reaction, such as Cu–Fe bimetals for two-component reaction,[24] Cu/SiO_2,[25] Cu/C,[26] and polymer capped Cu/Cu_2O[27] for three-component reaction. Copper nanoclusters have already been

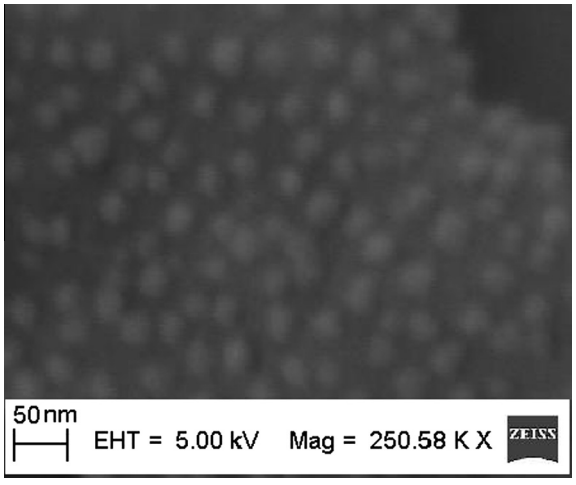

Figure 1. SEM micrograph of Cu NPs.

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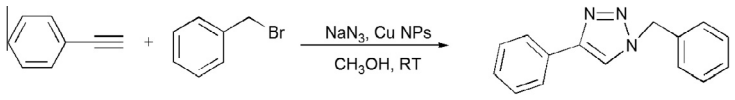
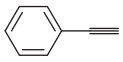
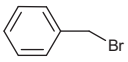
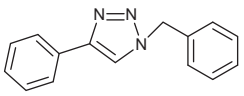
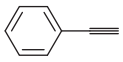
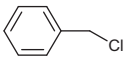
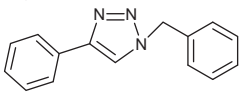
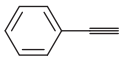
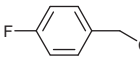
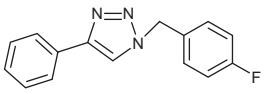
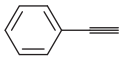
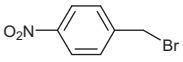
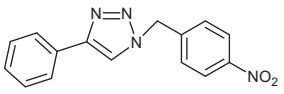
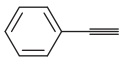
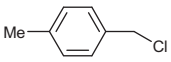
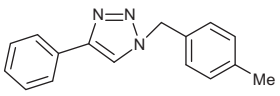
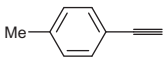
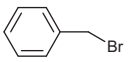
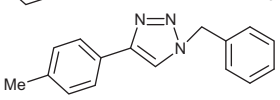
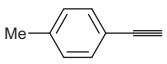
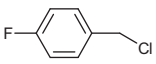
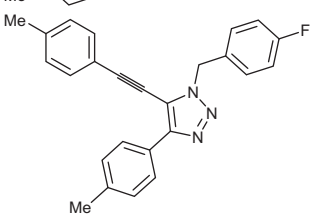
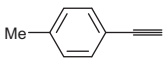
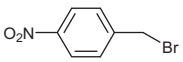
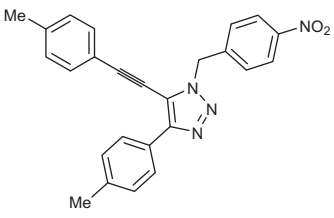
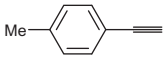
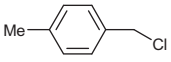
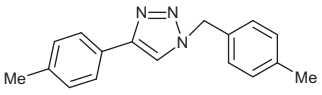
Table 1
Screening of the catalyst for the three-component click reaction[a]



Entry	Catalyst	Yield [b](%)
1	CuBr	70
2	CuI	83
3	$CuCl_2$	82
4	$CuSO_4{\cdot}5H_2O$	83
5	CuO	62
6	Cu NPs	93
7	Cu powder	45
8[c]	Cu NPs	85
9[d]	Cu NPs	91

[a] Reaction conditions: phenylacetylene (0.5 mmol), benzyl bromide (0.6 mmol), NaN_3 (0.6 mmol), catalyst (0.025 mmol), methanol (2 mL), r.t.
[b] Isolated yield.
[c] Catalyst (0.01 mmol).
[d] Catalyst (0.05 mmol).

Table 2
Cu NP catalyzed cycloaddition of phenylacetylenes, benzyl halides, and sodium azide[a]

Entry	Alkyne	Benzyl halide	Product	Time (h)	Yield[b] (%)
1				8	93
2				10	86
3				12	82
4				14	71
5				12	88
6				12	90
7				12	80
8				16	69
9				12	81

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