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Pd-Fe alginate beads as an efficient catalyst for Suzuki-Miyaura Reactions

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Highlights

Alginate acts as a natural reducing and stabilizing agent for Pd nanoparticles. The resulting Pd catalyst promotes C–C couplings under mild conditions, affording biphenyls in good yields.

Abstract

Alginate, a natural biopolymer extracted from marine algae, is widely recognized for its hydrogel-forming capacity, biodegradability, low toxicity, and ability to act as a reducing and stabilizing agent for metallic nanoparticles.[1] At the same time, palladium catalysts are fundamental to cross-coupling reactions, but their high cost and limited availability underscore the need for more sustainable catalytic systems.[2,3] In this context, this work proposes the development of a sustainable catalyst composed of palladium nanoparticles dispersed within iron alginate spheres, in which alginate acts simultaneously as a reducing and stabilizing agent for the metallic nanoparticles.

The Pd/FeAB catalyst was synthesized by reducing $Pd(OAc)_2$ in an aqueous sodium alginate (SA) solution. The mixture was heated until it turned dark, then slowly dripped through a glass syringe into a $FeCl_3$ solution and allowed to cure for 24 hours after the complete addition of Pd (0)/SA. The resulting alginate beads were filtered, washed, and air-dried to produce the Pd/FeAB catalyst (Figure 1). Comprehensive characterization using UV-Vis, FT-IR, SEM, TEM, EDS, and ICP-OES confirmed the formation of Pd NPs (Figure 2).

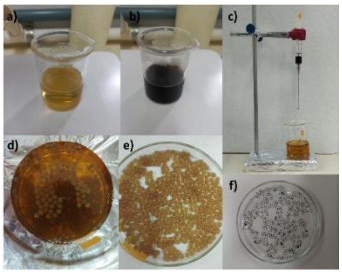


Figure 1. Preparation of the Pd/FeAB catalyst.

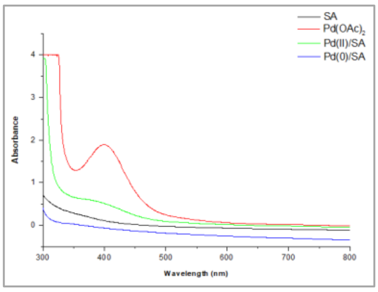
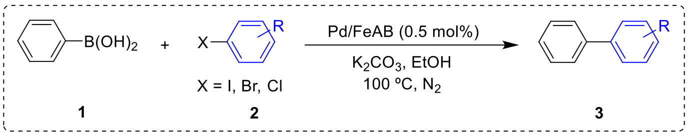


Figure 2. UV–Vis spectra of SA, Pd(OAc)₂, Pd(II)/SA, and Pd(0)/SA species.

Entry #	Halides	Time (h)	Yield (%)
1	4-iodoanisole	3	81
2	4-iodotoluene	3	72
3	4-bromobenzonitrile	24	90
4	1-bromo-4-nitrobenzene	24	69
5	4-bromoanisole	24	12
6	1-chloro-4-nitrobenzene	30	NR
7	4-chloroanisole	30	NR

Table 1. Synthesis of biphenyls via Suzuki-Miyaura cross-coupling reaction between phenylboronic acid and different aryl halides.

The catalyst was tested in the Suzuki–Miyaura reaction between phenylboronic acid (**1**) and aryl halides (**2**) using 0.5 mol% Pd at 100 °C under a nitrogen atmosphere (Scheme 1). The corresponding biphenyl products were obtained in excellent yields when aryl iodides were used as substrates (entries 1–2, Table 1). In contrast, lower yields were observed with aryl bromides, particularly those bearing electron-donating substituents (entries 3-5), while aryl chlorides remained unreactive under the tested conditions (entries 6-7).



Scheme 1. Pd/FeAB-mediated synthesis of biphenyls.

In summary, in the present work we developed a catalyst containing Pd nanoparticles dispersed in alginate. The yields obtained so far demonstrate the catalytic capacity of Pd/FeAB in Suzuki-Miyaura cross-coupling reactions.

References: [1] *Polym. Int.* 57 (2008) 171-180. [2] *Chinese J. Chem. Eng.* 28(5) (2020) 1334-1343. [3] Asian *J. Org. Chem.* 14 (2025) e00269.

Acknowledgments

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